

**MS4 Southampton Creek TMDL Strategy**

For  
Warminster Township  
Bucks County

September 2012  
**Revised April 2016**

Prepared For:

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## I. Introduction

Warminster Township, located in Bucks County, is comprised of 10.2 square miles of land situated within the Neshaminy Creek and Pennypack Creek watersheds. The Township owns and maintains a small municipal separate storm sewer system (MS4) requiring a National Pollutant Discharge Elimination System (NPDES) permit to allow discharge of stormwater runoff to waters of the Commonwealth of Pennsylvania. The Neshaminy Creek watershed and a Pennypack Creek sub-watershed, Southampton Creek, have approved Total Maximum Daily Loads (TMDLs). These plans establish waste load allocations (WLA) for Warminster Township limiting the amount of pollutants that are permitted to be discharged to waters of the Commonwealth of Pennsylvania. At the time of this Strategy, the Neshaminy TMDL plan has siltation (sediment) WLAs attributed to the Township and the Southampton TMDL plan has siltation and nutrient (total phosphorous) WLAs attributed to the Township. This MS4 TMDL Strategy is prepared to satisfy the siltation and nutrient WLAs of the Southampton Creek Watershed TMDL Plan. The Strategy addressing the Neshaminy Creek TMDL will be presented in a separate document.

The intent of this MS4 TMDL Strategy is to establish the WLA of the Township and to present a plan to reduce waste loads discharged from the regulated small MS4 consistent with the WLAs in the approved Southampton Creek Watershed TMDL. Township staff has met with staff from the other municipalities located within the Southampton Creek watershed, where it was discussed that a multi-municipal watershed-based approach to the waste load reductions could ultimately benefit the overall health of the Southampton Creek. Though the municipalities have agreed to continue considering pursuing a comprehensive strategy, individual plans are being submitted.

Upon approval of this Strategy by the Pennsylvania Department of Environmental Protection (PADEP), the Township will provide MS4 TMDL Design Details for implementation of the Strategy. Together, these documents, the MS4 TMDL Strategy and the MS4 TMDL Design Details, comprise the MS4 TMDL Plan satisfying the requirement of the Township's NPDES MS4 Permit. Implementation of the TMDL Plan is an adaptive, iterative and dynamic process. The TMDL Plan will be evaluated and updated by the Township on an as-needed basis based upon its effectiveness in reducing pollutant loads in discharges from the regulated small MS4, the reasonableness of achieving the WLAs, and the cost/benefit of the best management practices (BMPs) under consideration.

### **Established TMDLs**

The Pennypack Creek watershed covers approximately 4.6 square miles of Warminster Township, of which approximately 2.1 square miles (1,344 acres) drains to the Southampton Creek sub-watershed before flowing into the main Pennypack Creek watershed. Please refer to the *Warminster Township Watershed Boundary Map*, included in Appendix A, for limits of the Southampton and Pennypack Creek Watersheds within the Township.

While no TMDL exists for the Pennypack Creek, which is an impaired stream for sediment, the USEPA established total phosphorous and sediment TMDLs for the Southampton Creek sub-watershed on June 30, 2008. The TMDL, titled *Nutrient and Sediment TMDLs for the Southampton Creek Watershed, Pennsylvania*, is for the Southampton Creek in Montgomery and Bucks counties within Hydrologic Unit Code 02040202 (Lower Delaware). TMDLs were also established for Upper Southampton Township in Bucks County and Lower Moreland Township, Upper Moreland Township, and Bryn Athyn Borough in Montgomery County.

Based on the land use loading rates in the TMDL, the following WLAs were established for Warminster Township:

<b>WARMINSTER TOWNSHIP SOUTHAMPTON CREEK TMDL SUMMARY</b>				
<b>Pollutant</b>	<b>Existing Load (lb/year)</b>	<b>WLA (lb/year)</b>	<b>Reduction (%)</b>	<b>Reduction (lb/year)</b>
Sediment	551,242	367,675	33.3%	183,567
Nutrient (Total Phosphorus)	270.74	2.19	99.2%	268.55

Since required reductions were not included in the TMDL, information detailing how the required reductions were calculated is provided in the "Waste Load Calculations" section below and data are available in Appendix B.

## II. Waste Load Calculations

The calculations described in this section are intended to provide baseline and allocated waste loads for the Township's goal of achieving the waste load removals outlined in the Southampton Creek TMDL. Only areas tributary to the Township MS4 were included as area contributing to waste loads.

### MS4 Tributary Area

The existing pollutant loads presented in Section II are allocated to the entire Township area within the Southampton Creek watershed. The Township's permit obligation applies only to runoff collected by and discharged from the MS4. The following table summarizes areas which are not tributary to the Township's MS4. The pollutant loads generated from these non-tributary areas are parsed from the Township loads to determine that which is attributed to only the MS4. The Township reserves the right to modify parsed areas in the future. Any modification to parsed areas will be documented in future updates of the MS4 TMDL Plan. Please refer to the *TMDL Map*, included in Appendix A, for limits of the parsed areas within the Southampton Creek Watershed in Warminster Township.

Area Description	Acres	%
Township within Watershed	1,344	100.00%
Tributary to PennDOT Roads	13.7	1.02%
Not Tributary to MS4	635.1	47.25%
<b>Parsed from MS4</b>	<b>648.8</b>	<b>48.27%</b>
<b>Tributary to MS4</b>	<b>695.2</b>	<b>51.73%</b>

### MS4 Waste Load Calculations

The following table summarizes the waste loads, WLAs and required pollutant reductions attributed to the MS4 after accounting for parsed areas. The values presented in Section II are reduced by 48.27%.

MS4 SOUTHAMPTON CREEK TMDL SUMMARY				
Pollutant	Existing Load (lbs/year)	WLA (lbs/year)	Reduction (%)	Reduction (lbs/year)
Sediment	285,157	190,198	33.3%	94,959
Nutrient (Total Phosphorus)	140.05	1.13	99.2%	138.92

### **III. TMDL Compliance Strategy**

As presented in Section III, Warminster Township has a significant requirement to reduce sediment and total phosphorus discharging from the MS4. The Township plans to achieve the sediment reduction using three basic approaches listed below and described in subsequent sections.

- Quantify existing best management practices (BMPs)
- Amend the Township Stormwater Management Ordinance to require pollutant reductions
- Implement new BMPs

The Township intends to implement this Strategy over 25 years. The Township intends that at or before the conclusion of 25 years the sediment reduction presented in Section III will be achieved and the assumptions made in the approved watershed TMDL Plan regarding attaining water quality will be satisfied.

The Township anticipates that setting realistic goals which can be quantified by “measurable” success, the reduction percentages outlined in the approved watershed TMDL Plan can be met and water quality in all waterways within the Township will be positively impacted by implementation of this MS4 TMDL Strategy. Implementation of the MS4 TMDL Plan is an adaptive, iterative and dynamic process. The MS4 TMDL Plan will be evaluated and updated by the Township on an as-needed basis based upon its effectiveness in reducing pollutant loads in discharges from the regulated small MS4, the reasonableness of achieving the WLAs and the cost/benefit of the BMP under consideration. Therefore, it is intended that this Strategy, in its entirety, including the implementation term, may be modified by the Township periodically to reflect actual results, achievable goals and obstacles encountered during the process of implementation of this Strategy. As funding or other opportunities become available, the BMPs discussed below may be altered or new BMPs added to this TMDL Strategy.

#### Planning Efforts

Staff from the five municipalities located within the Southampton Creek watershed have met on several occasions to discuss a multi-municipal watershed-based approach to compliance with the required loading reductions. Though no formal agreement has been prepared, there is consensus that a partnership strategy could benefit the overall health of the Southampton Creek. At this time, each municipality is preparing individual TMDL Strategies but plan to continue pursuing a comprehensive strategy.

#### Pollutant Load Concentration Method

In subsequent sections of this Strategy, pollutant load concentrations are required to quantify the amount of sediment generated from areas tributary to existing and potential new BMPs. The Water Quality Analysis of Pollutant Loading method from Worksheet 12 of the PADEP’s Pennsylvania Stormwater Best Management Practices Manual dated December 30, 2006 (PA BMP Manual), is utilized to approximate sediment generated on an annual basis. The method requires three input parameters:

- Pollutant event mean concentration (EMC) in mg/L from Table 8.3 of the PA BMP Manual
- Tributary area in acres (measured from a map)
- Annual runoff depth in feet

For the purposes of the Strategy, runoff depth was calculated using 4 years (2011 – 2014) of daily rain gauge data from the Ambler Borough Waste Water Treatment Plant (WWTP) and the SCS Runoff Curve Number Method (NRCS, TR-55) accounting for the initial abstraction and land cover classification. Since the Ambler Borough WWTP is within 8.8 miles of Warminster Township, the rainfall data is considered representative of average rainfall in the Township.

LAND COVER CLASSIFICATION	CN	AVERAGE ANNUAL RUNOFF (in/year)	AVERAGE ANNUAL RUNOFF (ft/year)
Forest	62	4.63	0.39
Meadow	60	4.10	0.34
Fertilized Planting Area	65	5.53	0.46
Native Planting Area	58	3.62	0.30
Lawn, Low Input	68	6.59	0.55
Lawn, High Input	65	5.53	0.46
Golf Course Fairway/Green	68	6.59	0.55
Grassed Athletic Field	70	7.39	0.62
Rooftop	98	43.51	3.63
High Traffic Street/Highway	97	39.80	3.32
Medium Traffic Street	90	23.96	2.00
Low Traffic/Residential Street	89	22.47	1.87
Res. Driveway, Play Courts, etc.	98	43.51	3.63
High Traffic Parkng Lot	98	43.51	3.63
Low Traffic Parking Lot	98	43.51	3.63

### Existing BMPs

The Southampton TMDL Plan was based on analysis completed through 2006. Several BMPs have been installed within the Township following the analysis included in the TMDL Plan. The following parameters are used to determine the sediment load from these areas and the reduction provided by the associated BMPs.

- Tributary area – determined by inspection of the storm sewer map.
- Area cover conditions – percentage of impervious pervious areas was determined from approved land development plans or from aerial photography.
- Runoff depth – values for impervious and lawn areas.
- TSS EMC – 21 mg/L and 58 mg/L were used for impervious areas to account for rooftops and low traffic parking areas respectively, 180 mg/L was used for lawns, low input.
- TP EMC – 0.13 mg/L and 0.15 mg/L were used for impervious areas to account for rooftops and low traffic parking areas respectively, 0.40 mg/L was used for lawns, low input.

While a detailed tabulation of the existing BMP calculations can be found in Appendix C, an example is included here.

EXISTING BMP SUMMARY				
	Sediment Load	Sediment Reduction	Phosphorus Load	Phosphorus Reduction
	(lbs/yr)	(lbs/yr)	(lbs/yr)	(lbs/yr)
McDonald Elementary School	4,612	3,920	12.45	10.58

### Ordinance Requirements

The current Township Ordinances require peak rate and volume reductions as well as water quality requirements. These requirements are typically met by the implementation of BMPs. However, the pollutant reduction associated with these BMPs is generally not quantified. The Township intends to include pollutant reduction requirements consistent with the WLAs in the approved TMDL to ensure developments and other projects achieve the pollutant reductions required by the TMDL Plans and that those benefits are quantified under the TMDL Plan requirements. It is not possible to quantify the pollutant reductions achievable from these new Ordinance requirements for inclusion in this Strategy. Any BMPs installed within the Township MS4 tributary area will be included in future reporting regarding implementation the MS4 TMDL Plan.

### Potential New BMPs

The Township anticipates that sediment reduction from existing BMPs and from future projects subject to new Ordinance requirements will not achieve the substantial pollutant reduction required by the TMDL Plan. The Township includes with this Strategy several potential BMPs that may be implementable in striving to meet the WLA requirements. These potential BMPs may be on private property and therefore, no guarantee is provided that these BMPs can or will be implemented. Implementation of any BMP expected to contribute to achieving the goal of this Strategy will require planning, design, permitting approval, property owner consent, etc. Therefore, the potential BMPs presented in this MS4 TMDL Plan are to be considered conceptual in scope and in no way imply any obligation of the Township to implement these specific BMPs in the locations identified. As stated previously, implementation of the TMDL Plan is an adaptive, iterative and dynamic process. The TMDL Plan will be evaluated and updated by the Township on an as-needed basis based upon its effectiveness in reducing pollutant loads in discharges from the regulated small MS4, the reasonableness of achieving the WLAs and the cost/benefit of the BMP under consideration.

The Southampton Creek TMDL plan requires reductions in sediment and total phosphorus of 33.3% and 99.2%, respectively. Calculations supporting each BMP listed in this summary table are provided in Appendix D.

<b>POTENTIAL BMP SUMMARY</b>		
<b>BMP</b>	<b>Sediment Reduction (lb/yr)</b>	<b>Phosphorus Reduction (lb/yr)</b>
Streetsweeping	3,975	4.67
Inlet Filter Inserts	24,115	75.45
Rain Barrels	2,641	16.35
Infiltration Trenches	26,346	71.89
Streambank Restoration	41,751	0.00
<b>TOTAL</b>	<b>98,828</b>	<b>168.35</b>

### TMDL Compliance Strategy Summary

The following table summarizes the sediment load, WLA and required sediment reduction attributed to the MS4 after accounting for parsed areas. It also includes a summary of the existing and potential BMPs contemplated to achieve the required sediment load reduction.

<b>Description</b>	<b>Unit</b>	<b>Sediment</b>	<b>Phosphorus</b>
MS4 Sediment Load	lb/year	285,157	140.05
MS4 Required Pollutant Reduction	%	33.3%	99.2%
<b>MS4 Required Pollutant Reduction</b>	<b>lb/year</b>	<b>94,959</b>	<b>138.92</b>
Existing BMPs	lb/year	-3,920	-10.58
Future Potential BMPs	lb/year	-98,828	-168.35
<b>Pollutant Reduction Potential</b>	<b>lb/year</b>	<b>-102,748</b>	<b>-178.93</b>
<b>Net Potential Reduction</b>	<b>lb/year</b>	<b>-7,789</b>	<b>-40.01</b>

The table above indicates that implementation of this Strategy will potentially exceed the required pollutant reduction in the watershed by 7,789 lb/year and 40.01 lb/year for sediment and total phosphorus, respectively.

#### **IV. Public Participation**

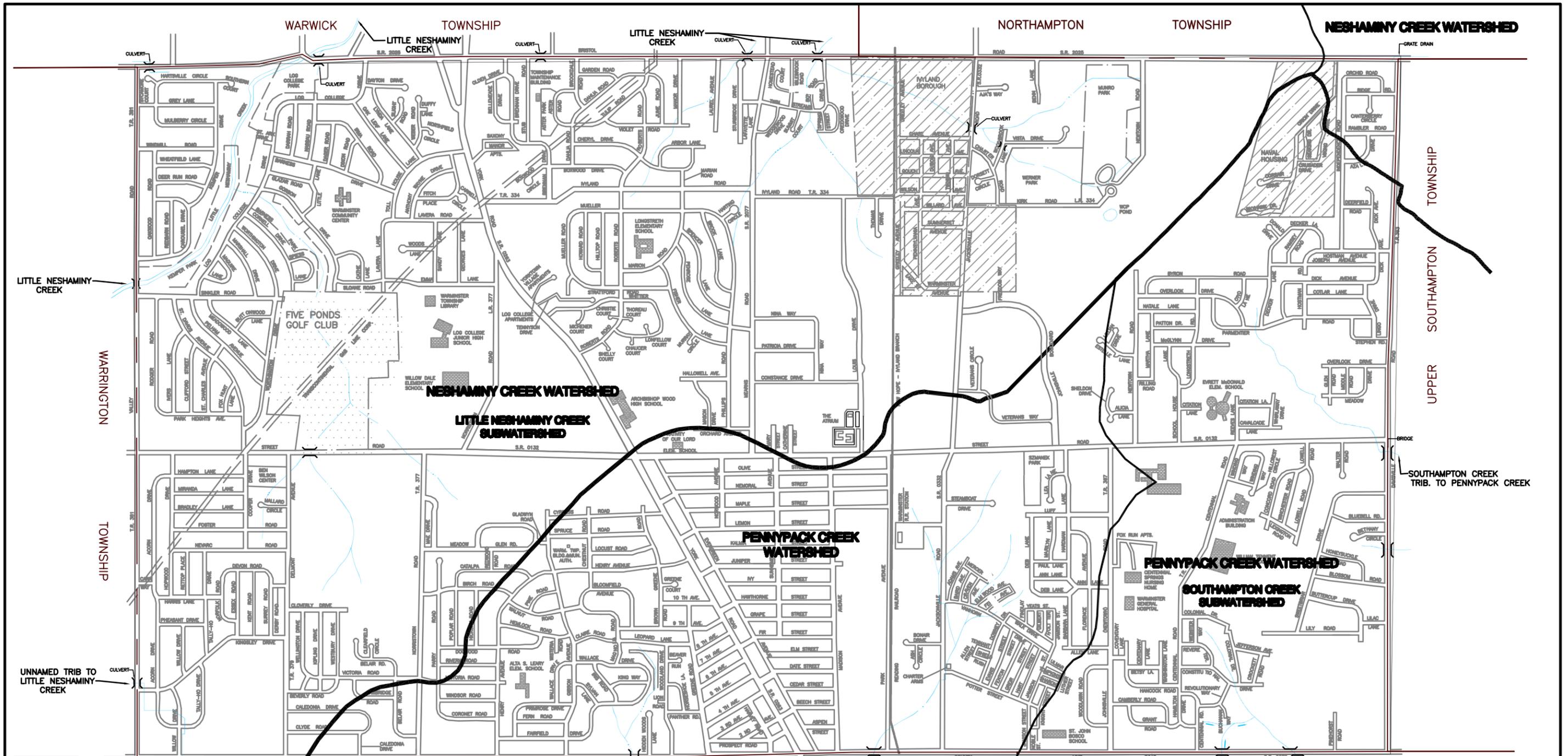
As part of the preparation of this MS4 TMDL Strategy, PADEP requires solicitation of public involvement and participation. The following are required:

- A copy of the MS4 TMDL Strategy must be available for public review.
- Publish, in a newspaper of general circulation in the area, a public notice containing a statement describing the Strategy, where it may be reviewed by the public, and the length of time provided for the receipt of comments.
- Accept written comments for a minimum of 30 days from the date of public notice.
- Accept any verbal or written comments from any interested member of the public at a public meeting or hearing.
- Consider and make a record of the consideration of each timely comment received from the public during the public comment period concerning the Strategy, identifying any changes made to the Strategy in response to the comment.

As required, a copy of the newspaper notice, a copy of all written comments received from the public, and a copy of the record of consideration of all timely comments received in the public comment period are included as Appendix E.

**APPENDIX A**

Warminster Township Watershed Boundary Map & TMDL Map



**WATERSHED BOUNDARY MAP**  
**WARMINSTER TOWNSHIP**  
 WARMINSTER TOWNSHIP, BUCKS COUNTY, PENNSYLVANIA

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## **APPENDIX B**

Sediment and Total Phosphorous WLA Calculations –Southampton Creek Watershed

**Appendix B1 - Sediment Waste Load Allocation Calculations for Southampton Creek Watershed**

Land Use Source	Warminster in Watershed (ac)	Existing Loading Rate (lb/ac/yr)	Existing Waste Load (lb/yr)	Target Loading Rate (lb/ac/yr)	Allocated Waste Load (lb/yr)	% Reduction
Hay/Pasture	56	93	5,208	42	2,342	55.03%
Cropland	51	758	38,658	623	31,890	17.51%
Forest	196	7	1,372	4	786	42.71%
Transitional Land	4	2,708	10,832	1,229	4,918	54.60%
Low Intensity Development	928	98	90,944	50	46,517	48.85%
High Intensity Development	110	56	6,160	45	4,927	20.02%
Streambank Erosion	32.72%	1,216,589	398,068	844,428	276,297	30.59%
<b>TOTAL:</b>	<b>1344</b>		<b>551,242</b>		<b>367,675</b>	<b>33.30%</b>

**NOTE:**

Area of Warminster in Watershed are from Table 18 "Sediment WLAs for MS4 Municipalities in Southampton Watershed" of Southampton Creek TMDL.

Existing Loading Rates (lb/ac/yr) based on Table 12 "Existing Sediment Load for Southampton Creek Watershed" of Southampton Creek TMDL.

Existing Waste Load (lb/yr) = Acres \* Existing Loading

Target Loading Rates (lb/ac/yr) from Table 19 "Land Use Loading Rates for MS4 WLAs" of Southampton Creek TMDL

Allocated Waste Load (lb/yr) = Acres \* Allocated Loading

Calculated Allocated Load (lb/yr) was compared to Table 18 "Sediment WLAs for MS4 Municipalities in Southampton Watershed" of Southampton Creek TMDL and found to be significantly similar

% Reduction = (Existing Waste Load - Allocated Waste Load)/Existing Waste Load

Warminster Area based on "Township Maintained Rights-of-Way within the Southampton Creek Watershed" and "Township-Owned Property within the Southampton Creek Watershed" spreadsheets.

Appendix B2 - Total Phosphorous Waste Load Allocation Calculations for Southampton Creek Watershed

Land Use Source	Total Area (Ha)	Total Area (ac)	23 Year Existing Waste Load TP Mass (kg)	23 Year Existing Waste Load TP Weight (lb)	Existing Loading Rate TP (lb/ac/yr)	Warminster Area (ac)	Warminster Existing Load (lb/yr)	Warminster Allocated Waste Load (lb/yr)	% Reduction
Hay/Pasture	19	46.95	3.26	231.42	0.2143	56	12.00	0.10	
Cropland	78	192.74	32.70	2,321.33	0.5236	51	26.71	0.22	
Coniferous Forest	25	61.78	0.12	8.52	0.0060		-	-	
Mixed Forest	28	69.19	0.13	9.23	0.0058	196	1.14	0.01	
Deciduous Forest	109	269.34	0.51	36.20	0.0058		0.00	0.00	
Transition	15	37.07	15.23	1,081.16	1.2682	4	-	-	
Low Intensity Development	973	2,404.33	56.56	4,015.12	0.0726	928	67.38	0.55	
High Intensity Development	329	812.98	46.51	3,301.69	0.1766	110	19.42	0.16	
Streambank			19.40	1,377.18	59.8775	32.72%	19.59	0.16	
Groundwater			116.88	8,297.17	360.7464	34.51%	124.50	1.01	
Septic System			3.41	242.07			0.00	0.00	
<b>TOTAL:</b>		<b>3,894.37</b>	<b>294.71</b>	<b>20,921.10</b>		<b>1344</b>	<b>270.74</b>	<b>2.19</b>	<b>99.19%</b>

Total Area (Ha) and 23 Year Existing TP (kg) from Appendix C "Summary of AVGWLF Model Output for Southampton Watershed" of Southampton Creek TMDL

Total Area (ac) and 23 Year Existing TP (lb) are based on standard conversion factors

1 Ha = 2.47105 ac

1 kg = 2.20462 lbm

Weight (lb) = mass (lbm) \* 32.2 ft/sec/sec

Existing Loading Rates (lb/ac/yr) = 23 Year Existing Waste Load TP (lb)/Total Area (ac)/23 years

Warminster Area (Ac) from Table 18 "Sediment WLAs for MS4 Municipalities in Southampton Watershed" of Southampton Creek TMDL.

All Forest assumed to be Mixed Forest, since no Forest type breakdown is available and all 3 forest types have existing loading rate TP of 0.0002 lb/ac/yr.

Existing Load (lb/yr) = Warminster Acres (Ac) \* Existing Loading TP (lb/ac/yr)

Total Allocated Load (lb/yr) from Table 24 "TP WLAs for MS4 Municipalities in Southampton Watershed" of Southampton Creek TMDL

% Reduction = (Existing Waste Load - Allocated Waste Load)/Existing Waste Load \* 100

## **APPENDIX C**

Existing Best Management Practices

Appendix C - Existing Best Management Practices

No.	LOCATION	TRIBUTARY AREA (ac)	IMPERVIOUS COVER (%)	IMPERVIOUS COVER (ac)	RUNOFF DEPTH (in)	TSS EMC IMPERVIOUS (mg/L)	IMPERVIOUS TSS (lb/year)	LAWN COVER (%)	LAWN COVER (ac)	RUNOFF DEPTH (in)	TSS EMC LAWN (mg/L)	LAWN TSS (lb/year)	TOTAL TSS (lb/year)	85% TSS REDUCTION (lb/year)
1*	Pinehorst Road & County Line	19.73	46%	9.08	43.51	39.5	3,510	54%	10.66	6.59	180	2,844	6,354	5,401
2*	William Tennent HS	63.74	35%	22.31	43.51	39.5	8,627	65%	41.43	6.59	180	11,058	19,685	16,732
3	McDonald Elementary School	15.35	28%	4.30	43.51	39.5	1,662	72%	11.05	6.59	180	2,950	4,612	3,920
4*	Wawa (County & Davisville)	1.75	74%	1.30	43.51	39.5	501	26%	0.46	6.59	180	121	622	529

BMP Manual Method

No.	LOCATION	TRIBUTARY AREA (ac)	IMPERVIOUS COVER (%)	IMPERVIOUS COVER (ac)	RUNOFF DEPTH (in)	TP EMC IMPERVIOUS (mg/L)	IMPERVIOUS TP (lb/year)	LAWN COVER (%)	LAWN COVER (ac)	RUNOFF DEPTH (in)	TP EMC LAWN (mg/L)	LAWN TP (lb/year)	TOTAL TP (lb/year)	85% TP REDUCTION (lb/year)
1*	Pinehorst Road & County Line	19.73	46%	9.08	43.51	0.14	12.44	54%	10.66	6.59	0.40	6.32	18.76	15.95
2*	William Tennent HS	63.74	35%	22.31	43.51	0.14	30.58	65%	41.43	6.59	0.40	24.57	55.15	46.88
3	McDonald Elementary School	15.35	28%	4.30	43.51	0.14	5.89	72%	11.05	6.59	0.40	6.55	12.45	10.58
4*	Wawa (County & Davisville)	1.75	74%	1.30	43.51	0.14	1.77	26%	0.46	6.59	0.40	0.27	2.04	1.74

NOTE:

BMPs noted with asterix (\*) are within parsed areas and not included in satisfying the MS4 requirement.

Pollutant Load = [EMC, (mg/L)] \* [Runoff Volume, (ac\*ft)] \* [2.7, unit conversion]

EMC = Event Mean Concentration (mg/L)

TSS EMC = 21 mg/L for Rooftops (Table A-1, PA BMP Manual)

TSS EMC = 58 mg/L for Low Traffic Parking Lot (Table A-1, PA BMP Manual)

TSS EMC Impervious = (21 + 58)/2

TSS EMC = 180 mg/L for Lawn, Low Input (Table A-1, PA BMP Manual)

TSS EMC = 0.13 mg/L for Rooftops (Table A-2, PA BMP Manual)

TSS EMC = 0.15 mg/L for Low Traffic Parking Lot (Table A-2, PA BMP Manual)

TSS EMC Impervious = (0.13 + 0.15)/2

TSS EMC = 0.40 mg/L for Lawn, Low Input (Table A-2, PA BMP Manual)

Runoff Volume = [Area, (ac)] \* [Runoff Depth, (ft)]

Runoff depth is from Ambler Borough WWTP rain gauge from 2011 to 2014 and calculated using the SCS Runoff Curve Number method

BMP Removal Efficiencies from Table A-4, PA BMP Manual

	TSS	TP
6.4.2 Infiltration Basin	85%	85%

## **APPENDIX D**

Potential New Best Management Practices

Appendix D1 - Streetsweeping & Inlet Filter BMPs

Street Name	Land Use Classification	Sidewalks	Curb	Roadway Length (ft)	Right-of-Way Width (ft)	Roadway Width (ft)	Impervious Area (sf)	Grass Area (sf)	Area (ac)	TSS Load (lb/yr)	Phosphorus Load (lb/yr)	9%	3%	60%	50%
												Streetsweeping TSS Reduction (lb/yr)	Streetsweeping TP Reduction (lb/yr)	Inlet Filters TSS Reduction (lb/yr)	Inlet Filters TP Reduction (lb/yr)
Alicia La	Low Int Dev	YES	YES	581	50	24	17,424	11,616	0.67	245	0.89	22	0.0	134.0	0.4
Allen Ln	Low Int Dev	YES	YES	396	50	24	11,880	7,920	0.45	167	0.61	15	0.0	91.4	0.3
Azalea Dr	Low Int Dev	NO	NO	317	50	18	5,702	10,138	0.36	119	0.38	11	0.0	65.1	0.2
Bethany Cir	Low Int Dev	NO	YES	634	50	38	25,344	6,336	0.73	292	1.15	26	0.0	159.5	0.6
Betsy La	Low Int Dev	YES	YES	528	50	24	15,840	10,560	0.61	223	0.81	20	0.0	121.8	0.4
Blossom Rd	Low Int Dev	NO	YES	1,373	50	26	38,438	30,202	1.58	570	2.02	51	0.1	311.0	1.0
Bluebell Rd	Low Int Dev	NO	YES	1,056	50	24	27,456	25,344	1.21	430	1.49	39	0.0	234.7	0.7
Buchanan Way	Low Int Dev	NO	YES	422	50	24	10,982	10,138	0.48	172	0.60	15	0.0	93.9	0.3
Buttercup Dr	Low Int Dev	NO	YES	422	50	25	11,405	9,715	0.48	174	0.61	16	0.0	94.8	0.3
Byron Rd	Low Int Dev	YES	YES	2,534	50	20	65,894	60,826	2.91	1,032	3.59	93	0.1	563.4	1.7
Camberly Rd	Low Int Dev	YES	YES	1,162	50	24	34,848	23,232	1.33	491	1.77	44	0.1	268.0	0.9
Cavalcade Rd	Low Int Dev	NO	NO	739	50	32	23,654	13,306	0.85	318	1.17	29	0.0	173.7	0.6
Centenary Ln	Low Int Dev	YES	YES	422	50	24	12,672	8,448	0.48	178	0.65	16	0.0	97.5	0.3
Centennial Rd	Low Int Dev	YES	YES	5,914	60	35	242,458	112,358	8.15	3,113	11.68	280	0.4	1699.6	5.7
Citation La	Low Int Dev	NO	NO	634	50	18	11,405	20,275	0.73	238	0.75	21	0.0	130.2	0.4
Colonial Dr	Low Int Dev	NO	NO	1,531	50	24	36,749	39,811	1.76	612	2.08	55	0.1	333.9	1.0
Concord Rd	Low Int Dev	YES	YES	1,373	50	30	49,421	19,219	1.58	612	2.33	55	0.1	334.1	1.1
Constitutional Dr	Low Int Dev	NO	YES	2,957	50	18	59,136	88,704	3.39	1,135	3.68	102	0.1	619.9	1.8
Cotlar Dr	Low Int Dev	YES	YES	1,056	50	24	31,680	21,120	1.21	446	1.61	40	0.0	243.6	0.8
Coventry La	Low Int Dev	YES	YES	264	50	24	7,920	5,280	0.30	112	0.40	10	0.0	60.9	0.2
Crockett Rd	Low Int Dev	NO	YES	422	50	24	10,982	10,138	0.48	172	0.60	15	0.0	93.9	0.3
Davisville Rd	Low Int Dev	NO	YES	7,603	100	30	243,302	517,018	17.45	5,604	17.23	504	0.5	3060.0	8.4
Decker La	Low Int Dev	YES	YES	3,168	50	22	88,704	69,696	3.64	1,314	4.66	118	0.1	717.6	2.3
Deerfield Dr	Low Int Dev	YES	YES	581	50	24	17,424	11,616	0.67	245	0.89	22	0.0	134.0	0.4
Dick Av	Low Int Dev	YES	YES	3,696	50	24	110,868	73,912	4.24	1,562	5.65	141	0.2	852.7	2.7
Donald Dr	Low Int Dev	YES	YES	211	50	22	5,914	4,646	0.24	88	0.31	8	0.0	47.8	0.2
Estelle La	Low Int Dev	YES	YES	792	50	24	23,760	15,840	0.91	335	1.21	30	0.0	182.7	0.6
Glen Rd	Low Int Dev	NO	YES	2,112	50	26	59,136	46,464	2.42	876	3.11	79	0.1	478.4	1.5
Grant Ave	Low Int Dev	YES	YES	1,373	50	22	38,438	30,202	1.58	570	2.02	51	0.1	311.0	1.0
Hamilton Dr	Low Int Dev	NO	YES	264	50	30	8,448	4,752	0.30	114	0.42	10	0.0	62.0	0.2
Hancock Rd	Low Int Dev	YES	YES	1,478	50	24	44,352	29,568	1.70	625	2.26	56	0.1	341.1	1.1
Honeysuckle Dr	Low Int Dev	NO	YES	1,162	50	24	30,202	27,878	1.33	473	1.64	43	0.0	258.2	0.8
Hostman Dr	Low Int Dev	YES	YES	950	50	26	30,413	17,107	1.09	409	1.51	37	0.0	223.3	0.7
Hostman Av	Low Int Dev	YES	YES	1,267	50	30	45,619	17,741	1.45	565	2.15	51	0.1	308.4	1.0
Independence Rd	Low Int Dev	YES	YES	950	50	24	28,512	19,008	1.09	402	1.45	36	0.0	219.3	0.7
Jefferson Ave	Low Int Dev	NO	YES	528	50	22	12,672	13,728	0.61	211	0.72	19	0.0	115.1	0.3
Joseph Av	Low Int Dev	YES	YES	1,795	50	20	46,675	43,085	2.06	731	2.54	66	0.1	399.1	1.2
Lexington Rd	Low Int Dev	YES	YES	634	50	24	19,008	12,672	0.73	268	0.97	24	0.0	146.2	0.5
Lilac Ln	Low Int Dev	NO	YES	422	50	24	10,982	10,138	0.48	172	0.60	15	0.0	93.9	0.3
Lillian La	Low Int Dev	YES	YES	317	50	22	8,870	6,970	0.36	131	0.47	12	0.0	71.8	0.2
Lily Rd	Low Int Dev	NO	YES	1,742	50	24	45,302	41,818	2.00	709	2.47	64	0.1	387.3	1.2
Lingo Dr	Low Int Dev	YES	YES	1,109	50	26	35,482	19,958	1.27	477	1.76	43	0.1	260.5	0.9
Longstreth Rd	Low Int Dev	YES	YES	2,112	50	22	59,136	46,464	2.42	876	3.11	79	0.1	478.4	1.5
Lowell Rd	Low Int Dev	YES	YES	1,795	50	30	64,627	25,133	2.06	800	3.05	72	0.1	436.9	1.5
Martha La	Low Int Dev	YES	YES	1,267	50	22	35,482	27,878	1.45	526	1.86	47	0.1	287.0	0.9
McGlynn Rd	Low Int Dev	YES	YES	1,214	50	24	36,432	24,288	1.39	513	1.86	46	0.1	280.2	0.9
Meadow Dr	Low Int Dev	NO	YES	1,109	50	24	28,829	26,611	1.27	451	1.57	41	0.0	246.5	0.8
Middle Ave	Low Int Dev	NO	YES	528	50	24	13,728	12,672	0.61	215	0.75	19	0.0	117.4	0.4
Natale La	Low Int Dev	YES	YES	1,056	50	20	27,456	25,344	1.21	430	1.49	39	0.0	234.7	0.7
S Newtown Rd	Low Int Dev	YES	YES	5,386	50	35	220,810	48,470	6.18	2,504	9.90	225	0.3	1367.4	4.8
N Newtown Rd	Low Int Dev	NO	YES	2,904	50	20	63,888	81,312	3.33	1,138	3.78	102	0.1	621.1	1.8
Orchid Rd	Low Int Dev	YES	YES	898	50	16	19,747	25,133	1.03	352	1.17	32	0.0	192.0	0.6

Appendix D1 - Streetsweeping & Inlet Filter BMPs

Street Name	Land Use Classification	Sidewalks	Curb	Roadway Length (ft)	Right-of-Way Width (ft)	Roadway Width (ft)	Impervious Area (sf)	Grass Area (sf)	Area (ac)	TSS Load (lb/yr)	Phosphorus Load (lb/yr)	9%	3%	60%	50%
												Streetsweeping TSS Reduction (lb/yr)	Streetsweeping TP Reduction (lb/yr)	Inlet Filters TSS Reduction (lb/yr)	Inlet Filters TP Reduction (lb/yr)
Otto Ln	Low Int Dev	YES	YES	475	50	24	14,256	9,504	0.55	201	0.73	18	0.0	109.6	0.4
Overlook Dr	Low Int Dev	YES	YES	2,323	50	28	78,989	37,171	2.67	1,018	3.81	92	0.1	555.6	1.8
Parmentier Rd	Low Int Dev	YES	YES	2,165	50	24	64,944	43,296	2.48	915	3.31	82	0.1	499.5	1.6
Patton Dr	Low Int Dev	YES	YES	739	50	20	19,219	17,741	0.85	301	1.05	27	0.0	164.3	0.5
Ramsey Rd	Low Int Dev	YES	YES	792	50	25	24,552	15,048	0.91	338	1.23	30	0.0	184.4	0.6
Reeves Ln	Low Int Dev	NO	NO	792	50	24	19,008	20,592	0.91	316	1.08	28	0.0	172.7	0.5
Revere Ter	Low Int Dev	NO	YES	898	50	24	23,338	21,542	1.03	365	1.27	33	0.0	199.5	0.6
Revolutionary Wy	Low Int Dev	NO	YES	634	50	22	15,206	16,474	0.73	253	0.86	23	0.0	138.2	0.4
Rilling Rd	Low Int Dev	YES	YES	264	50	18	6,336	6,864	0.30	105	0.36	9	0.0	57.6	0.2
Schoolhouse La	Low Int Dev	YES	YES	1,690	50	26	54,067	30,413	1.94	727	2.68	65	0.1	397.0	1.3
Sheldon Dr	Low Int Dev	YES	YES	264	50	24	7,920	5,280	0.30	112	0.40	10	0.0	60.9	0.2
Stephen Rd	Low Int Dev	YES	YES	686	50	24	20,592	13,728	0.79	290	1.05	26	0.0	158.4	0.5
Sweetbriar Rd	Low Int Dev	NO	YES	3,643	60	24	94,723	123,869	5.02	1,707	5.65	154	0.2	931.9	2.7
Walter Rd	Low Int Dev	NO	NO	581	50	20	11,616	17,424	0.67	223	0.72	20	0.0	121.8	0.4
Washington Dr	Low Int Dev	YES	YES	739	50	28	25,133	11,827	0.85	324	1.21	29	0.0	176.8	0.6
Watson Glen Dr	Low Int Dev	YES	YES	422	50	25	13,094	8,026	0.48	180	0.66	16	0.0	98.3	0.3
Webster Way	Low Int Dev	YES	YES	528	50	25	16,368	10,032	0.61	225	0.82	20	0.0	122.9	0.4
Whirlaway Dr	Low Int Dev	NO	NO	581	50	24	13,939	15,101	0.67	232	0.79	21	0.0	126.7	0.4
Winchester Rd	Low Int Dev	YES	YES	1,056	50	22	29,568	23,232	1.21	438	1.55	39	0.0	239.2	0.8
Winding Way	Low Int Dev	YES	YES	1,426	50	24	42,768	28,512	1.64	602	2.18	54	0.1	328.9	1.1
Woodlawn Rd	Low Int Dev	YES	YES	1,795	50	24	53,856	35,904	2.06	759	2.74	68	0.1	414.2	1.3
<b>TOTAL</b>									<b>123.01</b>	<b>44,167</b>	<b>155.56</b>	<b>3,975.03</b>	<b>4.67</b>	<b>24,115.21</b>	<b>75.45</b>

NOTE:

Pollutant Load = [EMC, (mg/L)] \* [Runoff Volume, (ac\*ft)] \* [2.7, unit conversion]

EMC = Event Mean Concentration (mg/L)

TSS EMC = 86 mg/L for Low Traffic Residential Streets (Table A-1, PA BMP Manual)

TSS EMC = 180 mg/L for Lawn, Low Input (Table A-1, PA BMP Manual)

TP EMC = 0.36 for Low Traffic Residential Streets (Table A-2, PA BMP Manual)

TP EMC = 0.40 for Lawn, Low Input (Table A-2, PA BMP Manual)

Runoff Volume = [Area, (ac)] \* [Runoff Depth, (ft)]

Runoff Depth = 22.5 in = 1.875 ft

Runoff Depth = 6.6 in = 0.55 ft

Runoff depth is from Ambler Borough WWTP rain gauge from 2011 to 2014 and calculated using the SCS Runoff Curve Number method.

BMP Removal Efficiencies

	TSS	TP	REFERENCE
5.9.1 Streetsweeping	9%	3%	"Deriving Reliable Pollutant Removal Rates for Municipal Street Sweeping and Storm Drain Cleanout Programs in the Chesapeake Bay Basin," CWP, 9/2006
6.6.4 Inlet Filter	60%	50%	Table A-4, PA BMP Manual

Streetsweeping and inlet filter BMPs are assumed to be in series.

**Appendix D2 - Rain Barrel BMP**

Total Area Tributary to MS4	695.20	ac
Total Municipal Owned Property	124.26	ac
Total Remaining Area (Residential Area)	570.94	ac
Estimated 15% of Remaining Area as Rooftop	85.64	ac
Estimated 15% Participation by Property Owners	12.85	ac
Rooftop TSS EMC	21	mg/L
Rooftop Runoff	3.63	feet
<b>Rooftop TSS</b>	<b>2,641</b>	<b>lb/yr</b>
Rooftop TP EMC	0.13	mg/L
Rooftop Runoff	3.63	feet
<b>Rooftop TP</b>	<b>16.35</b>	<b>lb/yr</b>

NOTE:

Pollutant Load = [EMC, (mg/L)] \* [Runoff Volume, (ac\*ft)] \* [2.7, unit conversion]

EMC = Event Mean Concentration (mg/L)

TSS EMC = 21 mg/L for Rooftops (Table A-1, PA BMP Manual)

TSS EMC = 0.13 mg/L for Rooftops (Table A-2, PA BMP Manual)

Runoff Volume = [Area, (ac)] \* [Runoff Depth, (ft)]

Runoff depth is from Ambler Borough WWTP rain gauge from 2011 to 2014 and calculated using the SCS Runoff Curve Number method.

BMP Removal Efficiencies from Table A-4, PA BMP Manual

	TSS	TP
6.5.2 Rooftop Runoff Capture and Reuse	100%	100%

Assumptions:

15% of residential areas are rooftops.

15% of residential property owners install rain barrels.

Appendix D3 - Roadside Infiltration Trench BMP

No.	TRIBUTARY AREA (ac)	IMPERVIOUS COVER (%)	IMPERVIOUS COVER (ac)	RUNOFF DEPTH (in)	TSS EMC IMPERVIOUS (mg/L)	IMPERVIOUS TSS (lb/year)	LAWN COVER (%)	LAWN COVER (ac)	RUNOFF DEPTH (in)	TSS EMC LAWN (mg/L)	LAWN TSS (lb/year)	TOTAL TSS (lb/year)	85% TSS REDUCTION (lb/year)
R1	14.5	30%	4.35	43.51	39.5	1,682	70%	10.15	6.59	180	2,709	4,391	3,732
R2	10.2	30%	3.06	43.51	39.5	1,183	70%	7.14	6.59	180	1,906	3,089	2,626
R3	12.6	30%	3.78	43.51	39.5	1,462	70%	8.82	6.59	180	2,354	3,816	3,243
R4	5.33	30%	1.60	43.51	39.5	618	70%	3.731	6.59	180	996	1,614	1,372
R5	14.2	30%	4.26	43.51	39.5	1,647	70%	9.94	6.59	180	2,653	4,300	3,655
R6	10.2	30%	3.06	43.51	39.5	1,183	70%	7.14	6.59	180	1,906	3,089	2,626
R7	20	30%	6.00	43.51	39.5	2,320	70%	14	6.59	180	3,737	6,057	5,148
R8	9.1	30%	2.73	43.51	39.5	1,056	70%	6.37	6.59	180	1,700	2,756	2,342
R9	6.22	30%	1.87	43.51	39.5	722	70%	4.354	6.59	180	1,162	1,884	1,601
<b>TOTAL</b>												<b>30,995</b>	<b>26,346</b>

No.	TRIBUTARY AREA (ac)	IMPERVIOUS COVER (%)	IMPERVIOUS COVER (ac)	RUNOFF DEPTH (in)	TP EMC IMPERVIOUS (mg/L)	IMPERVIOUS TP (lb/year)	LAWN COVER (%)	LAWN COVER (ac)	RUNOFF DEPTH (in)	TP EMC LAWN (mg/L)	LAWN TP (lb/year)	TOTAL TP (lb/year)	85% TP REDUCTION (lb/year)
R1	14.5	30%	4.35	43.51	0.14	5.96	70%	10.15	6.59	0.40	6.02	11.98	10.18
R2	10.2	30%	3.06	43.51	0.14	4.19	70%	7.14	6.59	0.40	4.23	8.43	7.16
R3	12.6	30%	3.78	43.51	0.14	5.18	70%	8.82	6.59	0.40	5.23	10.41	8.85
R4	5.33	30%	1.60	43.51	0.14	2.19	70%	3.731	6.59	0.40	2.21	4.40	3.74
R5	14.2	30%	4.26	43.51	0.14	5.84	70%	9.94	6.59	0.40	5.90	11.73	9.97
R6	10.2	30%	3.06	43.51	0.14	4.19	70%	7.14	6.59	0.40	4.23	8.43	7.16
R7	20	30%	6.00	43.51	0.14	8.22	70%	14	6.59	0.40	8.30	16.53	14.05
R8	9.1	30%	2.73	43.51	0.14	3.74	70%	6.37	6.59	0.40	3.78	7.52	6.39
R9	6.22	30%	1.87	43.51	0.14	2.56	70%	4.354	6.59	0.40	2.58	5.14	4.37
<b>TOTAL</b>												<b>84.58</b>	<b>71.89</b>

NOTE:

Pollutant Load = [EMC, (mg/L)] \* [Runoff Volume, (ac\*ft)] \* [2.7, unit conversion]

EMC = Event Mean Concentration (mg/L)

TSS EMC = 21 mg/L for Rooftops (Table A-1, PA BMP Manual)

TSS EMC = 58 mg/L for Low Traffic Parking Lot (Table A-1, PA BMP Manual)

TSS EMC Impervious = (21 + 58)/2

TSS EMC = 180 mg/L for Lawn, Low Input (Table A-1, PA BMP Manual)

TSS EMC = 0.13 mg/L for Rooftops (Table A-2, PA BMP Manual)

TSS EMC = 0.15 mg/L for Low Traffic Parking Lot (Table A-2, PA BMP Manual)

TSS EMC Impervious = (0.13 + 0.15)/2

TSS EMC = 0.40 mg/L for Lawn, Low Input (Table A-2, PA BMP Manual)

Runoff Volume = [Area, (ac)] \* [Runoff Depth, (ft)]

Runoff depth is from Ambler Borough WWTP rain gauge from 2011 to 2014 and calculated using the SCS Runoff Curve Number method.

BMP Removal Efficiencies from Table A-4, PA BMP Manual

	TSS	TP
6.4.4 Infiltration Trench	85%	85%

**Appendix D4 - Streambank Restpration BMP**

Total Length of Southampton Creek Stream in Warminster Township	9,806	lf
Existing Streambank Erosion for Southampton Creek Watershed	1,216,589	lb/yr
Warminster Township Percentage of Streambank Erosion	32.72	%
Warminster Township Existing Streambank Erosion	398,068	lb/yr
Warminster Township Annual Streambank Erosion Rate, per unit length of stream	40.59	lb/lf/yr
Warminster Township Sediment from 1,210 lf Streambank	49,119	lb/yr
<b>Warminster Township Sediment Removed from 1,210 lf Streambank Restoration</b>	<b>41,751</b>	<b>lb/yr</b>

References:

Length of Southampton Creek stream in Warminster Township measured from mapping.

Existing Streambank Erosion for Watershed - Table 12, Southampton Watershed TMDL, 2008, EPA.

Warminster Township's percentage of streambank erosion - Table 18, Southampton Watershed TMDL, 2008, EPA.

Assumption:

Streambank restoration eliminates 85% of erosion from streambanks

## **APPENDIX E**

Public Comment and Response

(Appendix E will be completed following the 30-day public review and comment period.)