TOWNSHIP-WIDE STORMWATER MANAGEMENT PLAN
FOR
UPPER MERION TOWNSHIP, MONTGOMERY COUNTY, PENNSYLVANIA

Prepared For Upper Merion Township

October 2018 (revised July 2019)

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1.0 Introduction

1.1 Background

Upper Merion Township (UMT) is a highly urbanized Township located approximately 15 miles northwest of Philadelphia, bordering the Schuylkill River. In 1995, Gannett Fleming was selected to provide the engineering consulting services necessary for the preparation of a Township-Wide Stormwater Management Plan. The purpose of the Township-Wide Stormwater Management Plan was to identify and evaluate existing stormwater related problems within the Township, evaluate the impact of future development activities on runoff related problems and develop a plan for the implementation of prioritized solutions in the chronic problem areas of the Township.

In 2017, the Upper Merion Municipal Utility Authority (UMMUA) selected the Gannett Fleming/Wood Environment & Infrastructure Solutions (formerly Amec Foster Wheeler) Team for the engineering consulting services for preparation of an updated Stormwater Master Plan for Upper Merion Township. The purpose of the Updated Township-Wide Stormwater Management Plan is to properly and effectively address stormwater deficiencies and needed infrastructure improvements throughout the Township. UMMUA will use this new Updated Township-Wide Stormwater Management Plan to prioritize capital improvements, provide a comprehensive review of operations and maintenance capabilities and pursue financing of stormwater capital and operations improvements. Detailed hydraulic modeling, water quality assessment, land use planning and an evaluation of structural and non-structural stormwater controls, along with a cost prioritization analysis was included in this undertaking. This report details the hydrologic analysis, hydraulic analysis and the flooding problem areas considered. The watersheds analyzed and methodologies used for the analysis are consistent with the 1995 study to enable comparison with prior results.

1.2 1995 Study Scope

The scope of the 1995 Township-Wide Stormwater Management Plan study involved hydrologic and hydraulic analysis to form the basis for recommended improvements to address stormwater needs within the Township. Hydrologic analyses included the calculation of runoff rates based upon individual rainfall events, surface cover types, underlying soils classifications, and various other hydrologically sensitive parameters. Problem areas of flooding were identified through information gathered from Township residents using a written survey form and through hydraulic analysis. Additional hydraulic analysis were completed to evaluate possible solutions to alleviate the identified stormwater problems. Recommended solutions (either Capital Improvements Project or Operations and Maintenance Project) were identified for each watershed. The report also discussed implementation of the recommended solutions.

1.3 Current Study Scope

The Gannett Fleming/Wood Team was charged with executing a detailed scope of services related to updating the Upper Merion Stormwater Management Plan. Hydrologic determinations and hydraulic analysis leading to the development and evaluation of alternatives and recommendations are described within this report. The scope of those analyses includes the study of runoff and

flooding from seven significant watershed within Upper Merion Township: Trout Creek, Crow Creek, Abrams Creek, Frog Run, Matsunk Creek, Gulph Mills Creek and the watershed of an unnamed tributary to the Schuylkill River (Unnamed Watershed A). Watersheds are delineated and runoff characteristics are developed based on the most recently published soil and land cover data. Hydrologic modeling for each of the watersheds is completed for a range of flood events. Township staff are consulted regarding the location and severity of historical flooding and results are compared. Hydraulic analysis is completed to identify and corroborate areas of potential flooding, and to evaluate structural alternates. These alternates are described within this report.

The scope of services also included other related services that are documented within this report (**Section 5**). These services included an evaluation of the existing Township Municipal Separate Storm Sewer System (MS4) Permit compliance program including evaluating minimum control measures (MCM); inventorying current outreach and education activities; evaluating the existing MS4 mapping; providing recommendations on the stormwater controls for new development, redevelopment and Township projects; providing recommendations for pollution prevention; and providing recommendation for addressing privately owned storm sewer system facilities. In addition, an evaluation of potential future water quality compliance requirements, and land use planning tasks were completed as part of the scope of services. These findings were communicated to the Township in a variety of reports and are summarized within this report.

1.4 File Review

Prior to updating the Stormwater Master Plan, Gannett Fleming reviewed the 1995 Township-Wide Stormwater Management Plan provided by Upper Merion Township. A total of seven subwatersheds were delineated and modeled using the Natural Resources Conservation Service (NRCS) TR-20 computer program. Precipitation depths for the 2-, 5-, 10-, 25-, 50- and 100-year storm events were obtained from "Rainfall Duration-Frequency Tables for Pennsylvania" published by the Pennsylvania Department of Environmental Resources in 1983. Hydrologic parameters were determined using 1992 land use data, 1994 US Soil Map (STATSGO), and low resolution terrain data. The NRCS backwater computation program, WSP2, was used for hydraulic analysis. Model cross-sections were based on aerial mapping and topographic mapping of unknown resolution. While the methods and data sources used for the 1995 study were the best-available methods and data sources at the time, updated data and models are currently available. The current analysis utilizes updated precipitation estimates, recently-collected LiDAR terrain data, updated bridge and culvert data, updated land use and soil data and updated computer programs.

The Gannett Fleming/Wood Team also reviewed the Township's documents related to water quality and regular day to day operations of the MS4. These included the Township's MS4 annual reports, MCM implementation plans, dry weather storm sewer discharge reports, land development code, standard operating procedures for pollution prevention, and the Township Comprehensive Plan.

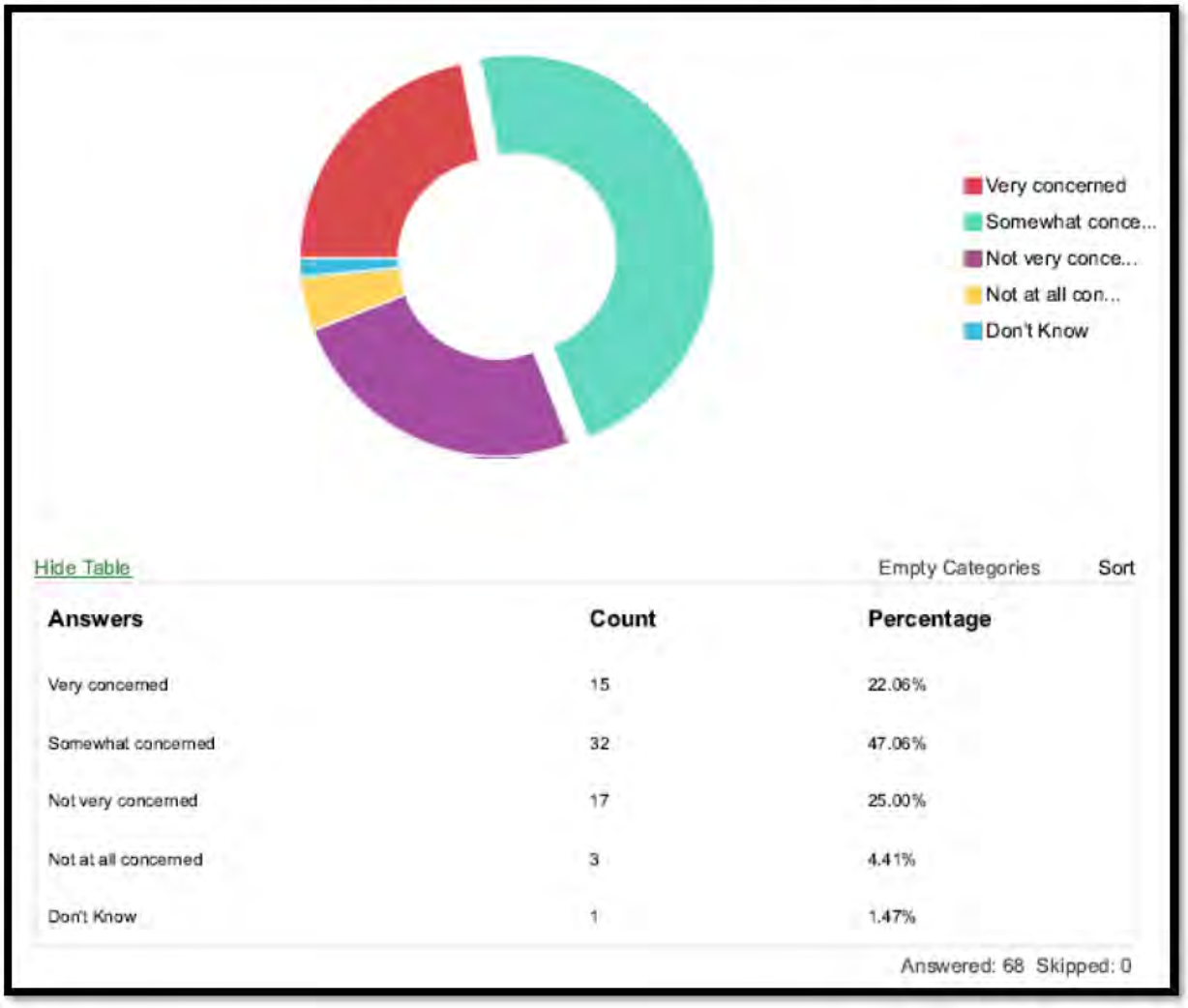
1.5 Initial Identification of Flooding Problems

1.5.1 Public Survey

To obtain additional information, the study includes a web-based survey which was promoted for Township residents and business owners to participate in the stormwater study. The survey included questions regarding the overall level of concern of flooding problems, comparing the current overall Township flooding versus ten years ago, and identifying the problem locations. A copy of the survey results are found in Appendix A.

The survey resulted in 68 responses in which 13 flooding problem locations were identified. The level of concern and ten year comparison results are provided in Exhibits A and B respectively.

How concerned are you about flooding problems in Upper Merion?



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Answers	Count	Percentage
Very concerned	15	22.06%
Somewhat concerned	32	47.06%
Not very concerned	17	25.00%
Not at all concerned	3	4.41%
Don't Know	1	1.47%

Answered: 68 Skipped: 0

Exhibit A: Public Survey Level of Concern

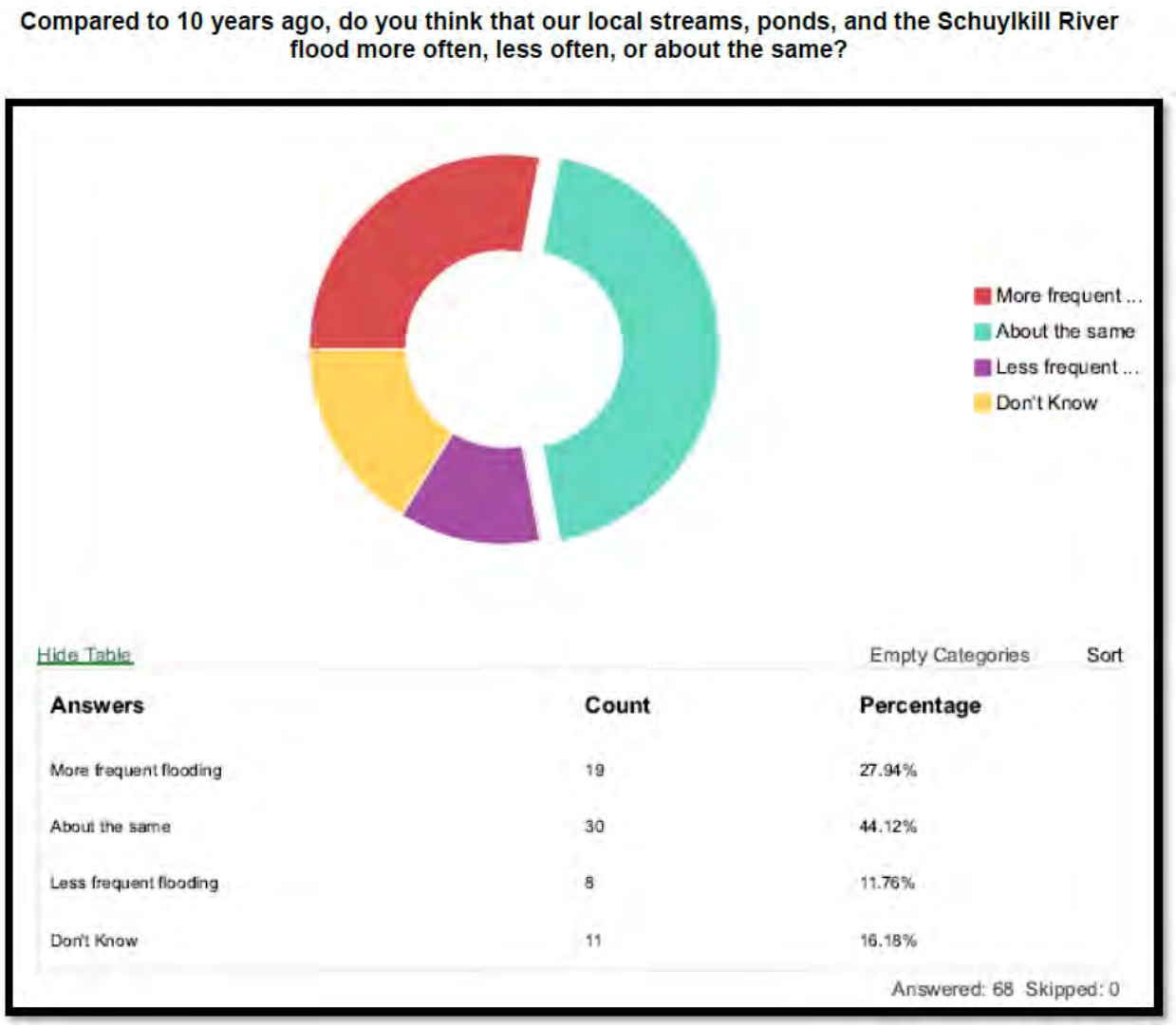

Exhibit B: Public Survey 10-Year Comparison results

The location of the 13 problem areas are used in the prioritization of recommendations as described in Section 5.0.

1.5.2 Township Emergency Management Staff

The second survey conducted as part of the study is with the Township's Emergency Management (EMA) staff. The survey collected EMA documented records since 1999 of rain events that caused flooding issues at various locations throughout the Township that required action by the EMA. The records provide 25 rain events since 1999 which lead to flooding conditions at 35 locations. A summary of the records are found in Appendix B.

The location of the 35 problem areas are used in the prioritization of recommendation as described in Section 5.0.

1.5.3 Open House Public Engagement Events

Both the consulting team and the Township (Authority and Board alike) recognized, during the updated study efforts, the need and importance of soliciting public feedback in an additional forum (beyond the previously mentioned web survey). As such, two public open house events were requested by the Township and organized collaboratively with the consulting team and the Township. Notices of both events (held on July 23, 2018 and September 24, 2018) were added to Township social media outlets (such as Facebook, Website, etc.), posted in Township owned public spaces, and provided as part of a letter, sent to specific stakeholders (for the second event only). The intent of each event was to host an open house style meeting, engage the public one-on-one and provided focused materials and take-away documents. Copies of the materials, sign in sheets and response forms are provided in the Appendices of this report.

The outcome of the initial meeting was an extremely low turnout of public and business entities in the Township. While some feedback was collected, it was noted that the second event would need to be more aggressively campaigned, to try and increase the turnout and level of public engagement. Immediately prior to the second event, a large scale (record setting) storm occurred that flooded many private and public properties and spaces in the Township. This event drew the attention of the public, dramatically increasing the attendance at the second event. Consistently, those who attended the second event wanted to discuss how the Township was addressing flooding in their specific location, provide a plan for what would be done for future preventative measures and express their concerns relative to perceived inaction by the Township. As the Township plots a course forward, to further refine, organize and bolster their stormwater program efforts (ranging from capital improvements, to permit compliance, to flooding mitigation) the comments, feedback and opinions of the public and business sectors should be carefully considered (as appropriate). Additional discussion on Flooding occurs in Section 7.1 of this report.

2.0 Hydrologic Analysis

2.1 Watershed Descriptions

2.1.1 *Crow Creek*

The Crow Creek watershed consists of approximately 5.5 square miles of mixed-use development. The soils within the watershed are predominantly D type soils indicating that the soils have high runoff potential when thoroughly wet. The watershed is approximately 95 percent contained within the limits of the Township. The southernmost portion of the watershed is in Tredyffrin Township. The upper reaches are predominantly residential areas. The commercial and industrial areas are concentrated in the central and lower reaches in the vicinity of the Schuylkill Expressway and the Pennsylvania Turnpike. Crow Creek accepts the drainage from three tributaries and discharges directly into the Schuylkill River.

Flooding problems within the Crow Creek Watershed were identified by both the public survey and the EMA staff including: Intersection flooding at Colonial Place and Powderhorn Road; insufficient culvert capacity on South Gulph Road and Church Road; insufficient culvert capacity on Croton Road near Roberts Elementary School; and flooding of a parking lot near the King of Prussia Fire Company; street and property flooding on Keebler Road near Springhouse Road; street and property flooding at Regimental Road near Caley Road; overtopping of Abrams Road bridge; flooding due to low ground at Walker Field; and flooding on East Valley Forge Road between Forge Springs Way and Lower E Valley Road.

2.1.2 *Trout Creek*

The Trout Creek watershed consists of approximately 8.4 square miles of multi-use land cover. The soils within the watershed are predominantly D type soils indicating that the soils have high runoff potential when thoroughly wet. The watershed encompasses a portion of the western area of the Township with the majority of the area outside of Upper Merion Township limits in Tredyffrin Township, Chester County. Trout Creek discharges directly into the Schuylkill River.

The upper reaches of the watershed consist of residential areas with densities increasing towards the river. The commercial and industrial areas of the watershed are concentrated in the lower reaches of the watershed, north and east of the Schuylkill Expressway, within Upper Merion Township.

Flooding problems within the Trout Creek Watershed were identified by both the public survey and the EMA including: Insufficient Culvert Capacity, low road elevation on W Valley Forge Road from Mancill Mill Road to Trout Creek bridge; low ground on Richards Road near N. Gulph Road; insufficient culvert capacity under 1st Street and American Avenue; and flooding on Guthrie Road.

2.1.3 *Abrams Creek*

The Abrams Creek watershed consists of approximately 220 acres of predominantly high density residential areas with D type soils. Type D soils indicate that the soils have high runoff potential when thoroughly wet. The entire watershed is contained within the Township boundaries. Abrams Creek discharges directly into the Schuylkill River.

Based on all four sources, the watershed is relatively free from stormwater problems.

2.1.4 *Frog Run*

The Frog Run watershed lies in the eastern portion of the Township and consists of approximately 2.1 square miles of predominantly industrial and high density residential areas with D type (high runoff potential) soils. A 110-acre quarry is located in the lower portion of the watershed. Frog Run discharges directly into the quarry, and the flow path downstream of the quarry is unclear. Frog Run eventually discharges into the Schuylkill River.

Flooding problems within the Crow Creek were identified by both the public survey and the EMA staff including: Culvert overtopping and street flooding at South Henderson Road and Shoemaker Road; Yerkes Road and Church Road overtopping due to backwater from railroad and Church Road culverts; Crooked Lane culvert overtopping; and Hughes Park street flooding.

2.1.5 *Matsunk Creek*

The Matsunk Creek watershed consists of approximately one square mile of predominantly open space and residential areas with an equal mix of type B and type C soils. The watershed is contained entirely within the Upper Merion Township boundaries. Matsunk Creek discharges directly into the Schuylkill River.

Flooding problems within the Matsunk Creek Watershed were identified by both the public survey and the EMA staff including: Road flooding on Schuykill River Road between Swedeland Road and 3rd Street; undersized culvert under Renaissance Boulevard and adjacent property; street flooding on B Street and Route 23.

2.1.6 *Unnamed Watershed A*

Watershed area A is located in the eastern portion of the Township and consists of approximately 230 acres of mixed use development.

Flooding problems within the Unnamed Watershed A Watershed were identified by both the public survey and the EMA staff including: Street flooding at the intersection of 3rd Street and Rt. 23; and flooding on B Street, erosion and debris build-up upstream of B Street.

2.1.7 *Gulph Mill Creek*

The Gulph Mills Creek watershed consists of approximately 6.1 square miles of predominantly residential areas. A large portion of the watershed lies outside of the Upper Merion Township boundaries within Delaware and Chester Counties. The upper reaches of the watershed are low to medium density residential areas. Commercial, industrial and increased density residential areas are located in the lower portions of the watershed within the Township limits. Gulph Mills Creek discharges directly into the Schuylkill River.

Flooding problems within the Gulph Mill Creek Watershed were identified by both the public survey and the EMA staff including: The Trinity Road bridge overtopping; South County Line Road bridge overtopping; flooding of properties from Garrison Way to Longview Road; property flooding between 947 and 961 Trinity Road; street flooding on South Gulph Road between Upper Gulph Road and Arden Road; and Jones Road bridge overtopping.

2.2 HEC-HMS Model

The United States Army Corps of Engineers' HEC-HMS hydrologic modeling program was used to estimate the peak flows for various frequency storms. Hydrologic parameters were estimated using the most updated input data and current state-of-the-practice methods.

2.2.1 *Data Sources*

Several datasets were required to develop hydrologic parameters for watersheds in Upper Merion Township. Reference information for the datasets used to delineate the watershed and develop hydrologic parameters is presented in Table 1.

Table 1: Data Sources for Watershed/Sub-basin Delineation and Hydrologic Parameters

Type of Data	Source	Use
Terrain	Light Detection and Ranging (LiDAR) Data (2008) Pennsylvania Spatial Data Access PAMAP Digital Elevation Model (DEM) http://www.pasda.psu.edu/	Watershed Delineation, Time of Concentration
Land Use/Land Cover	National Land Cover Database 2011 (NLCD2011) USGS National Map Viewer http://viewer.nationalmap.gov/basic/	Runoff Curve Number
Soils	Natural Resources Conservation Service (NRCS) Web Soil Survey (WSS) Soil Survey Geographic Database (SSURGO) http://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx	Runoff Curve Number
Aerial Photography	Google Earth Aerial Imagery & Microsoft Bing Maps Aerial Imagery Web Mapping Service	Time of Concentration
Frequency Storm Precipitation	National Oceanic and Atmospheric Association (NOAA) National Weather Service (NWS) Hydrometeorological Design Studies Center (HDSC) Precipitation Frequency Data Server (PFDS) http://dipper.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html	Time of Concentration, Frequency Storm Input

2.2.2 Watershed Delineation

The overall major watersheds can be further delineated into multiple subwatersheds. Including more subwatersheds in a hydrologic analysis allows for spatial variation in hydrologic parameters and can result in a better representation of the watershed.

Depending on size of the watersheds and tributary locations, each of the seven watersheds were delineated into one or more subwatersheds. For all seven watersheds, subwatersheds were delineated using ArcGIS to analyze the approximately 3.2-foot resolution DEM for the watershed area. This DEM was developed from LiDAR data flown in 2008 as part of the PAMAP Program. Altogether, 10 subwatersheds in the Crow Creek Watershed, 10 subwatersheds in the Trout Creek Watershed, 2 subwatersheds in the Abrams Creek Watershed, 4 subwatersheds in the Frog Run Watershed, 1 subwatershed in Watershed A, 3 subwatersheds in Matsunk Watershed, and 4 subwatersheds in Gulph Mill Creek Watershed were delineated. Hydrologic parameters were developed for all of the subwatersheds. Figure 1 shows the watersheds and subwatersheds delineated.

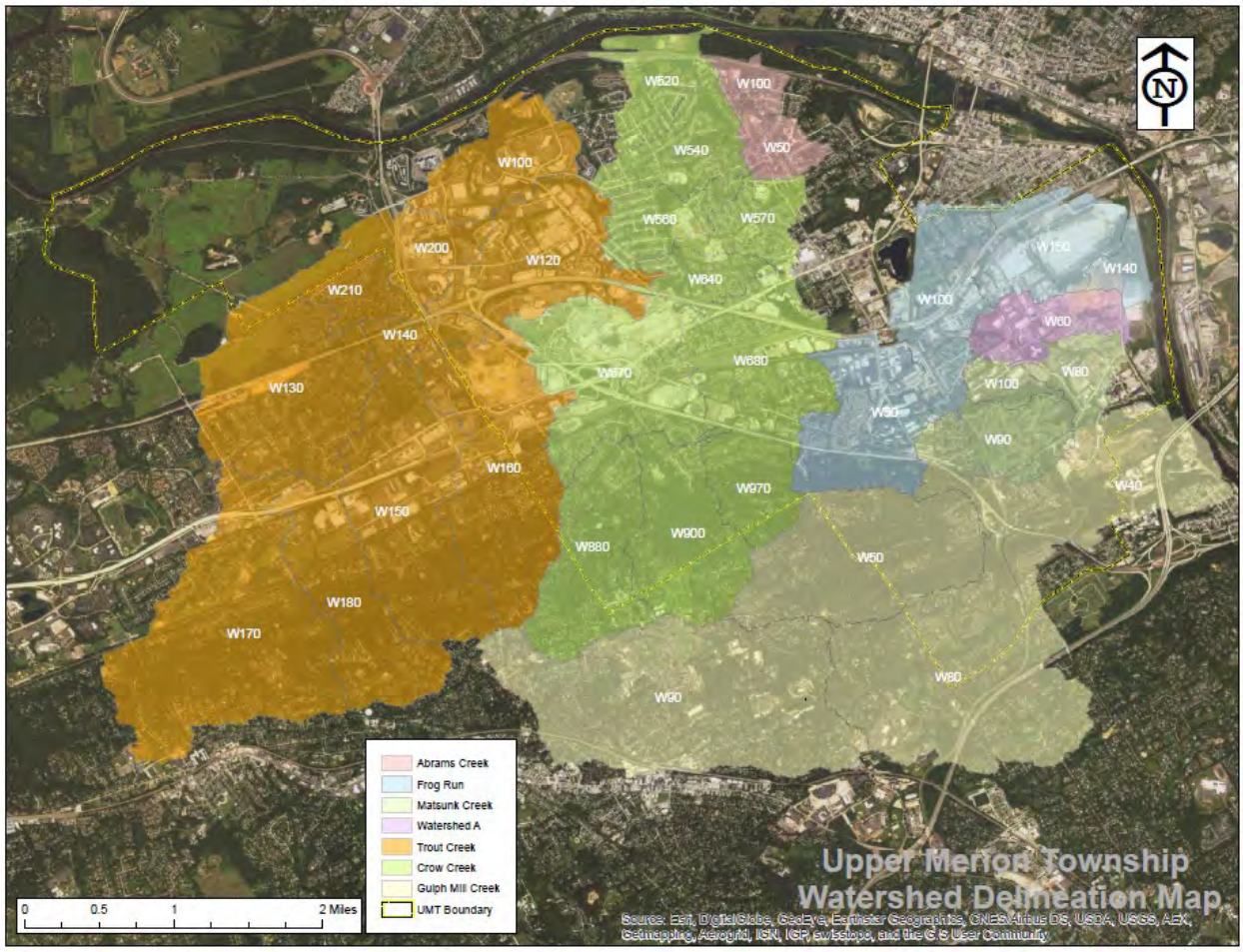

Figure 1: Watershed Delineation

2.2.3 *NRCS Curve Number*

The NRCS, formerly the Soil Conservation Service (SCS), Runoff Curve Number Loss Method was used to calculate the precipitation losses and the runoff potential within each of the sub-basins. The runoff curve number (CN) is an empirical coefficient that relates runoff potential to hydrologic condition, land cover, and hydrologic soil type.

The CNs were computed within a GIS environment using digital soil and land cover data, in conjunction with the digital sub-basin delineations. Soils data were obtained from the online NRCS Web Soil Survey application and a hydrologic soil group (HSG) was assigned to each geospatial soil map unit within the watershed. Land cover data was obtained from the online USGS National Map Viewer application, which referenced data from the National Land Cover Database of 2011. The spatial soil and land cover data were combined and CN values were assigned to each unique combination of soil and land cover codes using a custom CN lookup table. This table was derived from source material in the NRCS National Engineering Handbook (NEH) (Chapter 9: Hydrologic Soil-Cover Complexes).

Because each subwatershed contained many soil-land use polygons, each with a unique CN, a single aerially-weighted composite CN was computed for each sub-basin. The CN values computed for each sub-basin are presented in Table 2. Details of the CN calculations are included in Appendix C-1.

2.2.4 NRCS Time of Concentration

The NRCS/SCS Unit Hydrograph Transform Method (standard graph type) was used to predict the direct runoff hydrograph for the project sub-basins. This method requires a time of concentration (T_c) parameter, which the NEH defines as the time required for runoff to travel from the hydraulically most distant point in the watershed to the watershed outlet. In hydrograph analysis, T_c is the time from the end of excess rainfall to the point on the falling limb of the dimensionless unit hydrograph where the recession curve begins.

The T_c for each of the sub-watersheds was determined using the segmental velocity approach. GIS techniques, in combination with sensitivity analyses, were used to determine the longest (by travel time) hydraulic flow path. Velocity method computations for the T_c were completed in accordance with procedures detailed in Chapter 15 of the NEH. Each flow path was segmented into three different flow types; sheet flow, shallow concentrated flow, and open channel flow. Sheet flow length was estimated based on slope and Manning's roughness coefficient for a maximum length of 100 feet, where it is assumed to physically transition to shallow concentrated type flow regime. Shallow concentrated flow computations were applied from this point to where the topography became channelized or where the flow path intercepted a blue stream line on a USGS topographic quadrangle map. For the remainder of the stream course, Manning's open channel flow equation was used to compute flow velocities and travel times.

The total travel time is the summation of the individual travel times of these three flow type components.

From the T_c, basin lag time was calculated, which serves as the input into the HEC-HMS hydrologic model. As recommended in the NEH, the basin lag time was computed as 60 percent of the T_c. In the establishment of runoff hydrographs, lag is the time interval between the center of mass of the excess rainfall and the peak runoff rate. Table 2 contains a summary of the basin lag times computed for the watershed. Details of the Tc and basin lag time calculation are included in Appendix C-2.

2.2.5 Channel Routing

Channel routing was used to route flows from the outlets of the upstream subbasins downstream into watershed outlet. The Muskingum-Cunge reach routing method was used to route the hydrographs through the reaches. A representative trapezoidal cross section was chosen for each reach. Channel dimensions, slope, and a Manning's roughness coefficient for the channel cross-sections were estimated based on aerial imagery and terrain data.

In total, 15 stream sections were used in Crow Creek Watershed, 5 in Trout Creek Watershed, 1 in Abrams Creek Watershed, 3 in Frog Run Watershed, 0 in Watershed A, 1 in Matsunk Watershed, and 2 in Gulph Mill Creek Watershed.

2.2.6 Frequency Storms

Precipitation depths for the 2-, 10-, 25-, 50-, and 100-year frequency events were obtained from NOAA's Atlas 14 point precipitation frequency web data server (Appendix C-3). These depths, shown in Table 2, were applied as averages over the entire watershed and were distributed temporally using the frequency storm method within HEC-HMS. The frequency storm method produces a synthetic storm from statistical precipitation data. This temporal distribution is a critically-stacked design distribution that generally results in more intense precipitation patterns than are typically experienced, and therefore often results in a conservative peak discharges as compared with peak discharges developed based on statistical analysis of recorded discharges from actual events.

Table 2: NOAA Atlas 14 24-Hour Precipitation Depths for Upper Merion Township

Return Period (years)	NOAA ATLAS 14 Precipitation Depth (in.)							
	5-min	15-min	60-min	2-hr	3-hr	6-hr	12-hr	24-hr
2	0.412	0.828	1.44	1.72	1.87	2.33	2.83	3.26
10	0.532	1.08	2.03	2.46	2.70	3.36	4.14	4.79
25	0.591	1.19	2.35	2.89	3.18	4.01	5.00	5.78
50	0.631	1.27	2.60	3.23	3.55	4.53	5.72	6.62
100	0.669	1.34	2.84	3.56	3.93	5.07	6.50	7.52

2.2.7 Summary of Hydrologic Parameters

The hydrologic parameters and the precipitation data discussed in the previous sections were input into the HEC-HMS model. Table 3 summarizes the hydrologic parameters.

Table 3: Hydrologic Parameters

Watershed	Subwatersheds	Area (ac)	CN	Tc (min)
Trout Creek	W100	349.1	84	45
	W120	537.7	90	50
	W130	752.2	74	97
	W140	126.3	81	28
	W150	756.9	77	71
	W160	787.2	79	73
	W170	1134.1	75	64
	W180	509.3	78	79
	W200	241.4	84	91
	W210	183.5	76	70
Crow Creek	W520	234.5	83	85
	W540	281.3	83	36
	W560	206.6	85	68
	W570	201.9	86	34
	W640	147.9	85	93
	W670	652.8	89	73
	W680	548.3	84	35
	W880	499.0	71	93
	W900	476.9	70	55
	W970	242.2	76	69
Abrams Creek	W100	85.4	84	37
	W50	130.9	85	55
Frog Run	W140	89.8	81	145
	W150	362.9	86	34
	W100	403.5	85	59
	W50	465.5	81	44
Matsunk Creek	W80	158.4	88	36
	W90	294.5	73	70
	W100	88.1	83	48
Watershed A	W60	228.6	87	52
Gulph Mill Creek	W40	707.3	77	65
	W50	746.9	63	57
	W80	1121.9	69	55
	W90	1300.1	72	102

2.3 Hydrologic Model Results and Comparison

The peak flow discharges simulated using HEC-HMS in this study were compared with other available discharge estimates.

All seven watersheds modeled in this study are included in areas studied in detail by the Federal Emergency Management Agency (FEMA). FEMA published a series of Flood Insurance Rate Maps (FIRMs) and a Flood Insurance Study (FIS) for Montgomery County in March 2016, which included the seven watersheds/open channels in the Upper Merion Township included in this current study. In these locations, detailed hydraulic analyses were completed to establish base flood elevations and regulatory floodway limits. The FIS reports that the most of the hydrologic and hydraulic analyses for Upper Merion Township were last updated in 1977 by Gannett Fleming Corddry and Carpenter, Inc. Flood discharges in the 1977 study were based on the USGS Open-File Report 76-391, "Floods in Pennsylvania: A Manual for Estimation of Their Magnitude and Frequency," which is a regional method using regression equations relating drainage area, channel slope, percent area of storage, and an index of average annual excess precipitation. The hydrologic analyses for Trout Creek were based on a modification of the SCS procedure designated in the FIS study as "Segment Tc, Condition III".

The FIS for Upper Merion Township was revised in August 1999. In this revision, initial flow quantities for Abrams Creek were taken from the report entitled Township-Wide Stormwater Management Plan. Existing Hydrologic Conditions, Draft Report, prepared by Gannett Fleming, Inc., for the Township of Upper Merion. Flow quantities from the draft report were input at identified cross section locations to develop rating tables for each cross section. Peak discharges reported in the FEMA FIS are summarized in Tables 4-10.

As described previously, the 1995 Township-Wide Stormwater Management Plan Report prepared by Gannett Fleming simulated watershed response using the NRCS TR-20 computer model. Depths of rainfall for various frequencies were determined using the publication Rainfall Duration-Frequency Tables for Pennsylvania published by the Pennsylvania Department of Environmental Resources published in 1983. The hydrologic parameters were determined using the 1992 land use data, the 1994 US Soil Map (STATSGO). Peak discharges reported in the 1995 study are summarized in Tables 4-10.

As another means of comparison, Peak Discharges for the streams within Upper Merion Township were calculated using the USGS SIR 2008-5102 regression method as accessed through the United States Geological Survey (USGS) streamstats website. Although drainage areas for some streams are below the lower applicable limit for the regression equations, they provide another method for comparison. Peak discharges calculated using this method are included in Tables 4-10.

Table 4: Crow Creek Watershed Peak Discharges

Streams	FEMA					1995 Study				StreamStats				Current Study			
	Flow Change Location	Area (mi^2)	10 Year	50 Year	100 Year	Area (mi^2)	10 Year	50 Year	100 Year	Area (mi^2)	10 Year	50 Year	100 Year	Area (mi^2)	10 Year	50 Year	100 Year
Crow Creek	850 Feet Upstream of Confluence with Schuylkill River	4.64	1,645	2,883	3,544	4.65	2,505	4,146	4,873	4.77	1,360	2,030	2,350	5.46	3,476	5,355	6,164
	Covered Bridge Road	4.11	1,635	2,856	3,269	---	---	---	---	4.29	1,240	1,860	2,150	4.33	2,855	4,375	5,029
	Downstream of Confluence of Abrams Run	3.24	1,505	2,542	2,615	3.25	1,757	2,914	3,432	3.31	1,010	1,510	1,750	3.78	2,492	3,835	4,413
	Upstream of Confluence of Abrams Run	1.92	775	1,397	1,618	---	---	---	---	---	---	---	---	2.52	1,791	2,709	3,104
	Tannery Drive	1.54	625	1,219	1,462	1.54	709	1,265	1,513	1.48[1]	709	1,120	1,320	1.52	755	1,285	1,522
	Kerrwood Drive	0.73	251	524	637	---	---	---	---	0.69[1]	440	696	818	0.78	361	612	725
Abrams Run	Confluence with Crow Creek	1.07	448	673	765	1.07	724	1,122	1,303	1.21[1]	491	737	854	1.24	701	1,125	1,309
	Powderhorn Road	0.96	252	411	480	---	---	---	---	---	---	---	---	---	---	---	---
	Cemetery Road	0.57	314	447	509	---	---	---	---	---	---	---	---	---	---	---	---
	Croton Road	0.39	170	238	248	0.34	144	276	336	0.27[1]	261	421	498	0.38	263	413	477
	Falcon Road	0.3	147	278	339	---	---	---	---	---	---	---	---	---	---	---	---

1. Area Value is outside the suggested range.

Table 5: Trout Creek Watershed Peak Discharges

Streams	FEMA					1995 Study				StreamStats				Current Study			
	Flow Change Location	Area (mi^2)	10 Year	50 Year	100 Year	Area (mi^2)	10 Year	50 Year	100 Year	Area (mi^2)	10 Year	50 Year	100 Year	Area (mi^2)	10 Year	50 Year	100 Year
Trout Creek	Downstream of Confluence with the Schuylkill River	8.8	2,000	2,950	3,300	8.7	3111	5419	6475	8.84	1,740	2,480	2,830	8.4	5,292	8,280	9,569
	Township Boundary													6.6	4,345	6,818	7,882
Tributary	Upstream of Pennsylvania Turnpike Interstate Route 276	1.2	---	---	922	0.6	598	893	1016	1.19[1]	570	874	1,020	0.8	1,106	1,483	1,632

Table 6: Abrams Creek Watershed Peak Discharges

Streams	FEMA					1995 Study				StreamStats				Current Study			
	Flow Change Location	Area (mi^2)	10 Year	50 Year	100 Year	Area (mi^2)	10 Year	50 Year	100 Year	Area (mi^2)	10 Year	50 Year	100 Year	Area (mi^2)	10 Year	50 Year	100 Year
Abrams Creek	Beidler Road	0.26	169	281	329	0.26	168.9	280.5	329.4	0.25[1.2.]	245	400	475	0.34	374.1	530.1	593.1
	Brownlee Road	0.19	146	236	275	0.19	145.7	236.2	275.2	0.19[1.2.]	208	338	401	0.20	223.9	315.6	352.7

Table 7: Unnamed Watershed A Peak Discharges

Streams	FEMA					1995 Study				StreamStats				Current Study			
	Flow Change Location	Area (mi^2)	10 Year	50 Year	100 Year	Area (mi^2)	10 Year	50 Year	100 Year	Area (mi^2)	10 Year	50 Year	100 Year	Area (mi^2)	10 Year	50 Year	100 Year
Unnamed Creek A	0.21 Mile Upstream of Confluence with Matsunk Creek	0.42	205	335	387	0.42	417.1	659.5	763.2	0.35[1.3.]	160	252	297	0.36	428.7	591.2	656.2
	B Street	0.3	108	201	251	---	---	---	---	0.28[1.3.]	133	217	258	0.28	336.1	463.5	514.4

1. Area Value is outside the suggested range.
2. Percent Urban is outside the suggested range.
3. Percent Carbonate is outside the suggested range.

Table 8: Matsunk Creek Peak Discharges

Streams	FEMA					1995 Study				StreamStats				Current Study			
	Flow Change Location	Area (mi^2)	10 Year	50 Year	100 Year	Area (mi^2)	10 Year	50 Year	100 Year	Area (mi^2)	10 Year	50 Year	100 Year	Area (mi^2)	10 Year	50 Year	100 Year
Matsunk Creek	Swedeland Road	0.71	255	386	458	0.71	361.3	654.8	785.9	0.88[1]	308	471	550	0.85	653	985.6	1127.3
	Renaissance Blvd.	0.71	291	524	627	---	---	---	---	0.71[1]	265	414	486	0.60	413.7	650.8	753.1
	Crooked Lane	0.13	169	276	321	---	---	---	---	0.11[1]	113	178	209	0.46[2]	282.7	460.9	538.8
	150 feet upstream of School Line Drive	0.08	81	140	166	---	---	---	---	---	---	---	---	0.12[3]	70.68	115.23	134.70

Table 9: Frog Run Peak Discharges

Streams	FEMA					1995 Study				StreamStats				Current Study			
	Flow Change Location	Area (mi^2)	10 Year	50 Year	100 Year	Area (mi^2)	10 Year	50 Year	100 Year	Area (mi^2)	10 Year	50 Year	100 Year	Area (mi^2)	10 Year	50 Year	100 Year
Frog Run	1.11 Miles above Confluence with the Schuylkill River	1.47	551	675	728	1.47	1,034	1,632	1,887	1.55	512	762	880	1.92	1,841	2,695	3,047
	Upstream of I-276	1.4	653	821	889	---	---	---	---	---	---	---	---	1.36	1,464	2104	2,364
	Crooked Lane	1.08	646	816	870	---	---	---	---	1.07[1]	431	637	734	---	---	---	---
	Church Road	0.78	682	1,006	1,082	---	---	---	---	---	---	---	---	---	---	---	---
	Downstream of Yerkes Road	0.78	682	1,006	1,082	0.78	603.7	960.3	1,112	0.83[1]	385	580	672	0.73	810.9	1,177	1,326
	Upstream of Yerkes Road	0.42	316	518	602	---	---	---	---	---	---	---	---	---	---	---	---

1. Area Value is outside the suggested range.
2. Area delineated upstream of the railroad downstream of Crooked Lane.
3. Area delineated upstream of Crooked Lane.

Table 10: Gulph Mill Creek Peak Discharges

Streams	FEMA					1995 Study				StreamStats				Current Study			
	Flow Change Location	Area (mi^2)	10 Year	50 Year	100 Year	Area (mi^2)	10 Year	50 Year	100 Year	Area (mi^2)	10 Year	50 Year	100 Year	Area (mi^2)	10 Year	50 Year	100 Year
Gulph Mills Creek	South Gulph Road	4.83	1,199	1,694	1,921					5.32	1,700	2,580	3,000	6.06	2,437	4,395	5,288
	Downstream of Confluence of Gulph Mills Creek Tributary A	4.83	1,344	2,364	2,934	4.94	1,272	2,416	3,079	5.24	1,700	2,580	3,000	4.95	1,729	3,253	3,958
	Upstream of Confluence of Gulph Mills Creek Tributary A	1.02	584	1,043	1,254	---	---	---	---	---	---	---	---	---	---	---	---
	Downstream of Confluence of Gulph Mills Creek Tributary B	1.02	584	1,075	1,300	---	---	---	---	1.07[1,2]	614	953	1,110	1.17	487.5	930.6	1,135
	Upstream of Confluence of Gulph Mills Creek Tributary B	0.71	459	828	994	---	---	---	---	0.66[1,2]	466	737	866	0.85	383	717	868
	0.34 mile upstream of Confluence of Gulph Mills Creek Tributary B	0.37	251	444	530	---	---	---	---	---	---	---	---	---	---	---	---
Tributary A	Upstream of confluence with Gulph Mills Creek	3.71	963	1,726	2,071	3.71	916.3	1,801	2,211	4.05	1,430	2,210	2,580	3.78	1241	2,322	2,823
Tributary B	Lantern Lane	0.37	134	262	321	1.02	468.9	871	1,052	0.32[1,2]	267	422	495	0.32	104	214	267

1. Area Value is outside the suggested range.
2. Percent Urban is outside the suggested range.

In general, the subwatersheds areas delineated in the current study agree with the subwatersheds areas identified in the other studies. Differences in area are attributed to slight differences in subwatershed outlet locations, differences in terrain data used for delineation, and in some instances the consideration of small scale stormwater sewersheds. At the scale of the current study, the delineations completed as part of this study are based on the best available data and are considered to be the best representation of watershed boundaries.

Peak discharges calculated in the current study are generally higher than those calculated in the 1995 study. One reason for this difference is an increase in precipitation depth from the 1995 study to the current study. Precipitation depths used in the 1995 study were determined using the publication Rainfall Duration-Frequency Tables by the PADER in 1983. Precipitation depths used in the current study were based on NOAA Atlas 14, the most recent and best-available source for precipitation frequency data. A comparison between the 24-hour precipitation depths for storms with various return periods is presented in Table 11. The latest precipitation depths are generally 10% higher than the 1995 estimates.

Table 11: Comparison of Precipitation Depths

Storm Magnitude	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
Precipitation Depth for 1995 Study (inches)	2.96	3.78	4.46	5.29	5.93	6.54
Precipitation Depth for Current Study (inches)	3.26	4.10	4.79	5.78	6.62	7.52
Percent Increase (1995 to Current Study)	10%	8%	7%	9%	12%	15%

Other reasons for the difference between the 1995 study and the current study include the use of better resolution land cover and soil data and increases in impervious area from the prior study. Increases in impervious area will result in a shorter watershed response time and a larger runoff volume and peak discharge.

Another apparent pattern is that the discharges computed by the watershed model are generally larger than the discharges computed using the USGS regional regression equations. The larger discharges computed using the watershed model are attributed mainly to the critically stacked temporal precipitation distribution used within the model. Critically stacked precipitation distributions result in runoff hydrographs that are maximized for the return period and exceed discharges estimates based on streamflow statistics developed from actual events.

Based on these comparison, it is concluded that the discharge estimates developed as part of the current study are conservatively large estimates of peak discharge and may overestimate flooding extents for a given return period. Although the hydraulic analysis will use these conservatively large estimates of peak discharge for a given return period, the purpose of the analyses is to identify locations where flooding occurs most frequently. In this regard, the study is actually a comparative analysis of hydraulic efficiency at various locations and using conservatively large discharges will not affect the results of the study. The discharges developed as part of this study are based on state-of-the-practice methods and best available data and will be used in the subsequent hydraulic analysis.

3.0 Hydraulic Analysis

3.1 HEC-RAS Model Setup

In order to evaluate the flooding condition and the hydraulic effects of the existing structures (bridges and culverts), the HEC-RAS (v5.0.3) computer software was used. HEC-RAS was developed by the USACE and performs one-dimensional steady and unsteady, subcritical and supercritical flow modeling for various hydraulic structures and applications.

Seven HEC-RAS models were developed for Upper Merion Township based on the discharges described in the previous section. The extents of the HEC-RAS models are confined within the Township boundary.

Bathymetry survey was not performed for this study. All cross sections for the stream developed for the HEC-RAS program were generated from the LiDAR topographic data obtained from the PAMAP Program. The LiDAR was flown in the spring of 2008 and supports vertical accuracies of 18.5 cm in open areas and 37 cm in forested areas. The LiDAR data is referenced horizontally to PA State Plane (South Zone) and vertically to North American Vertical Datum of 1988 (NAVD88). Due to the nature of the LiDAR data, the river channel bathymetry below the water surface at the time of data collection was not included in the model. Because flow area below the normal water surface is very small in these streams, the exclusion of this area in the model was judged to have insignificant impact on the predicted water surface elevations.

Streams within Upper Merion Township are included in the FEMA detailed study area. All available 1976 FEMA HEC-2 models, 1995 detailed WSP2 models (effective FIS), and the 2017 approximate HEC-RAS models were requested from FEMA. In an effort to include more accurate stream bathymetry in the model, cross-section geometries in the FEMA models and the stream thalweg profiles presented in the FEMA were obtained and compared to the cross-section created based on the LiDAR data. Based on this comparison, the stream thalweg reported in the FIS study is consistently 1-2 feet higher than the thalweg obtained from LiDAR. Cross-sections used in the HEC-2 and the WSP2 models are less detailed the LiDAR-based cross-sections. The cross-section geometries and the stream thalweg obtained from the LiDAR terrain data is the best-available data and most accurately represents the current channel conditions; therefore the FEMA cross-sections and thalweg were not incorporated into the HEC-RAS model developed in this study.

Information regarding the type, size, and location of the major stream crossing structures were gathered from 1995 Study, FEMA FIS Study, Google Satellite Image and Street View. Additional measurements were obtained from several field visits.

Manning's roughness values have been selected based on the FEMA WSP2 model. Channel roughness ranges from 0.035 to 0.04. Overland roughness ranges from 0.04-0.05 depending on the land cover types.

Downstream boundary conditions were assumed to be known water surface elevations from the effective FIS Study or normal depths where no study was available. The upstream boundary condition was set to be normal depth. Peak discharge value calculated in the HEC-HMS model

during the 10-year, 50-year, and 100-year events were used in the steady flow condition. A mix flow regime was used in the steady flow simulation.

3.2 Hydraulic Models

3.2.1 *Crow Creek*

The Crow Creek Watershed encompasses the entire central portion of the Township from the Schuylkill River to beyond the Montgomery/Chester County Line. Five stream segments were modeled in the Crow Creek HEC-RAS model. The Tributary Reach and Upper Reach Crow Creek converge into the Middle Reach Crow Creek near Tannery Drive. Abrams Run joins Upper Reach Crow Creek upstream of the PA Turnpike and runs into Lower Reach Crow Creek. The downstream limit of the model is the confluence of Crow Creek and Schuylkill River. The upstream model limit of Upper Reach is downstream of Martins Dam. The upstream model limit of Tributary extents about 1500 feet upstream of Croton Road. The upstream model limit of Abrams Run extents about 720 feet upstream of Route 76 (Schuylkill Expressway). An aerial map showing the model extents is included as Figure 2. A total of 26 stream crossing structures are modeled within Crow Creek Watershed.

Figure 2: Crow Creek Watershed Hydraulic Model Extents

3.2.2 Trout Creek

The Trout Creek Watershed encompasses the entire western portion of the Township from the Schuylkill River to beyond the Montgomery/Chester County Line. Three stream segments were modeled in the Trout Creek HEC-RAS model. Tributary and Upper Reach Trout Creek converge near E 8th Avenue and runs into Lower Reach Trout Creek. The downstream limit of the model is the confluence of Trout Creek and Schuylkill River. The upstream model limit of Upper Reach extents about 400 feet upstream of County Line Expressway. The upstream model limit of Tributary extents about 400 feet upstream of PA Turnpike. An aerial map showing the model extents is included as Figure 3. A total of 10 stream crossing structures are modeled within Trout Creek Watershed.

Figure 3: Trout Creek Watershed Hydraulic Model Extents

3.2.3 Abrams Creek

The Abrams Creek Watershed is a small watershed of approximately 0.33 square miles. It is located in the northern part of the Township. One stream segment was modeled in the Abrams Creek HEC-RAS model. The downstream limit of the model is the confluence of Abrams Creek and Schuylkill River. The upstream model limit of model extents about 600 feet upstream of Brownlie Road. An aerial map showing the model extents and cross-sections is included as Figure 4. A total of 4 stream crossing structures are modeled within Abrams Creek Watershed.

Figure 4: Abrams Creek Watershed Hydraulic Model Extents

3.2.4 *Frog Run*

The Frog Run Watershed is located in the northeast part of the Township. One stream segment was modeled in the Frog Run HEC-RAS model. The downstream limit of the model is the confluence of Crow Creek and Schuylkill River. The upstream model limit of Upper Reach is the coal mine near PA Turnpike. The upstream model limit extents about 270 feet downstream of S

Gulph Road. An aerial map showing the model extents is included as Figure 5. A total of 17 stream crossing structures are modeled within Frog Run Watershed.

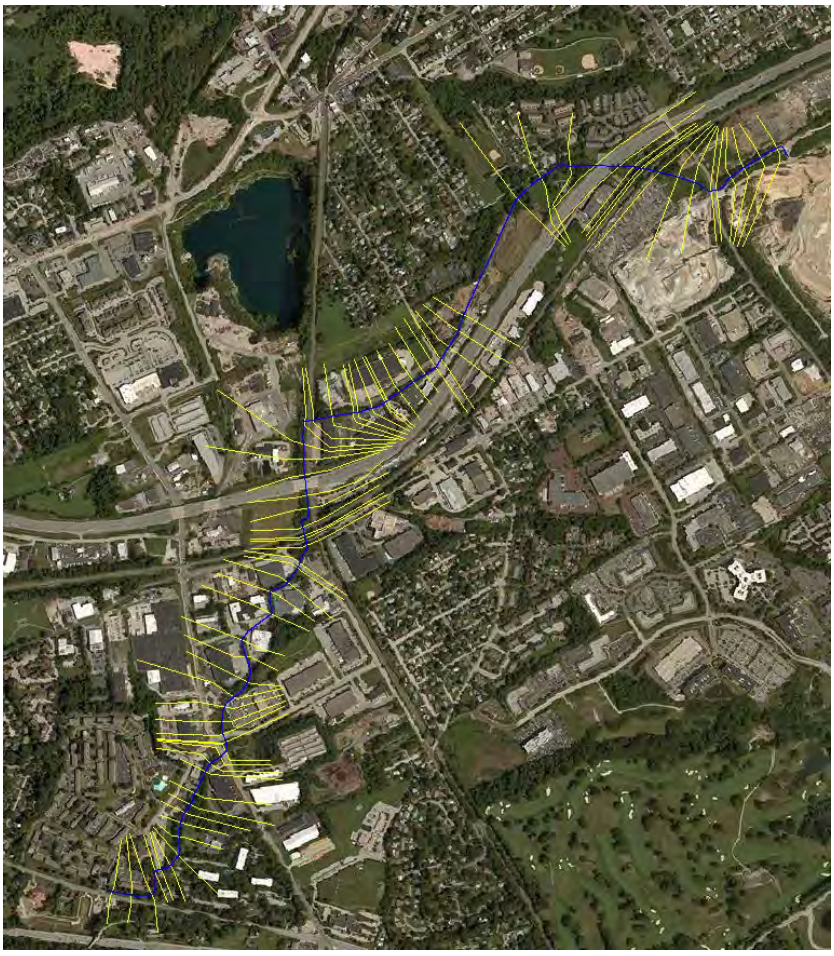

Figure 5: Frog Run Watershed Hydraulic Model Extents

3.2.5 *Matsunk Creek*

Matsunk Creek is located in the eastern portion of the Township. The watershed has a drainage area of 0.9 square miles. One stream segment was modeled in the Matsunk Creek HEC-RAS model. The downstream limit extents about 230 feet downstream of Schuylkill River Road. The upstream model limit extents near School Line Drive and Crook Lane. An aerial map showing the model extents is included as Figure 6. A total of 8 stream crossing structures are modeled within Matsunk Creek Watershed.

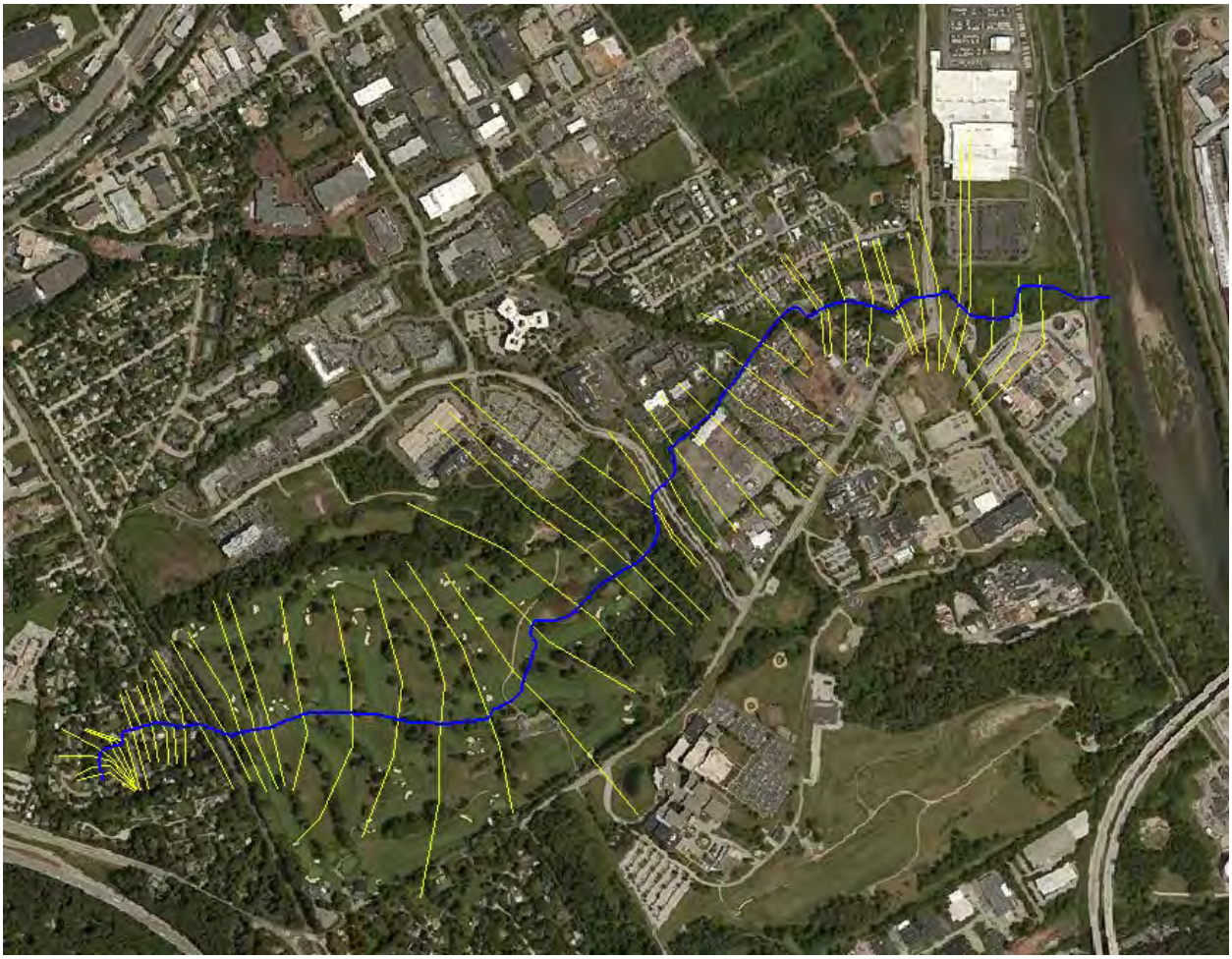

Figure 6: Matsunk Creek Watershed Hydraulic Model Extents

3.2.6 *Unnamed Watershed A*

Watershed A is a small watershed of approximately 0.4 square miles. The downstream limit of the model is the confluence of Crow Creek and Schuylkill River. The downstream limit extents about 230 feet downstream of Schuylkill River Road. The upstream model limit extents about 250 feet downstream of Horizon Drive. An aerial map showing the model extents is included as Figure 7. A total of 7 stream crossing structures are modeled within Unnamed Watershed A.

Figure 7: Unnamed Watershed A Hydraulic Model Extents

3.2.7 Gulph Mill Creek

The Gulph Mill Watershed extends through the southeast part of the Township. The total watershed area is 6.1 square miles, most of which lies outside of the Township limits. Five stream segments were modeled in the Gulph Mill Creek HEC-RAS model. Tributary B and the Upper Reach of Gulph Mill Creek converge into the Middle Reach of Gulph Mill Creek near Lantern Lane. Tributary A joins the Middle Reach of Gulph Creek upstream of Schuylkill Expressway and runs into the Lower Reach of Gulph Creek. The downstream limit of the model is the confluence of Gulph Creek and Schuylkill River. The upstream model limit of the Upper Reach of Gulph Creek is upstream of Pine Hill Road. The upstream model limit of Tributary A extends upstream of County Line Road. The upstream model limit of Tributary B extends about 700 feet upstream of Joel Road. An aerial map showing the model extents is included as Figure 8. A total of 23 stream crossing structures are modeled within Gulph Mill Creek Watershed.

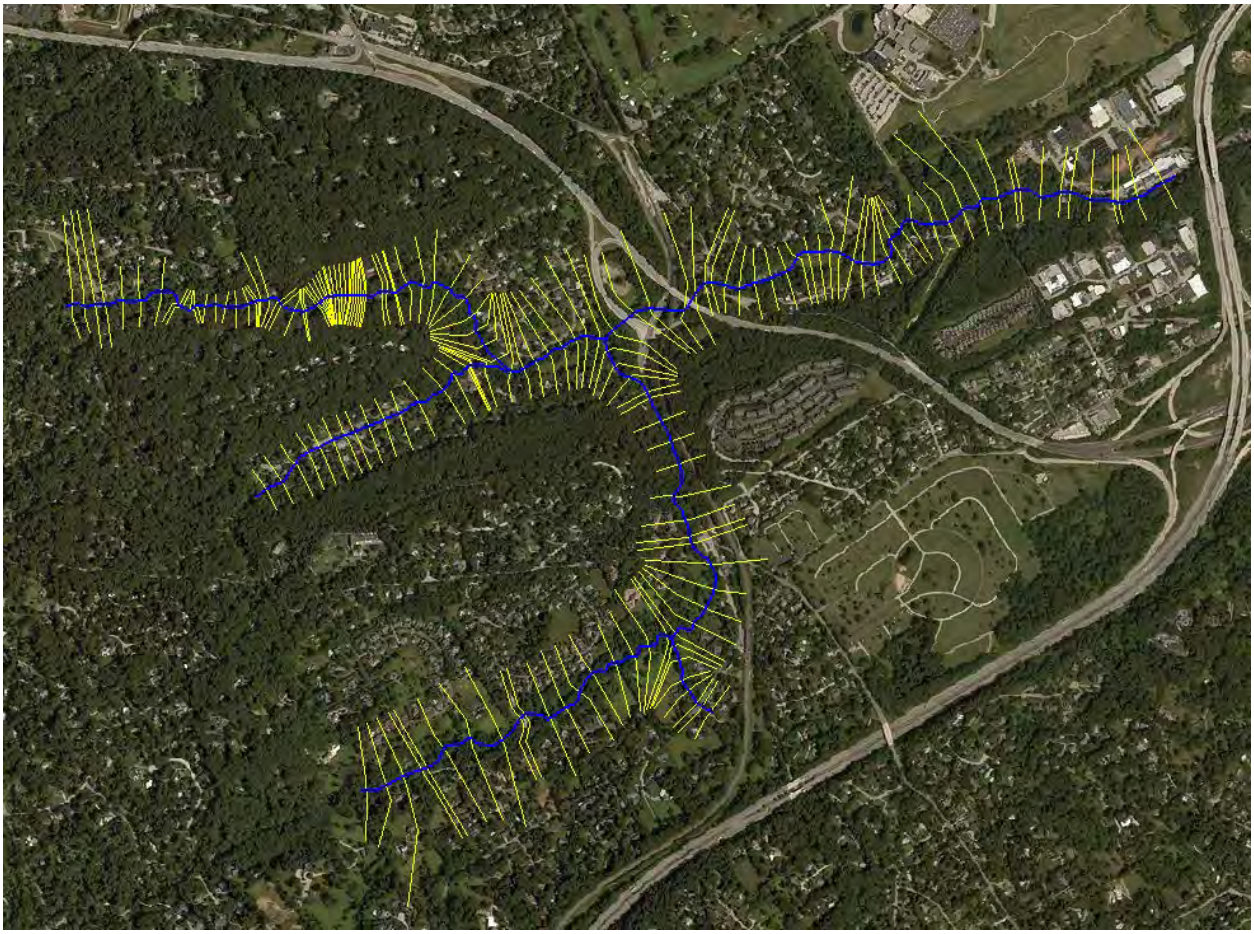

Figure 8: Gulph Mill Creek Watershed Hydraulic Model Extents

3.3 Hydraulic Model Results

As stated in Section 3.1, the 10-year, 50-year, and 100-year flood events were simulated in the HEC-RAS model.

Based on the hydraulic model, areas of potential flooding concerns were identified. This exercise provides an independent means for identifying locations of flooding concerns. Locations were identified by examining floodplain mapping prepared based on the results of the hydraulic models for the range of events modeled. Locations where flooding of roadways, parking lots or other infrastructure would occur frequently (at lower discharges) were identified. In general, these are locations where hydraulic structures were particularly undersized for the size of the channel or where surrounding development is located particularly close to the channel and within the floodplain. The probable cause of the flooding was examined through iterative model runs, examination of the surrounding topography and engineering judgement. The potential to reduce flood risks through local infrastructure improvements will be examined in subsequent sections. Table 12 identifies the potential flooding locations and the probable cause of flooding identified though hydraulic modeling.

Table 12: Potential Flooding Locations Identified Through Hydraulic Modeling

Watershed	Location/Description	Possible Cause
Crow Creek	Crossfield Rd &Thomas Dr	Low Ground,
Crow Creek	Walker Field Park Flooding	Low Ground
Crow Creek	Upstream of PA Tpke Near the Mall	Insufficient Culvert Capacity
Crow Creek	King of Prussia Mall Parking Lot	Low Ground & Possible Insufficient Capacity of Parking Lot Drainage System.
Crow Creek	King of Prussia Rd Near W Dekalb Pike	Insufficient Culvert Capacity & Low Ground
Crow Creek	US 76	Insufficient Culvert Capacity
Crow Creek	Croton Rd Near Elementary School	Insufficient Culvert Capacity
Crow Creek	W Dekalb Pike & Powderhorn Area	Insufficient Culvert Capacity
Crow Creek	Vally Forge Memorial Gardens	Insufficient Culvert Capacity
Crow Creek	S Gulph Rd	Insufficient Culvert Capacity
Crow Creek	Croton Rd Near W Church Rd	Insufficient Culvert Capacity
Crow Creek	US 76	Insufficient Culvert Capacity
Trout Creek	N Gulph Rd/SR363	Possible Insufficient Culvert Capacity
Trout Creek	Moore Rd	Insufficient Culvert Capacity
Trout Creek	Driveway	Insufficient Culvert Capacity
Trout Creek	American Ave. & 1st Ave.	Insufficient Culvert Capacity
Trout Creek	Parking Pot	Low Ground
Trout Creek	W Valley Forge Rd	Insufficient Culvert Capacity, Low Ground
Abrams Creek	Rail Road	Insufficient Culvert Capacity
Frog Run	Shoemaker Rd	Insufficient Culvert Capacity
Frog Run	S Henderson Rd	Insufficient Culvert Capacity
Frog Run	Shoemaker Rd	Insufficient Culvert Capacity
Frog Run	Yerkes Rd	Insufficient Culvert Capacity
Frog Run	E Church Rd	Insufficient Culvert Capacity
Frog Run	Railroad	Insufficient Culvert Capacity
Frog Run	Crooked Ln	Insufficient Culvert Capacity
Frog Run	Railroad	Insufficient Culvert Capacity
Matsunk Creek	Overland Flooding	Possible Insufficient Culvert Capacity
Matsunk Creek	Schuylkill Rd	Insufficient Culvert Capacity
Unnamed Watershed A	Driveway	Insufficient Culvert Capacity & Low Ground
Unnamed Watershed A	Driveway	Insufficient Culvert Capacity
Unnamed Watershed A	Flint Hill Rd	Insufficient Culvert Capacity
Unnamed Watershed A	B St	Insufficient Culvert Information
Unnamed Watershed A	Swedeland Park	Insufficient Culvert Information
Unnamed Watershed A	Schuylkill Rd	Insufficient Culvert Capacity
Gulph Mill Creek	Driveway	Possible Insufficient Culvert Capacity
Gulph Mill Creek	Jones Rd	Insufficient Culvert Capacity
Gulph Mill Creek	Trinity Rd	Insufficient Culvert Capacity
Gulph Mill Creek	S Gulph Rd	Insufficient Culvert Capacity
Gulph Mill Creek	US76 Ramp	Insufficient Culvert Capacity
Gulph Mill Creek	Confluence	Low Ground
Gulph Mill Creek	Denbigh Ln	Insufficient Culvert Capacity & Low Ground
Gulph Mill Creek	County Line Rd	Insufficient Culvert Capacity & Low Ground

4.0 Locations of Flooding Concerns

The locations of flooding concerns were identified from four different sources:

- The public through the web survey as described in Section 1.5.1 and with results found in Appendix A.
- The Township's Emergency Management (EMA) staff records as described in Section 1.5.2 and with results found in Appendix B.
- Locations identified in the 1995 study as described in Section 1.2.
- Locations identified through the current hydraulic study as described in Section 3 and summarized in Table 12.

A table displaying the flooding concerns information with the four different sources and a corresponding map displaying the flooding concerns locations are found in Appendix D.

5.0 Stormwater Program Analysis

Throughout the course of preparing this Plan, the Gannett Fleming/Wood Team produced a set of topic papers documenting observations of the Township's stormwater program. Appendix F presents the complete set of topic papers produced for the Township as part of this study. The topic papers include detailed observations of the Township's current stormwater program activities, challenges, and opportunities. The following sections present a brief summary of these findings, organized into four Cost Centers:

1. MS4 Permit Compliance;
2. Operations and Maintenance;
3. Land Use Regulations; and
4. Planning and Administration.

Cost Centers allow local leaders to view stormwater activities that may be performed by multiple Township offices independent of the Township department structure. This is helpful in communicating the activity to citizens, business owners, stakeholders, and decisions makers, as well as for developing recommendations for program changes. These Cost Centers are used again in Section 6.2 to present stormwater management activities recommended to address program opportunities and opportunities identified in the topic papers.

5.1 MS4 Permit Compliance

The Township Public Works Department implements the MS4 permit compliance program, including preparation of the annual report for submittal to PADEP. The focus of the MS4 permit are the following six Minimum Control Measures (MCM) defined by PADEP:

1. Public Education and Outreach on Stormwater Impacts
2. Public Involvement/Participation
3. Illicit Discharge Detection and Elimination
4. Construction Site Stormwater Runoff Control
5. Post-Construction Stormwater Management
6. Pollution Prevention/Good Housekeeping

Table 13 summarizes the best management practices (BMP's) defined by PADEP for each of the MCM's. The Township is responsible to implement each BMP over the course of the five-year MS4 permit cycle.

In 2017, the Township also developed a Pollutant Reduction Plan (PRP) to reduce the discharge of sediment to local impaired streams by 10%, as required by PADEP's updated MS4 permit. The PRP identified approximately 1.2 miles of stream restoration projects and 16 stormwater basin retrofits that could be constructed to achieve this mandated sediment discharge reduction by 2023. In addition, Upper Merion committed to investigate suspected sources of PCB and prepare a report to submit to PADEP, as required by the MS4 permit.

Table 13: Best Management Practices Organized by Minimum Control Measures

Minimum Control Measure	Best Management Practice
1- Public Education and Outreach on Stormwater Impacts	Develop, implement, and maintain a written Public Education Outreach Program (PEOP).
	Develop and maintain a list of target audience groups that are present within the areas served by the Township's MS4 permit.
	Publish a newsletter, pamphlet, flyer, or website that includ3es stormwater educational information and the Township's program.
	Distribute stormwater educational materials to the target audience groups.
2- Public Involvement/ Participation	Develop, implement, and maintain a written Public Involvement and Participation Program (PIPP).
	Solicit input from the public on the Township's Stormwater Management Ordinances, Standard Operating Procedures (SOPs), and Pollutant Reduction Plans (PRPs) prior to adoption.
	Regularly solicit public involvement and participation from target audience groups.
3- Illicit Discharge Detection and Elimination	Maintain a written program to detect and eliminate illicit discharges into the MS4.
	Maintain a map showing location of all outfalls.
	Maintain a map showing the entire storm sewer collection system, including privately owned components.
	Conduct dry weather screenings of MS4 outfalls.
	Enact a Stormwater Management Ordinance to implement and enforce prohibition of non-stormwater discharges to the MS4.
	Educate the public about the program to detect and eliminate illicit discharges.
4- Construction Site Stormwater Runoff Control	Withhold issuance of building permits to those proposing earth disturbance activities requiring an NPDES permit until coverage is authorized.
	Notify the PADEP or the Conservation District of applications for a Township permit proposing greater than one acre of earth disturbance.
	Enact, implement, and enforce an ordinance to require the implementation and maintenance of erosion controls.
5- Post-Construction Stormwater Management in New Development and Redevelopment	Develop a written procedure describing implementation of this MCM.
	Require structural and/or non-structural practices that minimize water quality impacts from new development and redevelopment.
	Ensure that controls are installed to prevent water quality impacts.
	Enact, implement, and enforce an ordinance to address post-construction stormwater runoff from new development and redevelopment.
	Develop and implement measures to encourage the use of Low Impact Development.
	Ensure adequate operation and maintenance of post-construction stormwater management BMPs.
6- Pollution Prevention/ Good Housekeeping	Maintain an inventory of all operations owned or operated by the Township that have the potential for generating pollution in stormwater runoff to the MS4.
	Develop, implement, and maintain a written program for all operations that could contribute to the discharge of pollutants.
	Maintain an employee training program to further the goal of preventing/reducing the discharge of pollutants to the MS4.

5.1.1 *Opportunities/Challenges: MS4 Compliance*

This section presents an overview summary of opportunities and challenges associated with each MCM. For a complete analysis of MCM's, including details on current activities and recommendations for improvement, refer to the *Minimum Control Measure Compliance Report*, the *Cooperative Public Education Opportunities Report*, and the *Good House-Keeping Recommendations* in Appendix F**.**

MCM 1- Public Education and Outreach on Stormwater Impacts. The Township can improve how they communicate information about stormwater controls to the public by defining measurable goals and strategies in the PEOP, reviewing and updating the PEOP annually, and pursuing partnerships with other organizations in the region. By specifically defining target audiences for the distribution of specific messages and aggregated publications pertaining to stormwater, the Township will be able to more efficiently distribute educational materials to the public.

MCM 2- Public Involvement/ Participation. The Township can benefit from making improvements to the PIPP, including defining measurable goals, performing annual reviews, providing public access to reports, and routinely communicating with partners in the community. Using alternative advertising methods such as social media, radio/podcasts, and multilingual announcements, the Township will be able to engage a more diverse audience to regularly solicit public involvement.

MCM 3- Illicit Discharge Detection and Elimination. To direct the process of detecting and eliminating illicit discharge sources, the Township can identify and document priority management areas most likely to have non-stormwater discharges from the storm sewer. Maps can be updated annually giving special attention to these priority areas as well as confirming regulated outfalls, private stormwater features, and storm sewers serving the PennDOT right of way. Public outreach can also be improved to encourage reporting of illicit sources and discourage illegal dumping.

MCM 4- Construction Site Stormwater Runoff Control. As the Township transitions to the 2018 version of the MS4 permit, the Township should continue to rely on PADEP's program for issuing NPDES permits for construction sites and formally communicate with the Conservation District regarding responsibilities for overseeing land disturbance activities. Formal communication could be documented in a Memorandum of Understanding with the Conservation District that specifies responsibilities and expectations for reporting and notification of erosion control inspections and enforcement.

MCM 5- Post-Construction Stormwater Management in New Development and Redevelopment. The Township can ensure any ordinances are consistent with the model ordinance set forth by PADEP. Better tracking of private storm sewers and stormwater controls can be implemented to allow the Township to monitor function and maintenance of these critical features.

MCM 6- Pollution Prevention/ Good Housekeeping. By regularly maintaining an inventory of municipal facilities, including an understanding of threats to water quality, the Township can set priorities for planned improvements. Further, written operating procedures and inspection schedules can serve as a tool to train staff on standardized good housekeeping methods and promote awareness of potential threats to surface water.

Pollutant Reduction Plan- The Township does not have a process to regularly review and refine the delineation of the PRP planning area and sediment load calculation methods. Such a process would ensure that the appropriate degree of sediment reduction is a focus for the Township's MS4 service area. Documentation of the Township's preferred method and location of stormwater controls to reduce the discharge of sediment from the MS4 could promote opportunities for sharing project design, permitting, construction, and maintenance costs with partners (private property owners, PennDOT, etc.). Once sediment reduction measures are installed, the Township should have clear documentation of the operations and maintenance of each feature to protect the Township's investment in this infrastructure. The *Pollutant Reduction Plan Review* in Appendix F provides additional detail on these opportunities and challenges.

5.2 Operations & Maintenance

Public Works is responsible for maintaining the Township-owned stormwater conveyance system. General maintenance activities include inlet cleaning and removal of debris and storm sewer pipe clean out. Types of ordinary, day to day stormwater management activities performed by the Township include minor repair of stormwater infrastructure, debris removal from storm sewer inlets and pipes, street sweeping, and response to storm events (both before and after).

5.2.1 *Opportunities/ Challenges: Operations and Maintenance*

The Township does not actively track stormwater operations and maintenance activities; therefore, there is no way to accurately quantify the resources used. Further, there is no systematic approach to add detail to the map of storm sewer infrastructure such as condition, material, maintenance history, or ownership that could help to inform an Infrastructure Maintenance Plan. Such a Plan, complemented by a program of storm sewer televideo investigation, would set measurable goals for system operations and maintenances, track progress towards those goals, and allow the Township to direct resources to where they are most effective.

Land Use Regulations
Upper Merion's Subdivision and Land Development Ordinance (SALDO) (Chapter §145 of Upper Merion's code) provides Design Standards for proposed land developments (Article III) and a list of Plan Requirements necessary to include in a proposal package for submittal to the Township for review (Article IV). Stormwater-related requirements in the Township's SALDO primarily focus on landscaping standards (§145.24.1). The SALDO refers applicants to the Township's design standards for stormwater management controls in the two-part Stormwater, Grading and Erosion Control Ordinance (Stormwater Ordinance) (Chapters §140A and §140B). The Zoning Ordinance (Chapter §165) provides standards for developing in the Floodplain Conservation District (Article XXXII) and impervious surface coverage caps that apply to land use in specific zoning districts.

5.2.2 *Opportunities/ Challenges: Land Use Regulations*

Upper Merion can update land use regulations to improve the municipality's stormwater conveyance and management infrastructure through the land development process. There are several key drivers for why the Township would promote management of stormwater above the typical standards included in Pennsylvania's model stormwater ordinance. These drivers include the Township's responsibility to reduce the discharge of sediment from the MS4; improvements to stormwater runoff rate controls and flood protection structures; local habitat and environmental issues; and the desire for the quality of life and economic development aspects of green developments.

Upper Merion's current land use standards include stormwater management provisions that can support water quality through the development process. However, the Township could benefit from expanding the use of Green Stormwater Infrastructure (GSI), Low Impact Development (LID), and high-performing control of runoff rates and volumes in development and redevelopment projects. Promotion of these concepts will support the pursuit of community goals for water quality compliance, environmental protection, and community development. Land use regulations available include incentives for constructing GSI, a guidebook of the Township's GSI preferences for developers, and clear policy on entering into public private partnerships.

The *Subdivision & Land Development Ordinance Revision Recommendations* and the *BMP Recommendations for New Development, Redevelopment, and Township Projects* in Appendix F provide additional detail on these opportunities and challenges.

5.3 Planning and Administration

The Township's annual budget planning process reflects current priorities. Staff prepare budget recommendations to the Supervisors to direct Township resources to support ongoing stormwater management activities (MS4 compliance, operations and maintenance, land use regulations, property owner response) and capital improvement projects to rehabilitate and upgrade infrastructure. Other stormwater program administration tasks include communication with the County Conservation District and the County Planning Commission regarding stormwater-related issues, such as erosion and sediment control, floodplain development, and Act 167 stormwater management planning.

5.3.1 *Opportunities/ Challenges: Planning and Administration*

As the Township adapts its stormwater management activities to address regulatory standards, citizen requests, and flood mitigation needs, there is an opportunity to formalize the future stormwater program. Such a comprehensive program that is supported by dedicated resources, could establish long-term community strategies for stormwater activities and invest in building partnerships to gain program efficiencies. The result could be a plan that documents the Township's stormwater program, including strategies to mitigate flood damage, achieve water quality compliance, and pursue broader community development goals.

6.0 Recommendations

6.1 Capital Improvements

As an integral component of an effective stormwater management programs, managing and maintaining existing infrastructure as well as addressing hydraulic issues, is the function of a Capital Improvements program. This study took the results of the hydrological and hydraulic analysis, and developed a matrix of projects that warrant consideration. The recommendations for specific projects were established from the Locations of Flooding Concerns list described in Section 4.0. With guidance from the Township staff, a flooding concern location was chosen as "recommended" site if any of the following qualifiers were determined to be applicable:

- The location of flooding concern was included in the EMS records maintained by the Township, with a frequency of more than once since 1999,
- The location of flooding concern was a problem area in the current hydraulic study **and** at least one other source (public poll, etc.), or
- The location of flooding concern was a problem area in the current hydraulic study and was field verified by Township Staff and/or Project Team Members.

The EMA survey was determined to be the most accurate source, as a qualifier, since the flooding was documented as actually having occurred (in some cases with a degree of frequency). Aligned with the EMA survey, the current hydraulic study was determined to be the second most accurate source since it used current information sources (for rainfall, topography, etc.) and industry standard modeling techniques. However, given that verification and calibration is ultimately needed for its accuracy; hence it is appropriate that it serve as a secondary source. The 1995 study and the public survey are used as additional sources of verification, but not as the ultimate "driver" of any of the recommendations.

As a result of this methodic qualifying process, recommendations are provided at 32 locations of significant flooding concern. A list of the recommendations and corresponding maps are provided in Appendix E. Once feedback is provided by PADEP on the Township's PRP, the sediment reduction projects included in that Plan should be incorporated into this list of recommended locations. The Township should review and annually review its stormwater management priorities and update this list of capital improvements.

6.2 Stormwater Program Enhancements

The topic papers developed as part of this study (**Appendix F**) define the Township's current stormwater program, future opportunities, and stormwater program gaps. These are summarized in Section 5. These topic papers also include recommendations for how to address these gaps and provide effective and efficient stormwater management services to members of the Upper Merion community. Over 60 recommendations were defined in the complete set of topic papers. All of these recommendations are best practices for municipal stormwater management and should be considered as having a role helping the Township meet its stormwater management goals. Table 14 presents select recommendations from these topic papers that may be most impactful, organized into four Cost Centers. These select recommendations fall into one of two categories:

1. **Critical stormwater program elements** are needed to address services that will be required in the future to mitigate flooding and to meet the minimum standards of the MS4 permit. All of the critical elements recommended in the topic papers are included in Table 14.

2. **Elective stormwater program elements** are activities and projects that the Township could choose to implement to inform decisions for directing resources for capital stormwater projects and programmatic activities.

Table 14: Select Programmatic Recommendations

Cost Center	Activity/Project	Critical Program Element
MS4 Permit Compliance	Perform annual review of each MS4 program element	✓
	Formalize communication with the Conservation District regarding responsibilities for enforcing erosion control measures during land disturbance activities.	
	Review and update list of stormwater controls in Upper Merion (both public and private) and establish inspection protocol and schedule.	✓
	Update the defined planning area of the Pollutant Reduction Plan (PRP), considering regulated outfalls, stream impairments, PennDOT responsibilities, and the extent of PADEP's legal authority.	✓
	Update the public outreach and stormwater education program to: • Define target audiences and specific educational messages. • Routinely communicate with partners and invest in partnerships with the public and organizations.	✓
	Review the Township's list of MS4-regulated outfalls and transition to mobile data collection for illicit discharge detection.	✓
	Develop standard operating procedures, written maintenance timelines, and site inspection schedules for stormwater management at municipal facilities.	✓
Operations and Maintenance	Develop an Infrastructure Maintenance Plan	✓
	Add detail to the storm sewer map	
	Perform storm sewer infrastructure conditions assessment	
Land Use Regulations	Establish a Municipal Stormwater Maintenance Fund to hold in escrow funds for the Township inspection of privately-owned stormwater controls approved as part of the land development process.	
	Apply thresholds of impervious area and/or earth disturbance to the site improvement process that trigger the appropriate degree of design detail in applications submitted to the Township for approval.	
	Update the landscaping standards that specify plantings for parking lots and stormwater features.	
	Review right of way standards to expand their ability to serve as a location for stormwater management infrastructure.	
Planning and Administration	Prepare a Green Stormwater Infrastructure (GSI) Plan (and accompanying Stormwater Design Manual) that communicates the Township's preference for managing stormwater, including: • Prioritized installation of GSI elements at specific Township facilities; • Operations and maintenance standards for the Township-owned GSI system; • Vision for integrating GSI into Township, County, and PennDOT right of way;	

Cost Center	Activity/Project	Critical Program Element
	• Preferred methods for designing, locating, installing, inspecting, and maintaining stormwater management infrastructure linked to land development regulations; • Incentives offered to private property owners to encourage investment in GSI (grants, loans, flexibility within land development regulations, etc); • Identified specific locations on private properties ideally suited for regional GSI elements; • The Township's partnership strategy to work on private properties, including access, cost sharing, and maintenance agreements.	
	Prioritize watersheds in the Township for water quality and flood mitigation projects.	
	Inspect existing stormwater controls for their ability to be retrofitted to enhance their capacity to remove additional amounts of sediment through retrofits.	
	Establish a water quality monitoring program to develop understanding of the current status of impaired waters, the actions that may be necessary to improve water quality, and the Township's options for negotiating the terms of MS4 permit compliance with regulators.	

7.0 Implementation

For purposes of organizing the findings of this study report, and developing a subsequent (and appropriate) plan of action, to implement various needed stormwater improvement related projects, programs, staffing, etc., it is offered that the study could be divided into two tracks, "Flooding" and "Programmatic". This division of study results, allows for a brief overview of next steps towards the Authority's assessment of the scope and nature of addressing the various gaps in both how the stormwater program is administered (at a water quality level) and how flooding and associated mitigation is addressed.

7.1 Flooding

In the course of this study, with all of its technical findings, and certainly within recent rainfall events of the last few months (July and August notably) there has been a demonstrated need for the Township to adopt a more aggressive program to address localized and large-scale flooding. While this study certainly identified and corroborated specific sites of concern, it is widely accepted (by staff, by our team and by the public through open house engagements) that there are even more discrete areas of flooding that warrant additional subsequent detailed review. Rainfall events appear to occur at a higher frequency and with significant increases in intensity, that will only further add to the Township's need to have a strategy in place to address flooding. At its most basic, this will include an assessment and improvement on efficiency and funding of staffing for routine drainage maintenance. Stream channels, road crossings, piped systems, all need to be free of debris and need to be of a condition that is structurally sound to convey runoff. Antiquated metal systems should be assessed for future replacement with concrete or polyethylene replacements (to extend the design life), before they collapse and cause backups. Stormwater "best management practices" or BMP's must be regularly inspected to make sure they are in full operating condition (to manage and mitigate runoff peaks and volumes). As an aside, this is equally a condition of the Township's MS4 Permit (discussed in the Programmatic portion of this report below). The Township should collaborate with departments (road, sewer, storm, etc.) to ensure that routine effort is put to monitoring all drainage facilities, but with an emphasis on those facilities that are critical in nature (where a failure to function properly could cause road or property flooding). The Township should consider an in-house assessment of stormwater staffing and resources for maintenance to ensure that adequate manpower and equipment is available to increase proactive efforts for drainage (vs. just clean up after flooding events).

Secondary to the concept of a sustainable maintenance strategy, this study demonstrated (both by calculation and by valuable feedback obtained from residents and business owners alike) that there exist drainage improvement projects and needs of all magnitudes. The projected overall cost of addressing just the identified projects is $ 15M. This implies that like maintenance, a strategy is needed to ensure that projects are undertaken in a thoughtful, deliberate manner that yields a return on the investment (through decreased repetitive property damage, lower staffing resources needed to monitor and maintain facility, etc.). Part of this strategy has been initiated with the scoring systems used (both Preliminary by our team and "weighted" by Authority staff).

7.2 Stormwater Program

7.2.1 *Continue current services*

The Township should maintain its investment in continued operations and maintenance of the stormwater conveyance network, MS4 permit compliance, and responsiveness to citizens. The Township could initiate detailed tracking of staff time spent on these ongoing stormwater-related services, materials used to repair stormwater infrastructure, and the time equipment is used to clear grates and clean up after storms. With detailed documentation of costs, the Township will have a clearer picture of current services and a system to track progress of the stormwater management program.

7.2.2 *Define Future Stormwater Program*

It is likely that water quality mandates and the demand for the Township to provide stormwater services will increase. Therefore, the Township should expect to add stormwater management services to its current program over the next three to five years to adapt to these growing demands. Township leadership should prioritize the list of services and projects presented in Section 6.2 of this Plan. A clear and complete understanding of the preferred stormwater program of services, including understanding the revenue and cash flow requirements, is critical to a proactive stormwater management strategy. Timelines and responsible parties should be linked to each stormwater service or project so that the cost of the service can be tracked against measurable goals (i.e. inlets repaired annually, pipes inspected, miles of street sweeping). Once this future program is defined, the Township can complete a business model for long-term operation of the stormwater program that addresses roles, responsibilities, policy, and funding.

7.2.3 *Engage Stakeholders*

To inform the process of defining a future stormwater program and confirm Township decisions, the Township should establish a process to engage the community. Targeted outreach increases public awareness of the challenges the Township faces in delivery of stormwater services to address flooding, water quality and infrastructure needs. A consistent, easily understandable message to the public about the process, purpose, and policies impacting the Township creates the transparency that is critical during the process of making adjustments to the level of service in stormwater management.

This engagement could occur through establishment of a stakeholder advisory committee that meet periodically to recommend stormwater management strategies to Township leadership; or a series of public meetings or townhall events.

7.3 Funding

Understanding that the current revenue allocations do not permit a full or even partial expenditure of the $ 15M cost of the identified capital projects, a new or revised strategy is needed to address long term funding needs for flooding mitigation projects. Further, the Township has not yet calculated the cost of its existing stormwater program; nor has the Township defined the level of service or cost of its preferred future stormwater program. It is recommended that the Authority use this study as a platform and basis to engage the Township in that discussion, considering all possibilities such as public private partnerships (where mutual goals of flooding mitigation exist), traditional financing (bonds, tax revenues, etc.) or utility structured fees for stormwater funding (as a rate based on degree of imperviousness of property).

Appendix A – Public Survey Results

Appendix A
Upper Merion Township
Stormwater Survey Results

Reference Number	How concerned are you about flooding problems in Upper Merion?	Compared to 10 years ago, do you think that our local streams, ponds, and the Schuylkill River flood more often, less often, or about the same?	Has flooding personally affected your home or business in Upper Merion in the past five years?	Please provide the address at which you were affected.	Has flooding personally affected the home or business of someone you know in Upper Merion in the past five years?	Please provide the address where those you know were affected.	Over the past five years, have you experienced roadway flooding in Upper Merion?	Please provide the street or intersection you experienced roadway flooding.	Other comments on flooding in Upper Merion?	Optional - Please provide your name, address, phone, and email so we can contact you for additional information.
1	Very concerned	About the same	Yes, minor impact		Yes, minor impact		Yes, minor impact	Croton road Abrams Road by the train yard		
2	Somewhat concerned	About the same	Yes, major impact	243 Crest Way, King of Prussia, 19406	Yes, major impact	265 Swedeland Road, King of Prussia, 19406	Yes, major impact	Balligomingo Road and Trinity Lane intersection	Flooding at this intersection occurs because excess water from I-76 flows from overpass onto roadway below. Trinity is graded poorly; water pools so road becomes dangerously flooded. Trinity Lane/Holstein-hilly with no drainage. Holstein	Diane Reilly, 243 Crest Way, KOP; 610-828-4323; dianereilly@gmail.com
3	Very concerned	More frequent flooding	No		Yes, major impact	655 Caley Road, King of Prussia PA 19406, and the two houses across the street from that house: owned by Mr. Sirchio and Mr. Luciano	Yes, minor impact	Crossfield and Prince Frederick area, River Road, low area of Caley Road (just to the left of Caley Road School	I await the new Stormwater Study with great interest. Re: Caley - I trust that the new stormwater improvements being made - the retention basin etc. - will result in improved conditions for the adjacent and nearby residents.	Carole Kenney, 114 Cinnamon Hill Road, 610.812.9983
4	Not very concerned	About the same	No		No		Yes, minor impact	Croton Road near Roberts Elementary		
5	Somewhat concerned	More frequent flooding	No		Yes, minor impact		Yes, minor impact	Croton Road, Valley Forge Road, Crooked Lane		
6	Not very concerned	More frequent flooding	No		Don't Know		Yes, minor impact	River Road, East Church Road, South Gulph Rd by Bill Smith Blvd under train tracks		
7	Somewhat concerned	About the same	No		No		No			
8	Somewhat concerned	Less frequent flooding	No		No		Yes, minor impact			micosfol@yahoo.com
9	Not very concerned	About the same	Yes, minor impact	247 Foulkrod Blvd, King of Prussia, PA 19406	Yes, minor impact	247 Foulkrod Blvd, King of Prussia, PA 19406	No		Crooked and Church road often collects a large amount of water spewing rocks/pebbles on the roadway	
10	Not very concerned	Don't Know	No		No		Yes, minor impact	Beidler Road, near railroad tracks.		
11	Very concerned	About the same	Yes, minor impact	315 Crossfield Road, King of Prussia, PA 19406	Yes, major impact	Crossfield Road -- several homes	Yes, major impact	Crossfield Road and Signal Hill Road, King of Prussia, PA 19406	The stream behind Candlebook School and Crossfield Road overflows in heavy rain. The township does not come and clean out the area and it is so overgrown with weeds and bushes, that the water can not flow freely. The street also floods in heavy rain.	Barbara Engle, 315 Crossfield Road, King of Prussia, PA 19406 (610) 265-5798
12	Somewhat concerned	About the same	No		No		Don't Know			
13	Somewhat concerned	More frequent flooding	Yes, minor impact	435 Crossfield Road	Yes, minor impact	435 Crossfield Road	Yes, minor impact	Stonybrook & Prince Frederick, especially if leaves block storm drain		Frederick P. Remelius, UMASD, 435 Crossfield Road, KOP, 19406, 610-205-6411
14	Not very concerned	About the same	No		No		No			
15	Somewhat concerned	About the same	Yes, minor impact	610 Essex Cir, King of Prussia, PA 19406	Don't Know		Yes, minor impact	Abrams Rd, raod/ creek near train switching yard	Wegmans parking lot. Stormdrain at chelsea and Essex does not drain and frequently has standing water	Darren DeFrancesco, 610 Essex Cir, King of Prussia, PA 19406
16	Very concerned	More frequent flooding	Yes, major impact	432 Abrams Mil Road, King of Prussia PA 19406	Don't Know		Don't Know			maryannpascucci@comcast.net
17	Not very concerned	About the same	No		No		No			
18	Somewhat concerned	About the same	No		No		Yes, minor impact	Croton Road in front of Roberts elementary		katevaccaro@yahoo.com
19	Not very concerned	About the same	No		No		Yes, minor impact			
20	Not at all concerned	About the same	No		No		No		Have not noticed any problem areas in my travels around UM.	Bruce Herpich, 548 W Beidler Road, King of Prussia 610-354-9555

Appendix A
Upper Merion Township
Stormwater Survey Results

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21	Very concerned	More frequent flooding	No		Yes, major impact	CROSSFIELD RD	Yes, major impact	Old Fort and Country Ln		
22	Somewhat concerned	Less frequent flooding	No		No		Yes, major impact	River road		
23	Somewhat concerned	More frequent flooding	No		No		Yes, minor impact	Church Road near intersection with Crooked Lane, Flinthill Road near Gateway Cafe at the bottom of the hill.		
24	Somewhat concerned	About the same	No		No		Yes, minor impact			
25	Don't Know	Don't Know	Don't Know		Don't Know		Don't Know			aconlan@umtownship.org -- test submission
26	Somewhat concerned	More frequent flooding	No		Yes, major impact	Mastrocola Trucking, Yerkes Road.	Yes, minor impact	Croton Road near Roberts Elementary	Existing stormwater inlets need to be cleaned and maintained on a regular basis	Brian Sakal, 724 Ticonderoga Drive, King of Prussia, Pa. 19406 610-908-2527
27	Somewhat concerned	About the same	No		Don't Know		Yes, minor impact	Flint Hill Road, River Road, Crooked Lane		
28	Not very concerned	More frequent flooding	No		No		Yes, minor impact	Don't remember.	I see too many residents directing their stormwater to impervious surfaces which are leading causes of stormwater issues. We should be encouraging residents to divert stormwater away from their homes while keeping it as local as possible.	Chris Kaasmann 565 Hansen Rd. King of Prussia, PA 19406
29	Very concerned	About the same	Yes, minor impact	721 Washington St Bridgeport, Pa 19405	Yes, minor impact		Yes, major impact		The are very few storm drain in the lower end of Swedeburg	Daniel Armenti, 721 Washington St, Bridgeport PA 19406, 484-467-4260
30	Not very concerned	About the same	No		No		No			
31	Very concerned	Don't Know	No		Don't Know		Yes, minor impact	South Gulph @ Home Depot		
32	Somewhat concerned	More frequent flooding	Yes, major impact	Crestwyck Drive properties which border Valley Forge Church of Christ, 590 W. Valley Forge Rd., & Manor Care Health Services, 600 W. Valley Forge Rd.	Yes, major impact		Yes, major impact	General Scott Road & Valleywyck, W. Valley Forge Road at the S crves in front of the Community Center	Storm water management is an after thought with all of the new building in the township.	
33	Very concerned	About the same	Yes, minor impact	633 Bob white rd Wayne pa	Yes, minor impact	Property next to Bob white park	Yes, minor impact	Croton by Roberts school, Bob white park entrance		Jbates7294@aol.com
34	Very concerned	More frequent flooding	Yes, major impact	840 Tannery Drive, Wayne PA 19087	Don't Know		Yes, minor impact	Road in front of Roberts Elementary		Jon Hickey, 840 Tannery Drive, Wayne PA 19087, 302-540-5304
35	Not very concerned	About the same	No		No		No			
36	Not very concerned	Don't Know	No		No		No		our sttreets do have debris and leafs that are always clogging the sewers	Carol Ryan 705 W Valley Forge Road King of Prussia PA 19406 610 337 0517 wandadog@comcast.net
37	Somewhat concerned	Less frequent flooding	No		No		Yes, minor impact			
38	Somewhat concerned	Don't Know	Don't Know		Don't Know		Yes, minor impact	Valley Forge Road & Beidler Road, Valley Forge Road & Mancill Mill Road		
39	Very concerned	More frequent flooding	Yes, major impact	1091 Jones Rd Gulph Mills PA 19428	Yes, major impact	370 Balligomingo Rd Gulph Mills, PA 19428	Yes, major impact	Trinity Road & Balligomingo Road intersection	Too many to detail here. Please contact me for additional comments, and suggestions to mitigate, if Township has any interest in solutions. Thank You	Mark McKee, 1091 Jones Road, Gulph Mills, PA 19428. 610-834-0187
40	Somewhat concerned	Don't Know	No		No		No			

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Upper Merion Township
Stormwater Survey Results

Reference Number	How concerned are you about flooding problems in Upper Merion?	Compared to 10 years ago, do you think that our local streams, ponds, and the Schuylkill River flood more often, less often, or about the same?	Has flooding personally affected your home or business in Upper Merion in the past five years?	Please provide the address at which you were affected.	Has flooding personally affected the home or business of someone you know in Upper Merion in the past five years?	Please provide the address where those you know were affected.	Over the past five years, have you experienced roadway flooding in Upper Merion?	Please provide the street or intersection you experienced roadway flooding.	Other comments on flooding in Upper Merion?	Optional - Please provide your name, address, phone, and email so we can contact you for additional information.
41	Somewhat concerned	More frequent flooding	Yes, minor impact	171 Rebel Hill Road, Conshohocken, PA 19428	Yes, minor impact	171 Rebel Hill Road, Conshohocken, PA 19428	Yes, minor impact	S. Gulph Road and Rebel Hill Rd.		
42	Not very concerned	Less frequent flooding	No		No		No			
43	Somewhat concerned	About the same	No		Yes, minor impact	705 S. Gulph Road	Don't Know			
44	Somewhat concerned	More frequent flooding	No		Yes, minor impact		Yes, minor impact			
45	Somewhat concerned	About the same	No		No		Don't Know		About 10 years ago., we had a sump pump and associated piping installed in our basement. Since then, , no problems.	Jack Faude, 222 Fox Run Rd, King of Prussia, PA 19406, 610-265-7753, jhfaude@hotmail.com
46	Somewhat concerned	About the same	No		No		Yes, minor impact	Croton Road at the McKaig Creek by Roberts School		Vytas Masalaitis 665 Fletcher Wayne 484 580-9494
47	Somewhat concerned	Don't Know	No		Don't Know		Yes, minor impact	Croton Road at Roberts Elementary School at McKaig Creek		1005 WInsome COurt Wayne PA 19087 pattyclerkin@gmail.com
48	Not very concerned	Don't Know	No		No		Yes, minor impact	Prince Frederick Street over the creek (near the intersection of Prince Frederick and Crossfield)		
49	Not very concerned	About the same	No		No		No			Todd McKee, 619 W Valley Forge Rd., King of Prussia, PA 19406, johntodd619@yahoo.com
50	Somewhat concerned	About the same	Yes, minor impact	441 w church rd, king of prussia, pa 19406	Yes, minor impact	Neighbors	Yes, minor impact	S Gulph rd and chruch	Just that we live downstream from the homes on hilltop. Maybe some drainage between our homes would help?	Brian Avila 441 w church rd king of prussia pa 19406 2159063893 briavila963@gmail.com
51	Not very concerned	Less frequent flooding	No		No		Yes, minor impact	N Gulph rd btwn Mall and Warner. This was prior to the intersection modifications		Dave Camarda 555 Elliott Dr 610-265-0319
52	Very concerned	Don't Know	No		No		Yes, major impact	Balligomingo Road & Trinity Road Intersection- Car was totaled in flooded street 10/29/17		Matt Point, 241 Holly Drive, King of Prussia, PA 19406, 717-778-7939, mattpoint01@gmail.com
53	Not at all concerned	Less frequent flooding	No		No		No		I have taken care of the water retention issues in my back yard at my own expense. I am not aware of any kind of flooding elsewhere in the township. I am here all day everyday because I work from Home. I am out and about the township frequently.	Liz Abdill 266 Pleasant Valley Rd 19406 610-996-9208
54	Somewhat concerned	More frequent flooding	No		Yes, minor impact		Yes, minor impact	storm water drains are blocked often	I think you need to be more diligent with new construction in town and make sure resident properties are not affected by such construction	
55	Somewhat concerned	Don't Know	Yes, minor impact	214 Ross Road King of Prussia PA 19406	Don't Know		No			
56	Not at all concerned	About the same	No		No		Yes, minor impact	Valley Forge Rd @ Crow Creek		
57	Somewhat concerned	About the same	No		No		No			
58	Somewhat concerned	Don't Know	No		Don't Know		Yes, minor impact	intersection School Line Drive and Crooked Lane (near Pine Tree Rd), and on School Line Drive	the water run-off freezes in the winter and causes very slippery conditions at a hilly section and many cars get stuck	Margaret Lynch, 725 School Line Drive, King of Prussia (mkr.lynch@gmail.com)
59	Somewhat concerned	About the same	No		No		Yes, minor impact	River Road Between Third Street and Swedeland Road.		
60	Somewhat concerned	Less frequent flooding	No		No		Yes, minor impact	Prince Frederick St and Crossfield Road		

Appendix A
Upper Merion Township
Stormwater Survey Results

Reference Number	How concerned are you about flooding problems in Upper Merion?	Compared to 10 years ago, do you think that our local streams, ponds, and the Schuylkill River flood more often, less often, or about the same?	Has flooding personally affected your home or business in Upper Merion in the past five years?	Please provide the address at which you were affected.	Has flooding personally affected the home or business of someone you know in Upper Merion in the past five years?	Please provide the address where those you know were affected.	Over the past five years, have you experienced roadway flooding in Upper Merion?	Please provide the street or intersection you experienced roadway flooding.	Other comments on flooding in Upper Merion?	Optional - Please provide your name, address, phone, and email so we can contact you for additional information.
61	Somewhat concerned	More frequent flooding	No		No		Don't Know			
62	Very concerned	Less frequent flooding	Yes, major impact	365 thomas dr	No		No		38 years living in same house 2016 fema placed my home in 100 year flood plan, thank upper merion	bob brennan 365 thomas dr king of prussia brennan365@verizon.net
63	Very concerned	More frequent flooding	Yes, minor impact	704 caley rd , king of prussia, pa 19406	Yes, minor impact	655 caley rd , kinf of prussia, pa 19406	Yes, minor impact	caley rd and sweetbriar rd, king of prussia, pa 19406hopefu	hopefully this is being adressed by the new caley rd school being built with new storm drain system	stephen sirchio, 704 caley rd , king of prussia, pa 19406
64	Very concerned	More frequent flooding	Yes, minor impact	704 caley rd, king of prussia,pa,19406	Yes, minor impact	655 caley rd, king of prussia,pa,19406	Yes, minor impact	caley rd and sweetbriar rd, king of prussia,19406	hopefully this is being addressed with the new caley rd school being built and drainage system.	stephen sirchio, 704 caley rd, king of prussia,pa. 19406
65	Very concerned	More frequent flooding	Yes, major impact	655 CALEY rOAD	Yes, major impact	704 Caley Road , 380 Sweetbriar Road	Yes, major impact	Caley Road and Regimental Road	THE STORM DRAIN LOCATED ON CALEY ROAD, IN FRONT OF MY HOUSE AT 655 CALEY COAD	Elizabeth S. Rigg 655 Caley Road, King of Prussia. PA 19406 610-265-1184
66	Somewhat concerned	About the same	Yes, minor impact		Yes, major impact		Yes, minor impact			

Appendix B – EMA Event Summary

Appendix B
Upper Merion Township
Emergency Management Staff Survey

Stream Flooding

River Flooding Information

Ref. #	Location	From	To	16 Sep 1999 - Floyd	1-Aug-04	28 Sep 04 - Jean	14-Jan-05	28-Mar-05	2-Apr-05	08-Jul-05 - Cindy	8-Oct-05	28-Jun-06	25-Aug-06	15-Apr-07	11-Jul-07	2-Aug-09	22-Aug-09	25-Jan-10	1-Oct-10	27-Aug-11 - Irene	16-May-12	29-Jun-12	20-Jul-12	26 Oct 12 - Sandy	10-Jun-13	8-Aug-13	5-Feb-14	30-Apr-14	Score
			Norristown Flood Gauge	22.00		15.37			16.06		17.92	19.13							18.30	19.76								20.83	
1	Abrams Rd.	West Beidler Rd.	Henderson Rd.	1	1	1			1											1						1	1	1	8
2	Allendale Road	Court Blvd.	Wills Blvd.									1								1									2
3	Allendale Road	Keebler Road	Crossfield Rd									1																	1
4	Balligomingo Rd.	Trinity La.	I-76 Off-ramp	1	1	1		1	1									1	1	1						1			9
5	Balligomingo Rd.	at	Jones																1										1
6	Brandywine Lane	DeKalb	Hillview																1										1
7	Caley Road	Regimental																	1										1
8	Church Road	Brandenberg Way.	Yerkes Rd.									1							1										2
9	Croton Rd.	Alderbrook Dr.	Sharon Dr.	1	1	1	1		1	1	1			1	1		1	1		1						1				13
10	Croton Rd.	Kathwood Rd,	South Warner Rd.															1												1
11	DeKalb Pike	at	Saulin																1										1
12	East Valley Forge Rd.	Lower East Valley Forge Rd.	Schuykill Parkway	1		1																							2
13	First Ave.	Park Ave.	Allendale Rd.	1		1																							2
14	First Ave.	Clark	American Ave.																1										1
15	Flint Hill Rd.	Summit St.	Swedeland Rd	1		1			1										1										4
16	Guthrie Rd.	West Dekalb Pk.	North Gulph Rd.	1		1			1																				3
17	Henderson Road	Hansen Access Road	Queens Drive									1																	1
18	Keebler Road	at	Anthony																1										1
19	Keebler Road	at	Middle School																1										1
20	Keebler Road	at	General Knox																1										1
21	King Manor	Crooked	Dead End																1	1									2
22	Mall Blvd	Court Blvd.	DeKalb Pike															1											1
23	Mall Blvd	at	Pulaski																1										1
24	Matson Ford Road	South Gulph Rd.	County Line												1														1
25	North Gulph Rd.	Mall Blvd.	North Warner Rd.															1	1	1					1				4
26	North Gulph Rd.	Richards Rd.	First Ave.	1														1	1		1	0.5			1				5.5
27	River Rd.	Center St.	4th St.	1							1								1						1		1		5
28	River Rd.	Third St.	Swedeland Rd	1		1													1										3
29	River Rd.	Swedeland Rd.	West Conshy Line	1		1					1							1	1				1				1		7
30	South County Line Rd.	Meadowcroft Rd.	Gulph Creek Rd.	1																									1
31	South Gulph Road	West Church Rd.	Brooks Rd.	1																									1
32	South Gulph Road	Bill Smith Blvd.	Long Rd.	1																									1
33	South Gulph Road	Arden Rd.	Upper Gulph Rd.	1		1			1									1		1									5
34	Trinity Lane	South Gulph Rd.	Holstein Rd.	1	1	1		1	1									1	1	1			1		1				10
35	William Rd.	Walker Park	Park La.	1		1													1										3
36	Yerkes Rd.	Church Rd.	Crooked La.	1															1										2
			Total	18	4	12	1	2	7	1	1	2	4	1	1	1	1	1	8	24	5	1	0.5	2	1	6	1	3	109

Record Hurricane Agnes -- 1972: 25.10

Storm Intensity Data

	Rain Period (hours)				
Year-Storm	24	12	6	3	1
100	8.25	6.25	6	4.5	3
50	7.5	6	4.5	4	2.8
25	6.2	6	4.5	3.5	2.5
10	5.5	4.5	4		2.2
1	4	2.5	2	1.6	1.3

Rain Accumulation (inches)

Appendix C-1 – CN Calculations

Gannett Fleming

Upper Merion Township
Montgomery County, PA
RCN Composite Summary

Project: Upper Merion Township Stormwater Master Plan

By: YW Date: 5/5/2017

Location: Crow Creek Subwatershed 520

Checked: AKS Date: 5/24/2017

Drainage Area = 234.5 acres = 0.37 mi^2

Hydrologic Soil Group	Land Cover Description	Curve Number	Area (acres)	% of Area	CN x Area
B	11. Open Water	98	0.39	0.16%	38
B	21. Developed, Open Space	61	2.37	1.01%	144
B	22. Developed, Low Intensity	75	0.97	0.41%	73
B	23. Developed, Medium Intensity	85	0.51	0.22%	43
B	24. Developed, High Intensity	92	0.00	0.00%	0
B	41. Deciduous Forest	55	26.60	11.34%	1,463
B	52. Shrub/Scrub	48	3.11	1.33%	149
B	82. Cultivated Crops	75	5.11	2.18%	383
B	90. Woody Wetlands	98	10.08	4.30%	988
B	95. Emergent Herbaceous Wetlands	98	2.00	0.85%	196
D	11. Open Water	98	1.59	0.68%	156
D	21. Developed, Open Space	80	38.23	16.30%	3,058
D	22. Developed, Low Intensity	87	77.44	33.02%	6,737
D	23. Developed, Medium Intensity	92	30.72	13.10%	2,827
D	24. Developed, High Intensity	95	17.42	7.43%	1,655
D	41. Deciduous Forest	77	13.57	5.79%	1,045
D	82. Cultivated Crops	85	0.00	0.00%	0
D	90. Woody Wetlands	98	4.39	1.87%	430
D	95. Emergent Herbaceous Wetlands	98	0.03	0.01%	3
	Totals		234.52	100.0%	19,388
	Weighted CN =		**82.7**		

Gannett Fleming

Upper Merion Township
Montgomery County, PA
RCN Composite Summary

Project: Upper Merion Township Stormwater Master Plan

By: YW Date: 5/5/2017

Location: Crow Creek Subwatershed 540

Checked: AKS Date: 5/24/2017

Drainage Area = 281.3 acres = 0.44 mi^2

Hydrologic Soil Group	Land Cover Description	Curve Number	Area (acres)	% of Area	CN x Area
B	21. Developed, Open Space	61	5.17	1.84%	315
B	22. Developed, Low Intensity	75	1.00	0.36%	75
B	23. Developed, Medium Intensity	85	0.33	0.12%	28
B	24. Developed, High Intensity	92	0.00	0.00%	0
B	41. Deciduous Forest	55	10.88	3.87%	599
D	21. Developed, Open Space	80	77.14	27.42%	6,171
D	22. Developed, Low Intensity	87	141.09	50.15%	12,275
D	23. Developed, Medium Intensity	92	18.37	6.53%	1,690
D	24. Developed, High Intensity	95	1.33	0.47%	127
D	41. Deciduous Forest	77	26.03	9.25%	2,004
	Totals		281.35	100.0%	23,284

Weighted CN = 82.8

Gannett Fleming

Upper Merion Township
Montgomery County, PA
RCN Composite Summary

Project: Upper Merion Township Stormwater Master Plan

By: YW Date: 5/5/2017

Location: Crow Creek Subwatershed 560

Checked: AKS Date: 5/24/2017

Drainage Area = 206.6 acres = 0.32 mi^2

Hydrologic Soil Group	Land Cover Description	Curve Number	Area (acres)	% of Area	CN x Area
B	21. Developed, Open Space	61	0.43	0.21%	26
B	22. Developed, Low Intensity	75	0.33	0.16%	25
B	23. Developed, Medium Intensity	85	0.14	0.07%	12
B	41. Deciduous Forest	55	2.86	1.39%	157
D	21. Developed, Open Space	80	64.19	31.06%	5,135
D	22. Developed, Low Intensity	87	103.19	49.94%	8,978
D	23. Developed, Medium Intensity	92	20.00	9.68%	1,840
D	24. Developed, High Intensity	95	7.12	3.44%	676
D	41. Deciduous Forest	77	7.07	3.42%	544
D	43. Mixed Forest	77	1.33	0.65%	103
	Totals		206.66	100.0%	17,496

Weighted CN = 84.7

Gannett Fleming

Upper Merion Township
Montgomery County, PA
RCN Composite Summary

Project: Upper Merion Township Stormwater Master Plan

By: YW Date: 5/5/2017

Location: Crow Creek Subwatershed 570

Checked: AKS Date: 5/24/2017

Drainage Area = 201.9 acres = 0.32 mi^2

Hydrologic Soil Group	Land Cover Description	Curve Number	Area (acres)	% of Area	CN x Area
B	21. Developed, Open Space	61	2.36	1.17%	144
B	22. Developed, Low Intensity	75	0.76	0.38%	57
B	23. Developed, Medium Intensity	85	0.56	0.28%	48
C	21. Developed, Open Space	74	4.03	2.00%	298
C	22. Developed, Low Intensity	83	0.81	0.40%	68
C	23. Developed, Medium Intensity	90	0.57	0.28%	51
D	21. Developed, Open Space	80	46.35	22.96%	3,708
D	22. Developed, Low Intensity	87	107.44	53.22%	9,347
D	23. Developed, Medium Intensity	92	30.20	14.96%	2,778
D	24. Developed, High Intensity	95	8.32	4.12%	790
D	41. Deciduous Forest	77	0.50	0.25%	38
	Totals		201.89	100.0%	17,327

Weighted CN = 85.8

Gannett Fleming

Upper Merion Township
Montgomery County, PA
RCN Composite Summary

Project: Upper Merion Township Stormwater Master Plan

By: YW Date: 5/5/2017

Location: Crow Creek Subwatershed 640

Checked: AKS Date: 5/24/2017

Drainage Area = 147.9 acres = 0.23 mi^2

Hydrologic Soil Group	Land Cover Description	Curve Number	Area (acres)	% of Area	CN x Area
B	21. Developed, Open Space	61	1.58	1.07%	96
B	22. Developed, Low Intensity	75	0.14	0.10%	11
B	23. Developed, Medium Intensity	85	0.02	0.01%	2
D	21. Developed, Open Space	80	42.31	28.62%	3,385
D	22. Developed, Low Intensity	87	70.25	47.50%	6,111
D	23. Developed, Medium Intensity	92	18.71	12.65%	1,721
D	24. Developed, High Intensity	95	5.06	3.42%	481
D	41. Deciduous Forest	77	9.81	6.63%	755
	Totals		147.88	100.0%	12,562

Weighted CN = 85.0

Gannett Fleming

Upper Merion Township
Montgomery County, PA
RCN Composite Summary

Project: Upper Merion Township Stormwater Master Plan

By: YW Date: 5/5/2017

Location: Crow Creek Subwatershed 670

Checked: AKS Date: 5/24/2017

Drainage Area = 652.8 acres = 1.02 mi^2

Hydrologic Soil Group	Land Cover Description	Curve Number	Area (acres)	% of Area	CN x Area
B	21. Developed, Open Space	61	9.76	1.49%	595
B	22. Developed, Low Intensity	75	1.25	0.19%	93
B	23. Developed, Medium Intensity	85	0.14	0.02%	12
B	41. Deciduous Forest	55	2.07	0.32%	114
B	52. Shrub/Scrub	48	0.62	0.10%	30
C	21. Developed, Open Space	74	13.07	2.00%	967
C	22. Developed, Low Intensity	83	4.61	0.71%	382
C	23. Developed, Medium Intensity	90	1.20	0.18%	108
C	24. Developed, High Intensity	94	0.04	0.01%	4
C	41. Deciduous Forest	70	4.83	0.74%	338
C	43. Mixed Forest	70	1.07	0.16%	75
C	52. Shrub/Scrub	65	0.38	0.06%	25
D	21. Developed, Open Space	80	71.21	10.91%	5,697
D	22. Developed, Low Intensity	87	118.95	18.22%	10,349
D	23. Developed, Medium Intensity	92	174.25	26.69%	16,031
D	24. Developed, High Intensity	95	241.42	36.98%	22,935
D	41. Deciduous Forest	77	5.75	0.88%	443
D	43. Mixed Forest	77	0.30	0.05%	23
D	52. Shrub/Scrub	73	1.94	0.30%	141
	Totals		652.84	100.0%	58,361

Weighted CN = 89.4

Gannett Fleming

Upper Merion Township
Montgomery County, PA
RCN Composite Summary

Project: Upper Merion Township Stormwater Master Plan

By: YW Date: 5/5/2017

Location: Crow Creek Subwatershed 680

Checked: AKS Date: 5/24/2017

Drainage Area = 548.3 acres = 0.86 mi^2

Hydrologic Soil Group	Land Cover Description	Curve Number	Area (acres)	% of Area	CN x Area
B	21. Developed, Open Space	61	17.96	3.28%	1,095
B	22. Developed, Low Intensity	75	7.25	1.32%	544
B	23. Developed, Medium Intensity	85	2.76	0.50%	234
B	24. Developed, High Intensity	92	0.06	0.01%	6
B	41. Deciduous Forest	55	7.36	1.34%	405
B	52. Shrub/Scrub	48	4.94	0.90%	237
B	81. Pasture/Hay	61	9.08	1.66%	554
C	21. Developed, Open Space	74	35.57	6.49%	2,632
C	22. Developed, Low Intensity	83	6.52	1.19%	541
C	23. Developed, Medium Intensity	90	2.31	0.42%	208
C	41. Deciduous Forest	70	2.45	0.45%	172
C	52. Shrub/Scrub	65	2.33	0.43%	152
C	81. Pasture/Hay	74	19.05	3.47%	1,410
D	21. Developed, Open Space	80	88.29	16.10%	7,063
D	22. Developed, Low Intensity	87	166.61	30.39%	14,495
D	23. Developed, Medium Intensity	92	104.90	19.13%	9,651
D	24. Developed, High Intensity	95	50.46	9.20%	4,794
D	41. Deciduous Forest	77	7.24	1.32%	557
D	52. Shrub/Scrub	73	0.17	0.03%	12
D	81. Pasture/Hay	80	13.01	2.37%	1,041
	Totals		548.34	100.0%	45,804

Weighted CN = 83.5

Gannett Fleming

Upper Merion Township
Montgomery County, PA
RCN Composite Summary

Project: Upper Merion Township Stormwater Master Plan

By: YW Date: 5/5/2017

Location: Crow Creek Subwatershed 880

Checked: AKS Date: 5/24/2017

Drainage Area = 499.0 acres = 0.78 mi^2

Hydrologic Soil Group	Land Cover Description	Curve Number	Area (acres)	% of Area	CN x Area
B	21. Developed, Open Space	61	55.58	11.14%	3,390
B	22. Developed, Low Intensity	75	14.56	2.92%	1,092
B	23. Developed, Medium Intensity	85	2.13	0.43%	181
B	24. Developed, High Intensity	92	0.14	0.03%	13
B	41. Deciduous Forest	55	118.33	23.71%	6,508
B	42. Evergreen Forest	55	2.38	0.48%	131
B	43. Mixed Forest	55	4.61	0.92%	254
B	52. Shrub/Scrub	48	1.29	0.26%	62
C	21. Developed, Open Space	74	25.16	5.04%	1,862
C	22. Developed, Low Intensity	83	14.98	3.00%	1,244
C	23. Developed, Medium Intensity	90	1.31	0.26%	118
C	24. Developed, High Intensity	94	0.40	0.08%	37
C	41. Deciduous Forest	70	13.80	2.77%	966
C	42. Evergreen Forest	70	0.06	0.01%	4
C	43. Mixed Forest	70	0.44	0.09%	31
D	21. Developed, Open Space	80	142.95	28.65%	11,436
D	22. Developed, Low Intensity	87	29.04	5.82%	2,526
D	23. Developed, Medium Intensity	92	5.68	1.14%	522
D	24. Developed, High Intensity	95	0.43	0.09%	41
D	41. Deciduous Forest	77	56.29	11.28%	4,334
D	43. Mixed Forest	77	2.45	0.49%	188
D	52. Shrub/Scrub	73	7.00	1.40%	511
	Totals		499.00	100.0%	35,451

Weighted CN = 71.0

Gannett Fleming

Upper Merion Township
Montgomery County, PA
RCN Composite Summary

Project: Upper Merion Township Stormwater Master Plan

By: YW Date: 5/5/2017

Location: Crow Creek Subwatershed 900

Checked: AKS Date: 5/24/2017

Drainage Area = 476.9 acres = 0.75 mi^2

Hydrologic Soil Group	Land Cover Description	Curve Number	Area (acres)	% of Area	CN x Area
B	21. Developed, Open Space	61	52.20	10.95%	3,184
B	22. Developed, Low Intensity	75	0.93	0.20%	70
B	41. Deciduous Forest	55	125.68	26.35%	6,912
B	42. Evergreen Forest	55	0.22	0.05%	12
B	43. Mixed Forest	55	0.78	0.16%	43
B	52. Shrub/Scrub	48	0.02	0.00%	1
C	21. Developed, Open Space	74	39.91	8.37%	2,953
C	22. Developed, Low Intensity	83	2.28	0.48%	189
C	23. Developed, Medium Intensity	90	0.22	0.05%	20
C	41. Deciduous Forest	70	20.64	4.33%	1,445
C	42. Evergreen Forest	70	2.08	0.44%	146
C	43. Mixed Forest	70	1.33	0.28%	93
C	52. Shrub/Scrub	65	3.48	0.73%	226
D	21. Developed, Open Space	80	117.76	24.69%	9,421
D	22. Developed, Low Intensity	87	29.07	6.09%	2,529
D	23. Developed, Medium Intensity	92	2.76	0.58%	254
D	24. Developed, High Intensity	95	1.70	0.36%	162
D	41. Deciduous Forest	77	64.48	13.52%	4,965
D	42. Evergreen Forest	77	0.37	0.08%	28
D	43. Mixed Forest	77	1.26	0.26%	97
D	52. Shrub/Scrub	73	9.75	2.04%	712
	Totals		476.92	100.0%	33,462

Weighted CN = 70.2

Gannett Fleming

Upper Merion Township
Montgomery County, PA
RCN Composite Summary

Project: Upper Merion Township Stormwater Master Plan

By: YW Date: 5/5/2017

Location: Crow Creek Subwatershed 970

Checked: AKS Date: 5/24/2017

Drainage Area = 242.2 acres = 0.38 mi^2

Hydrologic Soil Group	Land Cover Description	Curve Number	Area (acres)	% of Area	CN x Area
B	21. Developed, Open Space	61	3.92	1.62%	239
B	22. Developed, Low Intensity	75	0.40	0.17%	30
B	23. Developed, Medium Intensity	85	0.17	0.07%	15
B	41. Deciduous Forest	55	17.49	7.22%	962
B	52. Shrub/Scrub	48	1.62	0.67%	78
C	21. Developed, Open Space	74	3.02	1.25%	223
C	22. Developed, Low Intensity	83	0.17	0.07%	14
C	41. Deciduous Forest	70	0.05	0.02%	3
C	52. Shrub/Scrub	65	1.18	0.49%	77
D	21. Developed, Open Space	80	80.36	33.18%	6,429
D	22. Developed, Low Intensity	87	11.15	4.60%	970
D	23. Developed, Medium Intensity	92	0.98	0.41%	91
D	41. Deciduous Forest	77	115.70	47.76%	8,909
D	43. Mixed Forest	77	1.55	0.64%	119
D	52. Shrub/Scrub	73	4.47	1.84%	326
	Totals		242.23	100.0%	18,485

Weighted CN = 76.3

Gannett Fleming

Upper Merion Township
Montgomery County, PA
RCN Composite Summary

Project: Upper Merion Township Stormwater Master Plan

By: YW Date: 5/5/2017

Location: Trout Creek Subwatershed 120

Checked: AKS Date: 5/24/2017

Drainage Area = 537.7 acres = 0.84 mi^2

Hydrologic Soil Group	Land Cover Description	Curve Number	Area (acres)	% of Area	CN x Area
B	21. Developed, Open Space	61	2.39	0.45%	146
B	22. Developed, Low Intensity	75	1.98	0.37%	149
B	23. Developed, Medium Intensity	85	0.92	0.17%	78
B	24. Developed, High Intensity	92	0.05	0.01%	5
B	41. Deciduous Forest	55	0.61	0.11%	33
C	21. Developed, Open Space	74	1.24	0.23%	92
C	22. Developed, Low Intensity	83	0.68	0.13%	56
C	23. Developed, Medium Intensity	90	0.29	0.05%	26
C	24. Developed, High Intensity	94	0.00	0.00%	0
C	41. Deciduous Forest	70	1.51	0.28%	105
D	21. Developed, Open Space	80	58.94	10.96%	4,715
D	22. Developed, Low Intensity	87	107.36	19.97%	9,340
D	23. Developed, Medium Intensity	92	231.35	43.02%	21,284
D	24. Developed, High Intensity	95	117.69	21.89%	11,181
D	41. Deciduous Forest	77	12.72	2.37%	979
	Totals		537.74	100.0%	48,191

Weighted CN = 89.6

Gannett Fleming

Upper Merion Township
Montgomery County, PA
RCN Composite Summary

Project: Upper Merion Township Stormwater Master Plan

By: YW Date: 5/5/2017

Location: Trout Creek Subwatershed 130

Checked: AKS Date: 5/24/2017

Drainage Area = 752.2 acres = 1.18 mi^2

Hydrologic Soil Group	Land Cover Description	Curve Number	Area (acres)	% of Area	CN x Area
A	21. Developed, Open Space	39	4.92	0.65%	192
A	23. Developed, Medium Intensity	77	0.09	0.01%	7
A	41. Deciduous Forest	30	0.04	0.00%	1
A	81. Pasture/Hay	39	13.14	1.75%	513
B	21. Developed, Open Space	61	72.59	9.65%	4,428
B	22. Developed, Low Intensity	75	8.84	1.18%	663
B	23. Developed, Medium Intensity	85	5.00	0.66%	425
B	24. Developed, High Intensity	92	0.07	0.01%	7
B	41. Deciduous Forest	55	25.79	3.43%	1,419
B	42. Evergreen Forest	55	1.21	0.16%	67
B	52. Shrub/Scrub	48	6.12	0.81%	294
B	81. Pasture/Hay	61	93.06	12.37%	5,677
B	90. Woody Wetlands	98	0.24	0.03%	23
C	21. Developed, Open Space	74	31.42	4.18%	2,325
C	22. Developed, Low Intensity	83	6.32	0.84%	525
C	23. Developed, Medium Intensity	90	2.62	0.35%	236
C	24. Developed, High Intensity	94	0.20	0.03%	19
C	41. Deciduous Forest	70	10.35	1.38%	725
C	43. Mixed Forest	70	1.31	0.17%	92
C	52. Shrub/Scrub	65	4.94	0.66%	321
C	81. Pasture/Hay	74	16.21	2.15%	1,200
C	90. Woody Wetlands	98	1.33	0.18%	131
D	21. Developed, Open Space	80	331.62	44.08%	26,530
D	22. Developed, Low Intensity	87	64.99	8.64%	5,654
D	23. Developed, Medium Intensity	92	12.58	1.67%	1,157
D	24. Developed, High Intensity	95	4.02	0.53%	382
D	41. Deciduous Forest	77	17.03	2.26%	1,311
D	42. Evergreen Forest	77	2.00	0.27%	154
D	43. Mixed Forest	77	2.33	0.31%	180
D	52. Shrub/Scrub	73	0.86	0.11%	63
D	81. Pasture/Hay	80	6.10	0.81%	488
D	90. Woody Wetlands	98	4.92	0.65%	482
	Totals		752.28	100.0%	55,687

Weighted CN = 74.0

Gannett Fleming

Upper Merion Township
Montgomery County, PA
RCN Composite Summary

Project: Upper Merion Township Stormwater Master Plan

By: YW Date: 5/5/2017

Location: Trout Creek Subwatershed 140

Checked: AKS Date: 5/25/2017

Drainage Area = 126.3 acres = 0.20 mi^2

Hydrologic Soil Group	Land Cover Description	Curve Number	Area (acres)	% of Area	CN x Area
B	21. Developed, Open Space	61	17.18	13.61%	1,048
B	22. Developed, Low Intensity	75	1.90	1.50%	142
B	23. Developed, Medium Intensity	85	0.70	0.56%	60
B	41. Deciduous Forest	55	0.17	0.14%	9
B	81. Pasture/Hay	61	5.10	4.04%	311
D	21. Developed, Open Space	80	39.30	31.13%	3,144
D	22. Developed, Low Intensity	87	24.20	19.17%	2,105
D	23. Developed, Medium Intensity	92	27.59	21.85%	2,538
D	24. Developed, High Intensity	95	6.95	5.50%	660
D	41. Deciduous Forest	77	1.61	1.27%	124
D	43. Mixed Forest	77	1.56	1.23%	120
D	81. Pasture/Hay	80	0.01	0.01%	1
	Totals		126.27	100.0%	10,263
	Weighted CN =		**81.3**		

Gannett Fleming

Upper Merion Township
Montgomery County, PA
RCN Composite Summary

Project: Upper Merion Township Stormwater Master Plan

By: YW Date: 5/5/2017

Location: Trout Creek Subwatershed 150

Checked: AKS Date: 5/25/2017

Drainage Area = 756.9 acres = 1.18 mi^2

Hydrologic Soil Group	Land Cover Description	Curve Number	Area (acres)	% of Area	CN x Area
B	21. Developed, Open Space	61	81.69	10.79%	4,983
B	22. Developed, Low Intensity	75	29.39	3.88%	2,204
B	23. Developed, Medium Intensity	85	9.73	1.29%	827
B	24. Developed, High Intensity	92	1.23	0.16%	113
B	41. Deciduous Forest	55	79.51	10.51%	4,373
B	43. Mixed Forest	55	4.63	0.61%	255
B	52. Shrub/Scrub	48	7.86	1.04%	377
B	81. Pasture/Hay	61	1.90	0.25%	116
B	90. Woody Wetlands	98	1.11	0.15%	109
C	21. Developed, Open Space	74	19.22	2.54%	1,422
C	22. Developed, Low Intensity	83	5.83	0.77%	484
C	23. Developed, Medium Intensity	90	2.80	0.37%	252
C	24. Developed, High Intensity	94	0.01	0.00%	1
C	41. Deciduous Forest	70	17.60	2.33%	1,232
C	43. Mixed Forest	70	0.41	0.05%	29
C	52. Shrub/Scrub	65	0.17	0.02%	11
C	81. Pasture/Hay	74	4.90	0.65%	363
D	21. Developed, Open Space	80	141.28	18.67%	11,302
D	22. Developed, Low Intensity	87	71.53	9.45%	6,223
D	23. Developed, Medium Intensity	92	125.05	16.52%	11,504
D	24. Developed, High Intensity	95	40.60	5.36%	3,857
D	41. Deciduous Forest	77	100.21	13.24%	7,716
D	43. Mixed Forest	77	7.13	0.94%	549
D	52. Shrub/Scrub	73	1.53	0.20%	112
D	81. Pasture/Hay	80	1.56	0.21%	125
	Totals		756.89	100.0%	58,540

Weighted CN = 77.3

Gannett Fleming

Upper Merion Township
Montgomery County, PA
RCN Composite Summary

Project: Upper Merion Township Stormwater Master Plan

By: YW Date: 5/5/2017

Location: Trout Creek Subwatershed 160

Checked: AKS Date: 5/25/2017

Drainage Area = 787.2 acres = 1.23 mi^2

Hydrologic Soil Group	Land Cover Description	Curve Number	Area (acres)	% of Area	CN x Area
B	21. Developed, Open Space	61	55.26	7.02%	3,371
B	22. Developed, Low Intensity	75	9.79	1.24%	734
B	23. Developed, Medium Intensity	85	7.59	0.96%	646
B	24. Developed, High Intensity	92	0.38	0.05%	35
B	41. Deciduous Forest	55	62.86	7.98%	3,457
B	43. Mixed Forest	55	3.10	0.39%	170
B	52. Shrub/Scrub	48	2.89	0.37%	139
C	21. Developed, Open Space	74	10.47	1.33%	775
C	22. Developed, Low Intensity	83	11.95	1.52%	992
C	23. Developed, Medium Intensity	90	7.38	0.94%	664
C	41. Deciduous Forest	70	16.13	2.05%	1,129
C	43. Mixed Forest	70	0.17	0.02%	12
C	52. Shrub/Scrub	65	2.05	0.26%	133
C	81. Pasture/Hay	74	0.09	0.01%	6
D	21. Developed, Open Space	80	210.13	26.69%	16,811
D	22. Developed, Low Intensity	87	110.21	14.00%	9,588
D	23. Developed, Medium Intensity	92	122.93	15.62%	11,310
D	24. Developed, High Intensity	95	30.44	3.87%	2,892
D	41. Deciduous Forest	77	110.23	14.00%	8,488
D	43. Mixed Forest	77	9.92	1.26%	764
D	52. Shrub/Scrub	73	3.27	0.42%	239
	Totals		787.24	100.0%	62,354

Weighted CN = 79.2

Gannett Fleming

Upper Merion Township
Montgomery County, PA
RCN Composite Summary

Project: Upper Merion Township Stormwater Master Plan

By: YW Date: 5/5/2017

Location: Trout Creek Subwatershed 170

Checked: AKS Date: 5/25/2017

Drainage Area = 1134.1 acres = 1.77 mi^2

Hydrologic Soil Group	Land Cover Description	Curve Number	Area (acres)	% of Area	CN x Area
B	21. Developed, Open Space	61	60.30	5.32%	3,678
B	22. Developed, Low Intensity	75	12.79	1.13%	959
B	23. Developed, Medium Intensity	85	3.93	0.35%	334
B	24. Developed, High Intensity	92	0.43	0.04%	39
B	41. Deciduous Forest	55	174.94	15.43%	9,622
B	43. Mixed Forest	55	6.89	0.61%	379
B	52. Shrub/Scrub	48	9.99	0.88%	480
B	81. Pasture/Hay	61	5.45	0.48%	333
B	82. Cultivated Crops	75	9.07	0.80%	680
C	21. Developed, Open Space	74	22.32	1.97%	1,652
C	22. Developed, Low Intensity	83	2.57	0.23%	213
C	23. Developed, Medium Intensity	90	0.95	0.08%	85
C	41. Deciduous Forest	70	43.07	3.80%	3,015
C	43. Mixed Forest	70	1.05	0.09%	74
D	21. Developed, Open Space	80	374.53	33.02%	29,962
D	22. Developed, Low Intensity	87	96.41	8.50%	8,387
D	23. Developed, Medium Intensity	92	46.35	4.09%	4,264
D	24. Developed, High Intensity	95	12.95	1.14%	1,230
D	41. Deciduous Forest	77	216.67	19.10%	16,684
D	42. Evergreen Forest	77	7.34	0.65%	565
D	43. Mixed Forest	77	17.73	1.56%	1,365
D	52. Shrub/Scrub	73	3.58	0.32%	261
D	81. Pasture/Hay	80	1.66	0.15%	133
D	82. Cultivated Crops	85	0.94	0.08%	80
D	90. Woody Wetlands	98	2.25	0.20%	221
	Totals		1,134.15	100.0%	84,695

Weighted CN = 74.7

Gannett Fleming

Upper Merion Township
Montgomery County, PA
RCN Composite Summary

Project: Upper Merion Township Stormwater Master Plan

By: YW Date: 5/5/2017

Location: Trout Creek Subwatershed 180

Checked: AKS Date: 5/25/2017

Drainage Area = 509.3 acres = 0.80 mi^2

Hydrologic Soil Group	Land Cover Description	Curve Number	Area (acres)	% of Area	CN x Area
B	21. Developed, Open Space	61	16.43	3.23%	1,002
B	22. Developed, Low Intensity	75	9.39	1.84%	704
B	23. Developed, Medium Intensity	85	1.81	0.36%	154
B	24. Developed, High Intensity	92	0.00	0.00%	0
B	41. Deciduous Forest	55	43.89	8.62%	2,414
B	52. Shrub/Scrub	48	3.39	0.67%	163
B	82. Cultivated Crops	75	4.17	0.82%	313
B	90. Woody Wetlands	98	0.09	0.02%	9
C	21. Developed, Open Space	74	7.11	1.40%	526
C	22. Developed, Low Intensity	83	1.29	0.25%	107
C	23. Developed, Medium Intensity	90	0.70	0.14%	63
C	41. Deciduous Forest	70	8.59	1.69%	601
C	82. Cultivated Crops	82	0.95	0.19%	78
C	90. Woody Wetlands	98	1.52	0.30%	149
D	21. Developed, Open Space	80	154.33	30.30%	12,346
D	22. Developed, Low Intensity	87	45.58	8.95%	3,966
D	23. Developed, Medium Intensity	92	41.70	8.19%	3,837
D	24. Developed, High Intensity	95	24.18	4.75%	2,297
D	41. Deciduous Forest	77	131.83	25.88%	10,151
D	42. Evergreen Forest	77	4.10	0.81%	316
D	43. Mixed Forest	77	5.15	1.01%	396
D	52. Shrub/Scrub	73	0.37	0.07%	27
D	90. Woody Wetlands	98	2.77	0.54%	271
	Totals		509.34	100.0%	39,890

Weighted CN = 78.3

Gannett Fleming

Upper Merion Township
Montgomery County, PA
RCN Composite Summary

Project: Upper Merion Township Stormwater Master Plan

By: YW Date: 5/5/2017

Location: Trout Creek Subwatershed 200

Checked: AKS Date: 5/25/2017

Drainage Area = 241.4 acres = 0.38 mi^2

Hydrologic Soil Group	Land Cover Description	Curve Number	Area (acres)	% of Area	CN x Area
A	21. Developed, Open Space	39	0.37	0.15%	14
A	22. Developed, Low Intensity	61	0.34	0.14%	21
A	23. Developed, Medium Intensity	77	0.05	0.02%	4
A	52. Shrub/Scrub	30	0.66	0.27%	20
A	81. Pasture/Hay	39	1.00	0.41%	39
A	82. Cultivated Crops	64	0.26	0.11%	17
B	21. Developed, Open Space	61	10.75	4.45%	656
B	22. Developed, Low Intensity	75	1.98	0.82%	149
B	23. Developed, Medium Intensity	85	0.00	0.00%	0
B	41. Deciduous Forest	55	1.61	0.67%	88
B	52. Shrub/Scrub	48	2.39	0.99%	115
B	81. Pasture/Hay	61	21.65	8.97%	1,321
B	82. Cultivated Crops	75	5.27	2.18%	395
C	21. Developed, Open Space	74	5.21	2.16%	386
C	22. Developed, Low Intensity	83	4.29	1.78%	356
C	23. Developed, Medium Intensity	90	0.85	0.35%	76
C	24. Developed, High Intensity	94	0.09	0.04%	8
C	41. Deciduous Forest	70	5.32	2.20%	372
C	82. Cultivated Crops	82	1.01	0.42%	83
D	21. Developed, Open Space	80	20.71	8.58%	1,657
D	22. Developed, Low Intensity	87	34.73	14.38%	3,021
D	23. Developed, Medium Intensity	92	84.55	35.02%	7,779
D	24. Developed, High Intensity	95	35.93	14.88%	3,413
D	41. Deciduous Forest	77	2.43	1.01%	187
D	81. Pasture/Hay	80	0.02	0.01%	1
	Totals		241.45	100.0%	20,177

Weighted CN = 83.6

Gannett Fleming

Upper Merion Township
Montgomery County, PA
RCN Composite Summary

Project: Upper Merion Township Stormwater Master Plan

By: YW Date: 5/5/2017

Location: Trout Creek Subwatershed 210

Checked: AKS Date: 5/25/2017

Drainage Area = 183.5 acres = 0.29 mi^2

Hydrologic Soil Group	Land Cover Description	Curve Number	Area (acres)	% of Area	CN x Area
A	52. Shrub/Scrub	30	0.20	0.11%	6
A	81. Pasture/Hay	39	4.31	2.35%	168
A	82. Cultivated Crops	64	0.01	0.00%	0
B	21. Developed, Open Space	61	9.99	5.44%	609
B	22. Developed, Low Intensity	75	0.92	0.50%	69
B	41. Deciduous Forest	55	1.98	1.08%	109
B	52. Shrub/Scrub	48	0.55	0.30%	26
B	81. Pasture/Hay	61	17.77	9.68%	1,084
B	82. Cultivated Crops	75	11.25	6.13%	844
C	21. Developed, Open Space	74	7.99	4.35%	591
C	22. Developed, Low Intensity	83	0.83	0.45%	69
C	41. Deciduous Forest	70	3.05	1.66%	214
C	43. Mixed Forest	70	4.66	2.54%	327
D	21. Developed, Open Space	80	80.57	43.89%	6,445
D	22. Developed, Low Intensity	87	30.41	16.57%	2,645
D	23. Developed, Medium Intensity	92	2.79	1.52%	256
D	24. Developed, High Intensity	95	0.37	0.20%	35
D	41. Deciduous Forest	77	4.86	2.65%	374
D	43. Mixed Forest	77	0.90	0.49%	69
D	52. Shrub/Scrub	73	0.16	0.09%	12
	Totals		183.55	100.0%	13,953

Weighted CN = 76.0

Gannett Fleming

Clark Lake Dam Watershed
Clark County, Ohio
RCN Composite Summary

Project: Upper Merion Township Stormwater Master Plan

By: YW Date: 5/5/2017

Location: Trout Creek Subwatershed 100

Checked: AKS Date: 5/24/2017

Drainage Area = 349.1 acres = 0.55 mi^2

Hydrologic Soil Group	Land Cover Description	Curve Number	Area (acres)	% of Area	CN x Area
A	21. Developed, Open Space	39	1.48	0.43%	58
A	22. Developed, Low Intensity	61	2.59	0.74%	158
A	23. Developed, Medium Intensity	77	0.91	0.26%	70
A	31. Barren Land (Rock/Sand/Clay)	77	2.66	0.76%	205
A	41. Deciduous Forest	30	1.73	0.50%	52
A	90. Woody Wetlands	98	4.27	1.22%	419
B	11. Open Water	98	0.13	0.04%	13
B	21. Developed, Open Space	61	8.56	2.45%	522
B	22. Developed, Low Intensity	75	5.25	1.50%	394
B	23. Developed, Medium Intensity	85	2.58	0.74%	219
B	24. Developed, High Intensity	92	0.01	0.00%	0
B	41. Deciduous Forest	55	17.06	4.89%	938
B	52. Shrub/Scrub	48	3.27	0.94%	157
B	90. Woody Wetlands	98	0.00	0.00%	0
C	21. Developed, Open Space	74	1.41	0.40%	104
C	22. Developed, Low Intensity	83	1.26	0.36%	105
C	23. Developed, Medium Intensity	90	0.36	0.10%	32
C	24. Developed, High Intensity	94	0.02	0.01%	2
C	41. Deciduous Forest	70	2.81	0.81%	197
C	52. Shrub/Scrub	65	0.10	0.03%	6
D	11. Open Water	98	1.43	0.41%	140
D	21. Developed, Open Space	80	30.86	8.84%	2,469
D	22. Developed, Low Intensity	87	59.46	17.03%	5,173
D	23. Developed, Medium Intensity	92	106.88	30.62%	9,833
D	24. Developed, High Intensity	95	40.61	11.63%	3,858
D	31. Barren Land (Rock/Sand/Clay)	94	1.11	0.32%	105
D	41. Deciduous Forest	77	46.19	13.23%	3,557
D	52. Shrub/Scrub	73	0.06	0.02%	4
D	90. Woody Wetlands	98	4.91	1.41%	481
D	95. Emergent Herbaceous Wetlands	98	1.11	0.32%	109
	Totals		349.07	100.0%	29,379

Weighted CN = 84.2

Gannett Fleming

Upper Merion Township
Montgomery County, PA
RCN Composite Summary

Project: Upper Merion Township Stormwater Master Plan

By: YW Date: 5/10/2017

Location: Abram Creek Subwatershed 50

Checked: AKS Date: 5/24/2017

Drainage Area = 130.9 acres = 0.20 mi^2

Hydrologic Soil Group	Land Cover Description	Curve Number	Area (acres)	% of Area	CN x Area
B	21. Developed, Open Space	61	3.95	3.02%	241
B	22. Developed, Low Intensity	75	1.33	1.02%	100
B	23. Developed, Medium Intensity	85	0.58	0.44%	49
B	24. Developed, High Intensity	92	0.03	0.02%	2
B	41. Deciduous Forest	55	0.00	0.00%	0
B	52. Shrub/Scrub	48	0.26	0.20%	12
D	21. Developed, Open Space	80	31.87	24.35%	2,550
D	22. Developed, Low Intensity	87	80.86	61.79%	7,035
D	23. Developed, Medium Intensity	92	7.13	5.45%	656
D	24. Developed, High Intensity	95	0.20	0.15%	19
D	31. Barren Land (Rock/Sand/Clay)	94	2.45	1.87%	230
D	41. Deciduous Forest	77	1.37	1.05%	106
D	52. Shrub/Scrub	73	0.85	0.65%	62
	Totals		130.87	100.0%	11,062

Weighted CN = 84.5

Gannett Fleming

Upper Merion Township
Montgomery County, PA
RCN Composite Summary

Project: Upper Merion Township Stormwater Master Plan

By: YW Date: 5/10/2017

Location: Abram Creek Subwatershed 100 Checked: AKS Date: 5/24/2017

Drainage Area = 85.4 acres = 0.13 mi^2

Hydrologic Soil Group	Land Cover Description	Curve Number	Area (acres)	% of Area	CN x Area
B	21. Developed, Open Space	61	1.39	1.63%	85
B	22. Developed, Low Intensity	75	0.61	0.71%	46
B	23. Developed, Medium Intensity	85	1.64	1.92%	140
B	41. Deciduous Forest	55	1.16	1.36%	64
B	52. Shrub/Scrub	48	0.00	0.01%	0
B	90. Woody Wetlands	98	1.14	1.34%	112
C	21. Developed, Open Space	74	0.05	0.06%	4
C	22. Developed, Low Intensity	83	0.96	1.12%	80
C	41. Deciduous Forest	70	3.98	4.66%	278
C	90. Woody Wetlands	98	0.93	1.09%	91
D	21. Developed, Open Space	80	17.89	20.94%	1,431
D	22. Developed, Low Intensity	87	33.14	38.80%	2,883
D	23. Developed, Medium Intensity	92	8.81	10.32%	811
D	24. Developed, High Intensity	95	3.49	4.08%	331
D	41. Deciduous Forest	77	9.82	11.50%	756
D	90. Woody Wetlands	98	0.40	0.47%	39
	Totals		85.43	100.0%	7,152

Weighted CN = 83.7

Gannett Fleming

Upper Merion Township
Montgomery County, PA
RCN Composite Summary

Project: Upper Merion Township Stormwater Master Plan

By: YW Date: 5/10/2017

Location: Frog Run Subwatershed 50

Checked: AKS Date: 5/24/2017

Drainage Area = 465.5 acres = 0.73 mi^2

Hydrologic Soil Group	Land Cover Description	Curve Number	Area (acres)	% of Area	CN x Area
B	21. Developed, Open Space	61	26.27	5.64%	1,602
B	22. Developed, Low Intensity	75	12.62	2.71%	946
B	23. Developed, Medium Intensity	85	6.59	1.42%	561
B	24. Developed, High Intensity	92	0.73	0.16%	67
B	41. Deciduous Forest	55	59.75	12.83%	3,286
B	52. Shrub/Scrub	48	2.26	0.48%	108
C	21. Developed, Open Space	74	7.63	1.64%	565
C	22. Developed, Low Intensity	83	2.50	0.54%	208
C	23. Developed, Medium Intensity	90	6.87	1.48%	618
C	24. Developed, High Intensity	94	1.66	0.36%	156
C	41. Deciduous Forest	70	2.26	0.49%	158
D	21. Developed, Open Space	80	58.36	12.54%	4,669
D	22. Developed, Low Intensity	87	77.51	16.65%	6,743
D	23. Developed, Medium Intensity	92	99.41	21.36%	9,146
D	24. Developed, High Intensity	95	56.69	12.18%	5,386
D	41. Deciduous Forest	77	36.44	7.83%	2,806
D	43. Mixed Forest	77	0.45	0.10%	35
D	52. Shrub/Scrub	73	1.97	0.42%	144
D	71. Grassland/Herbaceous	80	0.22	0.05%	18
D	81. Pasture/Hay	80	5.34	1.15%	427
	Totals		465.52	100.0%	37,648

Weighted CN = 80.9

Gannett Fleming

Upper Merion Township
Montgomery County, PA
RCN Composite Summary

Project: Upper Merion Township Stormwater Master Plan

By: YW Date: 5/10/2017

Location: Frog Run Subwatershed 100

Checked: AKS Date: 5/24/2017

Drainage Area = 403.5 acres = 0.63 mi^2

Hydrologic Soil Group	Land Cover Description	Curve Number	Area (acres)	% of Area	CN x Area
B	21. Developed, Open Space	61	19.25	4.77%	1,174
B	22. Developed, Low Intensity	75	8.32	2.06%	624
B	23. Developed, Medium Intensity	85	2.25	0.56%	191
B	24. Developed, High Intensity	92	0.26	0.06%	24
B	41. Deciduous Forest	55	5.59	1.38%	307
B	52. Shrub/Scrub	48	4.89	1.21%	234
B	81. Pasture/Hay	61	1.11	0.27%	68
C	21. Developed, Open Space	74	2.93	0.73%	217
C	22. Developed, Low Intensity	83	0.21	0.05%	17
C	23. Developed, Medium Intensity	90	0.10	0.02%	9
C	24. Developed, High Intensity	94	0.00	0.00%	0
C	52. Shrub/Scrub	65	0.23	0.06%	15
C	81. Pasture/Hay	74	1.67	0.41%	124
D	11. Open Water	98	0.03	0.01%	3
D	21. Developed, Open Space	80	75.69	18.76%	6,055
D	22. Developed, Low Intensity	87	134.75	33.39%	11,724
D	23. Developed, Medium Intensity	92	90.52	22.43%	8,328
D	24. Developed, High Intensity	95	47.07	11.66%	4,472
D	41. Deciduous Forest	77	6.34	1.57%	488
D	52. Shrub/Scrub	73	1.34	0.33%	97
D	81. Pasture/Hay	80	1.00	0.25%	80
D	90. Woody Wetlands	98	0.01	0.00%	1
	Totals		403.55	100.0%	34,253

Weighted CN = 84.9

Gannett Fleming

Upper Merion Township
Montgomery County, PA
RCN Composite Summary

Project: Upper Merion Township Stormwater Master Plan

By: YW Date: 5/10/2017

Location: Frog Run Subwatershed 140

Checked: AKS Date: 5/24/2017

Drainage Area = 89.8 acres = 0.14 mi^2

Hydrologic Soil Group	Land Cover Description	Curve Number	Area (acres)	% of Area	CN x Area
B	21. Developed, Open Space	61	0.67	0.75%	41
B	22. Developed, Low Intensity	75	0.61	0.68%	46
B	23. Developed, Medium Intensity	85	0.00	0.00%	0
B	41. Deciduous Forest	55	11.79	13.13%	648
B	52. Shrub/Scrub	48	2.17	2.42%	104
B	81. Pasture/Hay	61	0.01	0.01%	0
C	21. Developed, Open Space	74	1.59	1.78%	118
C	22. Developed, Low Intensity	83	0.68	0.76%	56
D	11. Open Water	98	0.08	0.09%	8
D	21. Developed, Open Space	80	5.73	6.38%	459
D	22. Developed, Low Intensity	87	10.39	11.57%	904
D	23. Developed, Medium Intensity	92	19.82	22.07%	1,823
D	24. Developed, High Intensity	95	11.83	13.18%	1,124
D	41. Deciduous Forest	77	2.18	2.43%	168
D	52. Shrub/Scrub	73	0.02	0.02%	1
D	71. Grassland/Herbaceous	80	1.33	1.49%	107
D	81. Pasture/Hay	80	20.67	23.03%	1,654
D	90. Woody Wetlands	98	0.21	0.23%	20
	Totals		89.79	100.0%	7,282

Weighted CN = 81.1

Gannett Fleming

Upper Merion Township
Montgomery County, PA
RCN Composite Summary

Project: Upper Merion Township Stormwater Master Plan

By: YW Date: 5/10/2017

Location: Frog Run Subwatershed 150

Checked: AKS Date: 5/25/2017

Drainage Area = 362.9 acres = 0.57 mi^2

Hydrologic Soil Group	Land Cover Description	Curve Number	Area (acres)	% of Area	CN x Area
B	21. Developed, Open Space	61	14.76	4.07%	900
B	22. Developed, Low Intensity	75	5.31	1.46%	398
B	23. Developed, Medium Intensity	85	3.74	1.03%	318
B	24. Developed, High Intensity	92	0.11	0.03%	10
B	41. Deciduous Forest	55	4.45	1.23%	245
B	52. Shrub/Scrub	48	7.27	2.00%	349
B	82. Cultivated Crops	75	3.49	0.96%	262
C	11. Open Water	98	0.38	0.11%	38
C	21. Developed, Open Space	74	1.81	0.50%	134
C	22. Developed, Low Intensity	83	2.90	0.80%	240
C	23. Developed, Medium Intensity	90	7.92	2.18%	713
C	24. Developed, High Intensity	94	8.21	2.26%	771
C	31. Barren Land (Rock/Sand/Clay)	91	0.72	0.20%	66
C	41. Deciduous Forest	70	2.28	0.63%	160
C	52. Shrub/Scrub	65	0.01	0.00%	0
C	82. Cultivated Crops	82	0.01	0.00%	1
D	11. Open Water	98	28.01	7.72%	2,745
D	21. Developed, Open Space	80	19.84	5.47%	1,587
D	22. Developed, Low Intensity	87	38.81	10.70%	3,377
D	23. Developed, Medium Intensity	92	63.31	17.45%	5,824
D	24. Developed, High Intensity	95	29.09	8.02%	2,763
D	31. Barren Land (Rock/Sand/Clay)	94	25.74	7.09%	2,420
D	41. Deciduous Forest	77	0.56	0.16%	43
D	52. Shrub/Scrub	73	0.05	0.01%	4
D	81. Pasture/Hay	80	2.75	0.76%	220
D	82. Cultivated Crops	85	91.36	25.18%	7,765
	Totals		362.87	100.0%	31,352

Weighted CN = 86.4

Gannett Fleming

Upper Merion Township
Montgomery County, PA
RCN Composite Summary

Project: Upper Merion Township Stormwater Master Plan

By: YW Date: 5/10/2017

Location: Matsunk Creek Subwatershed 80

Checked: AKS Date: 5/24/2017

Drainage Area = 158.4 acres = 0.25 mi^2

Hydrologic Soil Group	Land Cover Description	Curve Number	Area (acres)	% of Area	CN x Area
B	21. Developed, Open Space	61	0.53	0.34%	33
B	22. Developed, Low Intensity	75	0.42	0.27%	32
C	21. Developed, Open Space	74	10.93	6.90%	809
C	22. Developed, Low Intensity	83	4.11	2.60%	341
C	23. Developed, Medium Intensity	90	1.38	0.87%	125
C	41. Deciduous Forest	70	3.70	2.34%	259
C	81. Pasture/Hay	74	0.27	0.17%	20
D	21. Developed, Open Space	80	14.79	9.33%	1,183
D	22. Developed, Low Intensity	87	37.61	23.75%	3,272
D	23. Developed, Medium Intensity	92	59.03	37.27%	5,431
D	24. Developed, High Intensity	95	23.81	15.03%	2,262
D	41. Deciduous Forest	77	1.58	1.00%	121
D	90. Woody Wetlands	98	0.24	0.15%	23
	Totals		158.41	100.0%	13,911

Weighted CN = 87.8

Gannett Fleming

Upper Merion Township
Montgomery County, PA
RCN Composite Summary

Project: Upper Merion Township Stormwater Master Plan

By: YW Date: 5/10/2017

Location: Matsunk Creek Subwatershed 90

Checked: AKS Date: 5/24/2017

Drainage Area = 294.5 acres = 0.46 mi^2

Hydrologic Soil Group	Land Cover Description	Curve Number	Area (acres)	% of Area	CN x Area
B	21. Developed, Open Space	61	97.18	33.00%	5,928
B	22. Developed, Low Intensity	75	4.78	1.62%	358
B	23. Developed, Medium Intensity	85	1.55	0.53%	132
B	24. Developed, High Intensity	92	0.70	0.24%	64
B	41. Deciduous Forest	55	11.99	4.07%	659
B	81. Pasture/Hay	61	1.33	0.45%	81
C	21. Developed, Open Space	74	9.94	3.37%	735
C	22. Developed, Low Intensity	83	1.64	0.56%	136
C	41. Deciduous Forest	70	5.65	1.92%	395
C	81. Pasture/Hay	74	0.72	0.24%	53
D	21. Developed, Open Space	80	102.35	34.75%	8,188
D	22. Developed, Low Intensity	87	22.29	7.57%	1,940
D	23. Developed, Medium Intensity	92	11.33	3.85%	1,042
D	24. Developed, High Intensity	95	2.92	0.99%	277
D	41. Deciduous Forest	77	15.77	5.36%	1,214
D	81. Pasture/Hay	80	0.84	0.29%	67
D	90. Woody Wetlands	98	1.74	0.59%	171
D	95. Emergent Herbaceous Wetlands	98	1.78	0.61%	175
	Totals		294.51	100.0%	21,618

Weighted CN = 73.4

Gannett Fleming

Upper Merion Township
Montgomery County, PA
RCN Composite Summary

Project: Upper Merion Township Stormwater Master Plan

By: YW Date: 5/10/2017

Location: Matsunk Creek Subwatershed 100

Checked: AKS Date: 5/24/2017

Drainage Area = 88.1 acres = 0.14 mi^2

Hydrologic Soil Group	Land Cover Description	Curve Number	Area (acres)	% of Area	CN x Area
B	21. Developed, Open Space	61	7.65	8.68%	467
B	22. Developed, Low Intensity	75	0.54	0.61%	41
B	23. Developed, Medium Intensity	85	0.08	0.09%	7
B	24. Developed, High Intensity	92	0.05	0.06%	5
B	41. Deciduous Forest	55	8.83	10.02%	486
B	90. Woody Wetlands	98	1.14	1.29%	112
C	41. Deciduous Forest	70	0.06	0.07%	4
D	21. Developed, Open Space	80	12.02	13.63%	961
D	22. Developed, Low Intensity	87	13.11	14.87%	1,140
D	23. Developed, Medium Intensity	92	21.87	24.81%	2,012
D	24. Developed, High Intensity	95	11.96	13.57%	1,136
D	41. Deciduous Forest	77	7.51	8.52%	578
D	90. Woody Wetlands	98	3.33	3.78%	326
	Totals		88.14	100.0%	7,274

Weighted CN = 82.5

Gannett Fleming

Upper Merion Township
Montgomery County, PA
RCN Composite Summary

Project: Upper Merion Township Stormwater Master Plan

By: YW Date: 5/10/2017

Location: Watershed A

Checked: AKS Date: 5/25/2017

Drainage Area = 228.6 acres = 0.36 mi^2

Hydrologic Soil Group	Land Cover Description	Curve Number	Area (acres)	% of Area	CN x Area
B	21. Developed, Open Space	61	1.86	0.81%	113
B	22. Developed, Low Intensity	75	1.34	0.59%	101
B	23. Developed, Medium Intensity	85	0.88	0.39%	75
B	24. Developed, High Intensity	92	0.66	0.29%	61
B	41. Deciduous Forest	55	10.14	4.44%	558
B	52. Shrub/Scrub	48	10.31	4.51%	495
B	81. Pasture/Hay	61	1.82	0.80%	111
C	21. Developed, Open Space	74	1.41	0.62%	105
C	22. Developed, Low Intensity	83	0.67	0.29%	56
C	23. Developed, Medium Intensity	90	0.09	0.04%	8
D	21. Developed, Open Space	80	13.38	5.85%	1,070
D	22. Developed, Low Intensity	87	47.72	20.87%	4,151
D	23. Developed, Medium Intensity	92	84.34	36.90%	7,760
D	24. Developed, High Intensity	95	44.65	19.53%	4,242
D	41. Deciduous Forest	77	5.27	2.31%	406
D	52. Shrub/Scrub	73	0.20	0.09%	14
D	81. Pasture/Hay	80	3.86	1.69%	309
	Totals		228.61	100.0%	19,634

Weighted CN = 85.9

Gannett Fleming

Upper Merion Township
Montgomery County, PA
RCN Composite Summary

Project: Upper Merion Township Stormwater Master Plan

By: YW Date: 5/5/2017

Location: Gulph Mill Creek Subwatershed 40

Checked: AKS Date: 5/24/2017

Drainage Area = 707.3 acres = 1.11 mi^2

Hydrologic Soil Group	Land Cover Description	Curve Number	Area (acres)	% of Area	CN x Area
B	11. Open Water	98	0.06	0.01%	6
B	21. Developed, Open Space	61	52.55	7.43%	3,206
B	22. Developed, Low Intensity	75	9.65	1.36%	724
B	23. Developed, Medium Intensity	85	3.08	0.44%	262
B	24. Developed, High Intensity	92	0.08	0.01%	7
B	41. Deciduous Forest	55	105.52	14.92%	5,803
B	43. Mixed Forest	55	2.91	0.41%	160
B	52. Shrub/Scrub	48	0.82	0.12%	39
B	90. Woody Wetlands	98	4.08	0.58%	400
C	21. Developed, Open Space	74	19.21	2.72%	1,421
C	22. Developed, Low Intensity	83	8.24	1.16%	684
C	23. Developed, Medium Intensity	90	1.75	0.25%	157
C	24. Developed, High Intensity	94	0.00	0.00%	0
C	41. Deciduous Forest	70	30.90	4.37%	2,163
C	52. Shrub/Scrub	65	5.33	0.75%	347
C	81. Pasture/Hay	74	57.95	8.19%	4,288
D	11. Open Water	98	9.79	1.38%	959
D	21. Developed, Open Space	80	112.32	15.88%	8,986
D	22. Developed, Low Intensity	87	87.80	12.41%	7,639
D	23. Developed, Medium Intensity	92	98.05	13.86%	9,020
D	24. Developed, High Intensity	95	36.92	5.22%	3,507
D	41. Deciduous Forest	77	44.61	6.31%	3,435
D	43. Mixed Forest	77	6.38	0.90%	491
D	52. Shrub/Scrub	73	1.39	0.20%	102
D	81. Pasture/Hay	80	1.16	0.16%	93
D	90. Woody Wetlands	98	6.81	0.96%	668
	Totals		707.37	100.0%	54,568

Weighted CN = 77.1

Gannett Fleming

Upper Merion Township
Montgomery County, PA
RCN Composite Summary

Project: Upper Merion Township Stormwater Master Plan

By: YW Date: 5/5/2017

Location: Gulph Mill Creek Subwatershed 50

Checked: AKS Date: 5/24/2017

Drainage Area = 746.9 acres = 1.17 mi^2

Hydrologic Soil Group	Land Cover Description	Curve Number	Area (acres)	% of Area	CN x Area
B	21. Developed, Open Space	61	134.01	17.94%	8,175
B	22. Developed, Low Intensity	75	2.46	0.33%	185
B	23. Developed, Medium Intensity	85	0.25	0.03%	21
B	41. Deciduous Forest	55	363.69	48.69%	20,003
B	43. Mixed Forest	55	19.17	2.57%	1,054
C	21. Developed, Open Space	74	21.49	2.88%	1,590
C	22. Developed, Low Intensity	83	1.11	0.15%	92
C	41. Deciduous Forest	70	30.51	4.08%	2,135
C	43. Mixed Forest	70	0.50	0.07%	35
D	21. Developed, Open Space	80	105.32	14.10%	8,426
D	22. Developed, Low Intensity	87	17.16	2.30%	1,493
D	23. Developed, Medium Intensity	92	0.18	0.02%	16
D	41. Deciduous Forest	77	47.08	6.30%	3,625
D	43. Mixed Forest	77	3.97	0.53%	306
D	52. Shrub/Scrub	73	0.02	0.00%	2
	Totals		746.92	100.0%	47,158

Weighted CN = 63.1

Gannett Fleming

Upper Merion Township
Montgomery County, PA
RCN Composite Summary

Project: Upper Merion Township Stormwater Master Plan

By: YW Date: 5/5/2017

Location: Gulph Mill Creek Subwatershed 80

Checked: AKS Date: 5/24/2017

Drainage Area = 1121.9 acres = 1.75 mi^2

Hydrologic Soil Group	Land Cover Description	Curve Number	Area (acres)	% of Area	CN x Area
A	21. Developed, Open Space	39	34.36	3.06%	1,340
A	22. Developed, Low Intensity	61	3.39	0.30%	207
A	23. Developed, Medium Intensity	77	0.65	0.06%	50
A	41. Deciduous Forest	30	28.79	2.57%	864
A	52. Shrub/Scrub	30	2.14	0.19%	64
B	21. Developed, Open Space	61	214.42	19.11%	13,080
B	22. Developed, Low Intensity	75	40.19	3.58%	3,014
B	23. Developed, Medium Intensity	85	27.49	2.45%	2,337
B	24. Developed, High Intensity	92	1.92	0.17%	177
B	41. Deciduous Forest	55	194.49	17.34%	10,697
B	42. Evergreen Forest	55	2.00	0.18%	110
B	43. Mixed Forest	55	8.00	0.71%	440
B	52. Shrub/Scrub	48	1.32	0.12%	63
B	90. Woody Wetlands	98	0.56	0.05%	55
C	21. Developed, Open Space	74	29.40	2.62%	2,176
C	22. Developed, Low Intensity	83	1.36	0.12%	112
C	23. Developed, Medium Intensity	90	0.56	0.05%	50
C	41. Deciduous Forest	70	33.58	2.99%	2,351
C	43. Mixed Forest	70	0.02	0.00%	1
C	52. Shrub/Scrub	65	0.54	0.05%	35
C	90. Woody Wetlands	98	2.21	0.20%	216
D	21. Developed, Open Space	80	269.09	23.99%	21,527
D	22. Developed, Low Intensity	87	50.54	4.50%	4,397
D	23. Developed, Medium Intensity	92	14.40	1.28%	1,325
D	24. Developed, High Intensity	95	0.43	0.04%	40
D	41. Deciduous Forest	77	130.52	11.63%	10,050
D	42. Evergreen Forest	77	2.00	0.18%	154
D	43. Mixed Forest	77	7.16	0.64%	551
D	52. Shrub/Scrub	73	3.35	0.30%	245
D	90. Woody Wetlands	98	17.02	1.52%	1,668
	Totals		1,121.90	100.0%	77,397

Weighted CN = 69.0

Gannett Fleming

Upper Merion Township
Montgomery County, PA
RCN Composite Summary

Project: Upper Merion Township Stormwater Master Plan

By: YW Date: 5/5/2017

Location: Gulph Mill Creek Subwatershed 90

Checked: AKS Date: 5/24/2017

Drainage Area = 1300.1 acres = 2.03 mi^2

Hydrologic Soil Group	Land Cover Description	Curve Number	Area (acres)	% of Area	CN x Area
B	11. Open Water	98	0.08	0.01%	8
B	21. Developed, Open Space	61	213.51	16.42%	13,024
B	22. Developed, Low Intensity	75	38.87	2.99%	2,915
B	23. Developed, Medium Intensity	85	24.17	1.86%	2,054
B	24. Developed, High Intensity	92	3.53	0.27%	325
B	41. Deciduous Forest	55	172.01	13.23%	9,460
B	43. Mixed Forest	55	5.68	0.44%	312
B	52. Shrub/Scrub	48	4.37	0.34%	210
B	90. Woody Wetlands	98	0.17	0.01%	17
C	11. Open Water	98	0.74	0.06%	72
C	21. Developed, Open Space	74	283.27	21.79%	20,962
C	22. Developed, Low Intensity	83	73.39	5.64%	6,091
C	23. Developed, Medium Intensity	90	29.28	2.25%	2,635
C	24. Developed, High Intensity	94	8.13	0.63%	764
C	41. Deciduous Forest	70	75.38	5.80%	5,276
C	43. Mixed Forest	70	13.56	1.04%	949
C	52. Shrub/Scrub	65	1.64	0.13%	106
C	90. Woody Wetlands	98	5.68	0.44%	557
D	11. Open Water	98	2.96	0.23%	290
D	21. Developed, Open Space	80	196.38	15.10%	15,711
D	22. Developed, Low Intensity	87	52.52	4.04%	4,569
D	23. Developed, Medium Intensity	92	14.67	1.13%	1,349
D	24. Developed, High Intensity	95	1.45	0.11%	138
D	41. Deciduous Forest	77	73.28	5.64%	5,643
D	43. Mixed Forest	77	3.54	0.27%	272
D	52. Shrub/Scrub	73	0.00	0.00%	0
D	90. Woody Wetlands	98	1.93	0.15%	189
	Totals		1,300.18	100.0%	93,901

Weighted CN = 72.2

Appendix C-2 – Time of Concentration / Basin Lag Time Calculations

Gannett Fleming

Time of Concentration Calculation Summary

Project:	Upper Merion Township SWM		By:	YW	Date: 5/15/2017
Location:	Upper Merion Township, Montgomery County, PA		Checked:	AKS	Date: 5/30/2017
Subwatershed:	Crow Creek W970				

Sheet Flow Properties

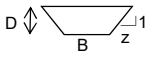
Segment ID	SH-1	SH-2
1. Surface description	Short-Grass Prairie	Not Used
2. Manning's roughness coefficient, n (NRCS NEH,Table 15-1)	0.150	
3. Flow length, L (ft)	100	
4. Two-year 24-hour rainfall, P2 (in) (NOAA HDSC PFDS)	3.26	
5. Land slope, s (ft/ft)	0.02420	
$T_t = \frac{0.007\,(nL)^{0.8}}{(P2)^{0.5}(s)^{0.4}}$	0.15 hours	#VALUE! hours

Shallow Concentrated Flow Properties

Segment ID	SC-1	SC-2	SC-3	SC-4
6. Surface description (NRCS NEH, Table 15-3)	Forest with heavy ground litter and hay meadows	Short-grass pasture	Not Used	Not Used
7. Flow length, L (ft)	1481	1526	0	0
8. Watercourse slope, s (ft/ft)	0.07151	0.04998	#DIV/0!	0.00021
9. Average velocity, V (NRCS NEH, Table 15-3)	0.673	1.556		
	V=2.516(s)^0.5	V=6.962(s)^0.5		
$T_t = \frac{L}{3600V}$	0.61 hours	0.27 hours	#VALUE! hours	#VALUE! hours

Open Channel Flow Properties

Segment ID	CH-1	CH-2	CH-3	CH-4	CH-5
10. Bottom width, B (ft)	4				
11. Depth flowing full, D (ft)	2.2				
12. Channel side slope, z H : 1 V	1.455				
13. Cross sectional area, A (sq ft)	15.8422	0	0	0	0
14. Wetted perimeter, P (ft)	11.77	0.00	0.00	0.00	0.00
15. Hydraulic radius, r = A/P (ft)	1.35	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
16. Channel slope, s (ft/ft)	0.02245	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
17. Manning's roughness coefficient, n	0.035				
18. Velocity, V (ft/sec)	7.78	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
$V = \frac{1.49(r^{2/3})(s^{1/2})}{n}$					
19. Flow length, L (ft)	3396	0	0	0	0
$T_t = \frac{L}{3600V}$	0.12 hours	#DIV/0! hours	#DIV/0! hours	#DIV/0! hours	#DIV/0! hours



Results

Time of Concentration =	**1.15**	**hours**	**=**	**69.30**	**minutes**
Lag Time =	**0.69**	**hours**	**=**	**41.58**	**minutes**

Gannett Fleming

Time of Concentration Calculation Summary

Project:	Upper Merion Township SWM		By:	YW	Date: 5/15/2017
Location:	Upper Merion Township, Montgomery County, PA		Checked:	AKS	Date: 6/1/2017
Subwatershed:	Crow Creek W900				

Sheet Flow Properties

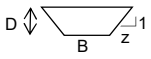
Segment ID	SH-1	SH-2
1. Surface description	Short-Grass Prairie	Not Used
2. Manning's roughness coefficient, n (NRCS NEH,Table 15-1)	0.150	
3. Flow length, L (ft)	100	0
4. Two-year 24-hour rainfall, P2 (in) (NOAA HDSC PFDS)	3.26	
5. Land slope, s (ft/ft)	0.00300	
$T_t = \frac{0.007\,(nL)^{0.8}}{(P2)^{0.5}(s)^{0.4}}$	0.35 hours	#VALUE! hours

Shallow Concentrated Flow Properties

Segment ID	SC-1	SC-2	SC-3	SC-4
6. Surface description (NRCS NEH, Table 15-3)	Short-grass pasture	Not Used	Not Used	Not Used
7. Flow length, L (ft)	1548	0	0	0
8. Watercourse slope, s (ft/ft)	0.04993	#DIV/0!	#DIV/0!	0.00021
9. Average velocity, V (NRCS NEH, Table 15-3)	1.556			
	V=6.962(s)^0.5			
$T_t = \frac{L}{3600V}$	0.28 hours	#VALUE! hours	#VALUE! hours	#VALUE! hours

Open Channel Flow Properties

Segment ID	CH-1	CH-2	CH-3	CH-4	CH-5
10. Bottom width, B (ft)	4	5			
11. Depth flowing full, D (ft)	1.97	2.26			
12. Channel side slope, z H : 1 V	2.5	3.64			
13. Cross sectional area, A (sq ft)	17.58225	29.891664	0	0	0
14. Wetted perimeter, P (ft)	14.61	22.06	0.00	0.00	0.00
15. Hydraulic radius, r = A/P (ft)	1.20	1.35	#DIV/0!	#DIV/0!	#DIV/0!
16. Channel slope, s (ft/ft)	0.03176	0.01698	#DIV/0!	#DIV/0!	#DIV/0!
17. Manning's roughness coefficient, n	0.035	0.035	0.040	0.040	0.040
18. Velocity, V (ft/sec)	8.58	6.79	#DIV/0!	#DIV/0!	#DIV/0!
$V = \frac{1.49(r^{2/3})(s^{1/2})}{n}$					
19. Flow length, L (ft)	5908	2462	0	0	0
$T_t = \frac{L}{3600V}$	0.19 hours	0.10 hours	#DIV/0! hours	#DIV/0! hours	#DIV/0! hours



Results

Time of Concentration =	**0.91**	**hours**	**=**	**54.83**	**minutes**
Lag Time =	**0.55**	**hours**	**=**	**32.90**	**minutes**

Gannett Fleming

Time of Concentration Calculation Summary

Project: Upper Merion Township SWM
Location: Upper Merion Township, Montgomery County, PA
Subwatershed: Crow Creek W880

By: YW Date: 5/15/2017
Checked: AKS Date: 6/1/2017

Sheet Flow Properties

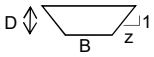
Segment ID	SH-1	SH-2
1. Surface description	Short-Grass Prairie	Not Used
2. Manning's roughness coefficient, n (NRCS NEH,Table 15-1)	0.150	
3. Flow length, L (ft)	100	
4. Two-year 24-hour rainfall, P2 (in) (NOAA HDSC PFDS)	3.26	
5. Land slope, s (ft/ft)	0.05040	
$T_t = \frac{0.007\,(nL)^{0.8}}{(P2)^{0.5}(s)^{0.4}}$	T_t = 0.11 hours	#VALUE! hours

Shallow Concentrated Flow Properties

Segment ID	SC-1	SC-2	SC-3	SC-4
6. Surface description (NRCS NEH, Table 15-3)	Short-grass pasture	Short-grass pasture	Forest with heavy ground litter and hay meadows	Not Used
7. Flow length, L (ft)	595	1848	935	0
8. Watercourse slope, s (ft/ft)	0.02260	0.05046	0.03436	0.00000
9. Average velocity, V (NRCS NEH, Table 15-3)	1.047	1.564	0.466	
	V=6.962(s)^0.5	V=6.962(s)^0.5	V=2.516(s)^0.5	
$T_t = \frac{L}{3600V}$ T_t =	0.16 hours	0.33 hours	0.56 hours	#VALUE! hours

Open Channel Flow Properties

Segment ID	CH-1	CH-2	CH-3	CH-4	CH-5
10. Bottom width, B (ft)	10	5			
11. Depth flowing full, D (ft)	1.47	1.44			
12. Channel side slope, z H : 1 V	2	12.5			
13. Cross sectional area, A (sq ft)	19.0218	33.12	0	0	0
14. Wetted perimeter, P (ft)	16.57	41.12	0.00	0.00	0.00
15. Hydraulic radius, r = A/P (ft)	1.15	0.81	#DIV/0!	#DIV/0!	#DIV/0!
16. Channel slope, s (ft/ft)	0.02498	0.01743	#DIV/0!	#DIV/0!	#DIV/0!
17. Manning's roughness coefficient, n	0.035	0.035	0.040	0.040	0.040
18. Velocity, V (ft/sec)	7.38	4.87	#DIV/0!	#DIV/0!	#DIV/0!
$V = \frac{1.49(r^{2/3})(s^{1/2})}{n}$					
19. Flow length, L (ft)	4285	4119	0	0	0
$T_t = \frac{L}{3600V}$ Tt =	0.16 hours	0.24 hours	#DIV/0! hours	#DIV/0! hours	#DIV/0! hours



Results

Time of Concentration =	**1.55**	**hours**	**=**	**93.09**	**minutes**
Lag Time =	**0.93**	**hours**	**=**	**55.85**	**minutes**

Gannett Fleming

Time of Concentration Calculation Summary

Project:	Upper Merion Township SWM		By:	YW	Date: 5/15/2017
Location:	Upper Merion Township, Montgomery County, PA		Checked:	AKS	Date: 6/1/2017
Subwatershed:	Crow Creek W680				

Sheet Flow Properties

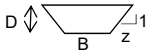
Segment ID	SH-1	SH-2
1. Surface description	Short-Grass Prairie	Not Used
2. Manning's roughness coefficient, n (NRCS NEH,Table 15-1)	0.150	
3. Flow length, L (ft)	100	0
4. Two-year 24-hour rainfall, P2 (in) (NOAA HDSC PFDS)	3.26	0.00
5. Land slope, s (ft/ft)	0.08340	0.00000
$T_t = \frac{0.007\,(nL)^{0.8}}{(P2)^{0.5}(s)^{0.4}}$ $T_t =$	0.09 hours	#VALUE! hours

Shallow Concentrated Flow Properties

Segment ID	SC-1	SC-2	SC-3	SC-4
6. Surface description (NRCS NEH, Table 15-3)	Short-grass pasture	Grassed waterways	Not Used	Not Used
7. Flow length, L (ft)	1329	1133	0	0
8. Watercourse slope, s (ft/ft)	0.03483	0.02514		
9. Average velocity, V (NRCS NEH, Table 15-3)	1.299	2.558		
	V=6.962(s)^0.5	V=16.135(s)^0.5		
$T_t = \frac{L}{3600V}$ $T_t =$	0.28 hours	0.12 hours	#VALUE! hours	#VALUE! hours

Open Channel Flow Properties

Segment ID	CH-1	CH-2	CH-3	CH-4	CH-5
10. Bottom width, B (ft)	2	3	14		
11. Depth flowing full, D (ft)	3.41	3.28	2.8		
12. Channel side slope, z H : 1 V	2.5	3	1.6		
13. Cross sectional area, A (sq ft)	35.89025	42.1152	51.744	0	0
14. Wetted perimeter, P (ft)	20.36	23.74	24.57	0.00	0.00
15. Hydraulic radius, r = A/P (ft)	1.76	1.77	2.11		
16. Channel slope, s (ft/ft)	0.01346	0.00976	0.00674		
17. Manning's roughness coefficient, n	0.035	0.035	0.025	0.040	0.040
18. Velocity, V (ft/sec)	7.21	6.16	8.04	0.00	0.00
$V = \frac{1.49(r^{2/3})(s^{1/2})}{n}$					
19. Flow length, L (ft)	2067	2121	2371	0	0
$T_t = \frac{L}{3600V}$ Tt =	0.08 hours	0.10 hours	0.08 hours	#DIV/0! hours	#DIV/0! hours



Results

Time of Concentration =	**0.58**	**hours**	**=**	**34.69**	**minutes**
Lag Time =	**0.35**	**hours**	**=**	**20.81**	**minutes**

Gannett Fleming

Time of Concentration Calculation Summary

Project: Upper Merion Township SWM
Location: Upper Merion Township, Montgomery County, PA
Subwatershed: Crow Creek W670

By: YW Date: 5/15/2017
Checked: AKS Date: 6/1/2017

Sheet Flow Properties

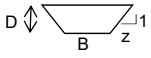
Segment ID	SH-1	SH-2
1. Surface description	Short-Grass Prairie	Not Used
2. Manning's roughness coefficient, n (NRCS NEH,Table 15-1)	0.150	
3. Flow length, L (ft)	100	0
4. Two-year 24-hour rainfall, P2 (in) (NOAA HDSC PFDS)	3.26	0.00
5. Land slope, s (ft/ft)	0.03900	0.00000
$T_t = \frac{0.007\,(nL)^{0.8}}{(P2)^{0.5}(s)^{0.4}}$ $T_t =$	0.12 hours	#VALUE! hours

Shallow Concentrated Flow Properties

Segment ID	SC-1	SC-2	SC-3	SC-4
6. Surface description (NRCS NEH, Table 15-3)	Short-grass pasture	Pavement and small upland gullies	Grassed waterways	Not Used
7. Flow length, L (ft)	385	1712	3324	0
8. Watercourse slope, s (ft/ft)	0.04411	0.02102	0.01048	
9. Average velocity, V (NRCS NEH, Table 15-3)	1.462	2.947	1.652	
	V=6.962(s)^0.5	V =20.328(s)^0.5	V=16.135(s)^0.5	
$T_t = \frac{L}{3600V}$ $T_t =$	0.07 hours	0.16 hours	0.56 hours	#VALUE! hours

Open Channel Flow Properties

Segment ID	CH-1	CH-2	CH-3	CH-4	CH-5
10. Bottom width, B (ft)	15	15			
11. Depth flowing full, D (ft)	1.2	1.4			
12. Channel side slope, z H : 1 V	1.82	1.82			
13. Cross sectional area, A (sq ft)	20.6208	24.5672	0	0	0
14. Wetted perimeter, P (ft)	19.98	20.81	0.00	0.00	0.00
15. Hydraulic radius, r = A/P (ft)	1.03	1.18	#DIV/0!	#DIV/0!	#DIV/0!
16. Channel slope, s (ft/ft)	0.00660	0.00578	#DIV/0!	#DIV/0!	#DIV/0!
17. Manning's roughness coefficient, n	0.035	0.013	0.040	0.040	0.040
18. Velocity, V (ft/sec)	3.53	9.73	#DIV/0!	#DIV/0!	#DIV/0!
$V = \frac{1.49(r^{2/3})(s^{1/2})}{n}$					
19. Flow length, L (ft)	1888	5223	0	0	0
$T_t = \frac{L}{3600V}$ Tt =	0.15 hours	0.15 hours	#DIV/0! hours	#DIV/0! hours	#DIV/0! hours



Results

Time of Concentration =	**1.22**	**hours**	**=**	**72.90**	**minutes**
Lag Time =	**0.73**	**hours**	**=**	**43.74**	**minutes**

Gannett Fleming

Time of Concentration Calculation Summary

Project: Upper Merion Township SWM
Location: Upper Merion Township, Montgomery County, PA
Subwatershed: Crow Creek W640

By: YW Date: 5/15/2017
Checked: AKS Date: 5/30/2017

Flowpath Description:

Sheet Flow Properties

Segment ID	SH-1	SH-2
1. Surface description	Smooth Surface (concrete, asphalt, gravel, or bare soil)	Not Used
2. Manning's roughness coefficient, n (NRCS NEH,Table 15-1)	0.011	
3. Flow length, L (ft)	100	0
4. Two-year 24-hour rainfall, P2 (in) (NOAA HDSC PFDS)	3.26	0.00
5. Land slope, s (ft/ft)	0.03640	0.00000

$$T_t = \frac{0.007\,(nL)^{0.8}}{(P2)^{0.5}(s)^{0.4}}$$

T_t = 0.02 hours | #VALUE! hours

Shallow Concentrated Flow Properties

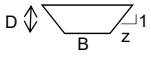
Segment ID	SC-1	SC-2	SC-3	SC-4
6. Surface description (NRCS NEH, Table 15-3)	Pavement and small upland gullies	Not Used	Not Used	Not Used
7. Flow length, L (ft)	3614	0	0	0
8. Watercourse slope, s (ft/ft)	0.00444	#DIV/0!	#DIV/0!	0.00021
9. Average velocity, V (NRCS NEH, Table 15-3)	1.355			
	V =20.328(s)^0.5			

$$T_t = \frac{L}{3600V}$$

T_t = 0.74 hours | #VALUE! hours | #VALUE! hours | #VALUE! hours

Open Channel Flow Properties

Segment ID	CH-1	CH-2	CH-3	CH-4	CH-5
10. Bottom width, B (ft)	20				
11. Depth flowing full, D (ft)	2.79				
12. Channel side slope, z H : 1 V	1.43				
13. Cross sectional area, A (sq ft)	66.931263	0	0	0	0
14. Wetted perimeter, P (ft)	29.74	0.00	0.00	0.00	0.00
15. Hydraulic radius, r = A/P (ft)	2.25	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
16. Channel slope, s (ft/ft)	0.01221	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
17. Manning's roughness coefficient, n	0.035	0.035	0.040	0.040	0.040
18. Velocity, V (ft/sec)	8.08	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!



$$V = \frac{1.49(r^{2/3})(s^{1/2})}{n}$$

19. Flow length, L (ft)	2392	0	0	0	0

$$T_t = \frac{L}{3600V}$$

Tt = 0.08 hours | #DIV/0! hours | #DIV/0! hours | #DIV/0! hours | #DIV/0! hours

Results

Time of Concentration =	**0.84**	**hours**	**=**	**50.33**	**minutes**
Lag Time =	**0.50**	**hours**	**=**	**30.20**	**minutes**

Gannett Fleming

Time of Concentration Calculation Summary

Project:	Upper Merion Township SWM		By:	YW	Date: 5/15/2017
Location:	Upper Merion Township, Montgomery County, PA		Checked:	AKS	Date: 6/1/2017
Subwatershed:	Crow Creek W570				

Sheet Flow Properties

Segment ID	SH-1	SH-2
1. Surface description	Short-Grass Prairie	Not Used
2. Manning's roughness coefficient, n (NRCS NEH,Table 15-1)	0.150	
3. Flow length, L (ft)	100	0
4. Two-year 24-hour rainfall, P2 (in) (NOAA HDSC PFDS)	3.26	0.00
5. Land slope, s (ft/ft)	0.01810	0.00000
$T_t = \frac{0.007\,(nL)^{0.8}}{(P2)^{0.5}(s)^{0.4}}$ $T_t =$	0.17 hours	#VALUE! hours

Shallow Concentrated Flow Properties

Segment ID	SC-1	SC-2	SC-3	SC-4
6. Surface description (NRCS NEH, Table 15-3)	Pavement and small upland gullies	Not Used	Not Used	Not Used
7. Flow length, L (ft)	2709	0	0	0
8. Watercourse slope, s (ft/ft)	0.03638	#DIV/0!	#DIV/0!	0.00021
9. Average velocity, V (NRCS NEH, Table 15-3)	3.877			
	V =20.328(s)^0.5			
$T_t = \frac{L}{3600V}$ $T_t =$	0.19 hours	#VALUE! hours	#VALUE! hours	#VALUE! hours

Open Channel Flow Properties

Segment ID	CH-1	CH-2	CH-3	CH-4	CH-5
10. Bottom width, B (ft)	2	4			
11. Depth flowing full, D (ft)	2.87	2.8			
12. Channel side slope, z H : 1 V	3.33	0			
13. Cross sectional area, A (sq ft)	33.168877	11.2	0	0	0
14. Wetted perimeter, P (ft)	21.96	9.60	0.00	0.00	0.00
15. Hydraulic radius, r = A/P (ft)	1.51	1.17	#DIV/0!	#DIV/0!	#DIV/0!
16. Channel slope, s (ft/ft)	0.00548	0.01100	#DIV/0!	#DIV/0!	#DIV/0!
17. Manning's roughness coefficient, n	0.035	0.014	0.040	0.040	0.040
18. Velocity, V (ft/sec)	4.15	12.37	#DIV/0!	#DIV/0!	#DIV/0!
$V = \frac{1.49(r^{2/3})(s^{1/2})}{n}$					
19. Flow length, L (ft)	2561	1379	0	0	0
$T_t = \frac{L}{3600V}$ Tt =	0.17 hours	0.03 hours	#DIV/0! hours	#DIV/0! hours	#DIV/0! hours

D, B, z, 1

Results

Time of Concentration =	**0.56**	**hours**	**=**	**33.89**	**minutes**
Lag Time =	**0.34**	**hours**	**=**	**20.33**	**minutes**

Gannett Fleming

Time of Concentration Calculation Summary

Project:	Upper Merion Township SWM		By:	YW	Date: 5/15/2017
Location:	Upper Merion Township, Montgomery County, PA		Checked:	AKS	Date: 5/30/2017
Subwatershed:	Crow Creek W560				

Flowpath Description:

Sheet Flow Properties

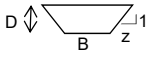
Segment ID	SH-1	SH-2
1. Surface description	Short-Grass Prairie	Not Used
2. Manning's roughness coefficient, n (NRCS NEH,Table 15-1)	0.150	
3. Flow length, L (ft)	100	0
4. Two-year 24-hour rainfall, P2 (in) (NOAA HDSC PFDS)	3.26	0.00
5. Land slope, s (ft/ft)	0.03740	0.00000
$T_t = \frac{0.007\,(nL)^{0.8}}{(P2)^{0.5}(s)^{0.4}}$ $T_t =$	0.13 hours	#VALUE! hours

Shallow Concentrated Flow Properties

Segment ID	SC-1	SC-2	SC-3	SC-4
6. Surface description (NRCS NEH, Table 15-3)	Short-grass pasture	Pavement and small upland gullies	Short-grass pasture	Not Used
7. Flow length, L (ft)	722	2871	877	0
8. Watercourse slope, s (ft/ft)	0.02492	0.00754	0.01179	
9. Average velocity, V (NRCS NEH, Table 15-3)	1.099	1.765	0.756	
	V=6.962(s)^0.5	V =20.328(s)^0.5	V=6.962(s)^0.5	
$T_t = \frac{L}{3600V}$ $T_t =$	0.18 hours	0.45 hours	0.32 hours	#VALUE! hours

Open Channel Flow Properties

Segment ID	CH-1	CH-2	CH-3	CH-4	CH-5
10. Bottom width, B (ft)	20				
11. Depth flowing full, D (ft)	4.47				
12. Channel side slope, z H : 1 V	1.25				
13. Cross sectional area, A (sq ft)	114.376125	0	0	0	0
14. Wetted perimeter, P (ft)	34.31	0.00	0.00	0.00	0.00
15. Hydraulic radius, r = A/P (ft)	3.33	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
16. Channel slope, s (ft/ft)	0.00383	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
17. Manning's roughness coefficient, n	0.035	0.014	0.040	0.040	0.040
18. Velocity, V (ft/sec)	5.88	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
$V = \frac{1.49(r^{2/3})(s^{1/2})}{n}$					
19. Flow length, L (ft)	1187	0	0	0	0
$T_t = \frac{L}{3600V}$ Tt =	0.06 hours	#DIV/0! hours	#DIV/0! hours	#DIV/0! hours	#DIV/0! hours



Results

Time of Concentration =	**1.14**	**hours**	**=**	**68.30**	**minutes**
Lag Time =	**0.68**	**hours**	**=**	**40.98**	**minutes**

Gannett Fleming

Time of Concentration Calculation Summary

Project:	Upper Merion Township SWM		By:	YW	Date: 5/15/2017
Location:	Upper Merion Township, Montgomery County, PA		Checked:	AKS	Date: 5/30/2017
Subwatershed:	Crow Creek W540				

Sheet Flow Properties

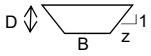
Segment ID	SH-1	SH-2
1. Surface description	Smooth Surface (concrete, asphalt, gravel, or bare soil)	Not Used
2. Manning's roughness coefficient, n (NRCS NEH,Table 15-1)	0.011	
3. Flow length, L (ft)	100	0
4. Two-year 24-hour rainfall, P2 (in) (NOAA HDSC PFDS)	3.26	0.00
5. Land slope, s (ft/ft)	0.02940	0.00000
$T_t = \frac{0.007\,(nL)^{0.8}}{(P2)^{0.5}(s)^{0.4}}$	T_t = 0.02 hours	#VALUE! hours

Shallow Concentrated Flow Properties

Segment ID	SC-1	SC-2	SC-3	SC-4
6. Surface description (NRCS NEH, Table 15-3)	Pavement and small upland gullies	Pavement and small upland gullies	Short-grass pasture	Not Used
7. Flow length, L (ft)	3932	3035	0	0
8. Watercourse slope, s (ft/ft)	0.02671	0.02766	#DIV/0!	
9. Average velocity, V (NRCS NEH, Table 15-3)	3.322	3.381	#DIV/0!	
	V =20.328(s)^0.5	V =20.328(s)^0.5	V=6.962(s)^0.5	
$T_t = \frac{L}{3600V}$ T_t =	0.33 hours	0.25 hours	#DIV/0! hours	#VALUE! hours

Open Channel Flow Properties

Segment ID	CH-1	CH-2	CH-3	CH-4	CH-5
10. Bottom width, B (ft)					
11. Depth flowing full, D (ft)					
12. Channel side slope, z H : 1 V					
13. Cross sectional area, A (sq ft)	0	0	0	0	0
14. Wetted perimeter, P (ft)	0.00	0.00	0.00	0.00	0.00
15. Hydraulic radius, r = A/P (ft)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
16. Channel slope, s (ft/ft)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
17. Manning's roughness coefficient, n	0.035	0.014	0.040	0.040	0.040
18. Velocity, V (ft/sec)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
$V = \frac{1.49(r^{2/3})(s^{1/2})}{n}$					
19. Flow length, L (ft)	0	0	0	0	0
$T_t = \frac{L}{3600V}$ Tt =	#DIV/0! hours	#DIV/0! hours	#DIV/0! hours	#DIV/0! hours	#DIV/0! hours



Results

Time of Concentration =	**0.60**	**hours**	**=**	**35.72**	**minutes**
Lag Time =	**0.36**	**hours**	**=**	**21.43**	**minutes**

Gannett Fleming

Time of Concentration Calculation Summary

Project:	Upper Merion Township SWM		By:	YW	Date: 5/15/2017
Location:	Upper Merion Township, Montgomery County, PA		Checked:	AKS	Date: 5/30/2017
Subwatershed:	Crow Creek W560				

Sheet Flow Properties

Segment ID	SH-1	SH-2
1. Surface description	Smooth Surface (concrete, asphalt, gravel, or bare soil)	Not Used
2. Manning's roughness coefficient, n (NRCS NEH,Table 15-1)	0.011	
3. Flow length, L (ft)	100	0
4. Two-year 24-hour rainfall, P2 (in) (NOAA HDSC PFDS)	3.26	0.00
5. Land slope, s (ft/ft)	0.03940	0.00000

$$T_t = \frac{0.007\,(nL)^{0.8}}{(P2)^{0.5}(s)^{0.4}}$$

T_t = 0.02 hours | #VALUE! hours

Shallow Concentrated Flow Properties

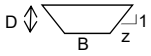
Segment ID	SC-1	SC-2	SC-3	SC-4
6. Surface description (NRCS NEH, Table 15-3)	Grassed waterways	Pavement and small upland gullies	Short-grass pasture	Grassed waterways
7. Flow length, L (ft)	1637	2280	1789	2174
8. Watercourse slope, s (ft/ft)	0.01218	0.01636	0.01978	0.01170
9. Average velocity, V (NRCS NEH, Table 15-3)	1.780	2.600	0.979	1.745
	V=16.135(s)^0.5	V =20.328(s)^0.5	V=6.962(s)^0.5	V=16.135(s)^0.5

$$T_t = \frac{L}{3600V}$$

T_t = 0.26 hours | 0.24 hours | 0.51 hours | 0.35 hours

Open Channel Flow Properties

Segment ID	CH-1	CH-2	CH-3	CH-4	CH-5
10. Bottom width, B (ft)	35				
11. Depth flowing full, D (ft)	3.5				
12. Channel side slope, z H : 1 V	1.43				
13. Cross sectional area, A (sq ft)	140.0175	0	0	0	0
14. Wetted perimeter, P (ft)	47.21	0.00	0.00	0.00	0.00
15. Hydraulic radius, r = A/P (ft)	2.97	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
16. Channel slope, s (ft/ft)	0.00358	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
17. Manning's roughness coefficient, n	0.035	0.000	0.000	0.000	0.000
18. Velocity, V (ft/sec)	5.26	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!



$$V = \frac{1.49(r^{2/3})(s^{1/2})}{n}$$

19. Flow length, L (ft)	1067	0	0	0	0
T_t =	0.06 hours	#DIV/0! hours	#DIV/0! hours	#DIV/0! hours	#DIV/0! hours

$$T_t = \frac{L}{3600V}$$

Results

Time of Concentration =	**1.42**	**hours**	**=**	**85.46**	**minutes**
Lag Time =	**0.85**	**hours**	**=**	**51.28**	**minutes**

Gannett Fleming

Time of Concentration Calculation Summary

Project:	Upper Merion Township SWM		By:	YW	Date: 6/20/2017
Location:	Upper Merion Township, Montgomery County, PA		Checked:	AKS	Date: 6/30/2017
Subwatershed:	Trout Creek W100				

Sheet Flow Properties

Segment ID	SH-1	SH-2
1. Surface description	Smooth Surface (concrete, asphalt, gravel, or bare soil)	Not Used
2. Manning's roughness coefficient, n (NRCS NEH,Table 15-1)	0.011	
3. Flow length, L (ft)	100	
4. Two-year 24-hour rainfall, P2 (in) (NOAA HDSC PFDS)	3.26	
5. Land slope, s (ft/ft)	0.08640	

$$T_t = \frac{0.007\,(nL)^{0.8}}{(P2)^{0.5}(s)^{0.4}}$$

T_t = 0.01 hours

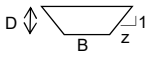
Shallow Concentrated Flow Properties

Segment ID	SC-1	SC-2	SC-3	SC-4
6. Surface description (NRCS NEH, Table 15-3)	Pavement and small upland gullies	Short-grass pasture	Not Used	Not Used
7. Flow length, L (ft)	1271	2260		
8. Watercourse slope, s (ft/ft)	0.03005	0.05523		
9. Average velocity, V (NRCS NEH, Table 15-3)	3.524	1.636		
	V =20.328(s)^0.5	V=6.962(s)^0.5		
T_t =	0.10 hours	0.38 hours		

$$T_t = \frac{L}{3600V}$$

Open Channel Flow Properties

Segment ID	CH-1	CH-2	CH-3	CH-4	CH-5
10. Bottom width, B (ft)	35				
11. Depth flowing full, D (ft)	4.3				
12. Channel side slope, z H : 1 V	2				
13. Cross sectional area, A (sq ft)	187.48				
14. Wetted perimeter, P (ft)	54.23				
15. Hydraulic radius, r = A/P (ft)	3.46				
16. Channel slope, s (ft/ft)	0.00299				
17. Manning's roughness coefficient, n	0.035				
18. Velocity, V (ft/sec)	5.32				
19. Flow length, L (ft)	4951				
Tt =	0.26 hours				



$$V = \frac{1.49(r^{2/3})(s^{1/2})}{n}$$

$$T_t = \frac{L}{3600V}$$

Results

Time of Concentration =	**0.75**	**hours**	**=**	**45.22**	**minutes**
Lag Time =	**0.45**	**hours**	**=**	**27.13**	**minutes**

Gannett Fleming

Time of Concentration Calculation Summary

Project:	Upper Merion Township SWM		By:	YW	Date: 6/20/2017
Location:	Upper Merion Township, Montgomery County, PA		Checked:	AKS	Date: 6/30/2017
Subwatershed:	Trout Creek W120				

Sheet Flow Properties

Segment ID	SH-1	SH-2
1. Surface description	Short-Grass Prairie	Not Used
2. Manning's roughness coefficient, n (NRCS NEH,Table 15-1)	0.150	
3. Flow length, L (ft)	100	
4. Two-year 24-hour rainfall, P2 (in) (NOAA HDSC PFDS)	3.26	
5. Land slope, s (ft/ft)	0.01960	

$$T_t = \frac{0.007\,(nL)^{0.8}}{(P2)^{0.5}(s)^{0.4}}$$

T_t = 0.16 hours

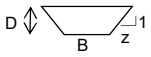
Shallow Concentrated Flow Properties

Segment ID	SC-1	SC-2	SC-3	SC-4
6. Surface description (NRCS NEH, Table 15-3)	Pavement and small upland gullies	Grassed waterways	Not Used	Not Used
7. Flow length, L (ft)	1754	1057		
8. Watercourse slope, s (ft/ft)	0.01314	0.02018		
9. Average velocity, V (NRCS NEH, Table 15-3)	2.330	2.292		
	V =20.328(s)^0.5	V=16.135(s)^0.5		
T_t =	0.21 hours	0.13 hours		

$$T_t = \frac{L}{3600V}$$

Open Channel Flow Properties

Segment ID	CH-1	CH-2	CH-3	CH-4	CH-5
10. Bottom width, B (ft)	20				
11. Depth flowing full, D (ft)	2.1				
12. Channel side slope, z H : 1 V	2.4				
13. Cross sectional area, A (sq ft)	52.584				
14. Wetted perimeter, P (ft)	30.92				
15. Hydraulic radius, r = A/P (ft)	1.70				
16. Channel slope, s (ft/ft)	0.00820				
17. Manning's roughness coefficient, n	0.035				
18. Velocity, V (ft/sec)	5.49				
19. Flow length, L (ft)	6660				
Tt =	0.34 hours				



$$V = \frac{1.49(r^{2/3})(s^{1/2})}{n}$$

$$T_t = \frac{L}{3600V}$$

Results

Time of Concentration =	**0.84**	**hours**	**=**	**50.23**	**minutes**
Lag Time =	**0.50**	**hours**	**=**	**30.14**	**minutes**

Gannett Fleming

Time of Concentration Calculation Summary

Project:	Upper Merion Township SWM		By:	YW	Date: 6/20/2017
Location:	Upper Merion Township, Montgomery County, PA		Checked:	AKS	Date: 6/30/2017
Subwatershed:	Trout Creek W130				

Sheet Flow Properties

Segment ID	SH-1	SH-2
1. Surface description	Short-Grass Prairie	Not Used
2. Manning's roughness coefficient, n (NRCS NEH,Table 15-1)	0.150	
3. Flow length, L (ft)	100	
4. Two-year 24-hour rainfall, P2 (in) (NOAA HDSC PFDS)	3.26	
5. Land slope, s (ft/ft)	0.03430	

$$T_t = \frac{0.007\,(nL)^{0.8}}{(P2)^{0.5}(s)^{0.4}}$$

T_t = 0.13 hours

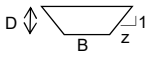
Shallow Concentrated Flow Properties

Segment ID	SC-1	SC-2	SC-3	SC-4
6. Surface description (NRCS NEH, Table 15-3)	Short-grass pasture	Pavement and small upland gullies	Not Used	Not Used
7. Flow length, L (ft)	3125	2367		
8. Watercourse slope, s (ft/ft)	0.01569	0.01796		
9. Average velocity, V (NRCS NEH, Table 15-3)	0.872	2.724		
	V=6.962(s)^0.5	V =20.328(s)^0.5		
T_t =	1.00 hours	0.24 hours		

$$T_t = \frac{L}{3600V}$$

Open Channel Flow Properties

Segment ID	CH-1	CH-2	CH-3	CH-4	CH-5
10. Bottom width, B (ft)	26				
11. Depth flowing full, D (ft)	2.9				
12. Channel side slope, z H : 1 V	1.9				
13. Cross sectional area, A (sq ft)	91.379				
14. Wetted perimeter, P (ft)	38.45				
15. Hydraulic radius, r = A/P (ft)	2.38				
16. Channel slope, s (ft/ft)	0.00656				
17. Manning's roughness coefficient, n	0.035				
18. Velocity, V (ft/sec)	6.14				
19. Flow length, L (ft)	5386				
Tt =	0.24 hours				



$$V = \frac{1.49(r^{2/3})(s^{1/2})}{n}$$

$$T_t = \frac{L}{3600V}$$

Results

Time of Concentration =	**1.61**	**hours**	**=**	**96.65**	**minutes**
Lag Time =	**0.97**	**hours**	**=**	**57.99**	**minutes**

Gannett Fleming

Time of Concentration Calculation Summary

Project:	Upper Merion Township SWM		By:	YW	Date: 6/20/2017
Location:	Upper Merion Township, Montgomery County, PA		Checked:	AKS	Date: 6/30/2017
Subwatershed:	Trout Creek W140				

Flowpath Description:

Sheet Flow Properties

Segment ID	SH-1	SH-2
1. Surface description	Smooth Surface (concrete, asphalt, gravel, or bare soil)	Not Used
2. Manning's roughness coefficient, n (NRCS NEH,Table 15-1)	0.011	
3. Flow length, L (ft)	100	
4. Two-year 24-hour rainfall, P2 (in) (NOAA HDSC PFDS)	3.26	
5. Land slope, s (ft/ft)	0.11800	

$$T_t = \frac{0.007\,(nL)^{0.8}}{(P2)^{0.5}(s)^{0.4}}$$

T_t = 0.01 hours

Shallow Concentrated Flow Properties

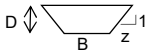
Segment ID	SC-1	SC-2	SC-3	SC-4
6. Surface description (NRCS NEH, Table 15-3)	Pavement and small upland gullies	Not Used	Not Used	Not Used
7. Flow length, L (ft)	2086			
8. Watercourse slope, s (ft/ft)	0.03179			
9. Average velocity, V (NRCS NEH, Table 15-3)	3.625			
	V =20.328(s)^0.5			

$$T_t = \frac{L}{3600V}$$

T_t = 0.16 hours

Open Channel Flow Properties

Segment ID	CH-1	CH-2	CH-3	CH-4	CH-5
10. Bottom width, B (ft)	5	7	20		
11. Depth flowing full, D (ft)	1	1.2	3		
12. Channel side slope, z H : 1 V	1	1	2		
13. Cross sectional area, A (sq ft)	6	9.84	78		
14. Wetted perimeter, P (ft)	7.83	10.39	33.42		
15. Hydraulic radius, r = A/P (ft)	0.77	0.95	2.33		
16. Channel slope, s (ft/ft)	0.00578	0.01370	0.00524		
17. Manning's roughness coefficient, n	0.030	0.035	0.035		
18. Velocity, V (ft/sec)	3.16	4.80	5.42		
19. Flow length, L (ft)	1130	2253	1287		
Tt =	0.10 hours	0.13 hours	0.07 hours		



$$V = \frac{1.49(r^{2/3})(s^{1/2})}{n}$$

$$T_t = \frac{L}{3600V}$$

Results

Time of Concentration =	**0.47**	**hours**	**=**	**27.91**	**minutes**
Lag Time =	**0.28**	**hours**	**=**	**16.75**	**minutes**

Gannett Fleming

Time of Concentration Calculation Summary

Project:	Upper Merion Township SWM		By:	YW	Date: 6/20/2017
Location:	Upper Merion Township, Montgomery County, PA		Checked:	AKS	Date: 6/30/2017
Subwatershed:	Trout Creek W150				

Sheet Flow Properties

Segment ID	SH-1	SH-2
1. Surface description	Short-Grass Prairie	Not Used
2. Manning's roughness coefficient, n (NRCS NEH,Table 15-1)	0.150	
3. Flow length, L (ft)	100	
4. Two-year 24-hour rainfall, P2 (in) (NOAA HDSC PFDS)	3.26	
5. Land slope, s (ft/ft)	0.02560	

$$T_t = \frac{0.007\,(nL)^{0.8}}{(P2)^{0.5}(s)^{0.4}}$$

T_t = 0.15 hours

Shallow Concentrated Flow Properties

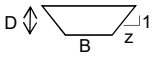
Segment ID	SC-1	SC-2	SC-3	SC-4
6. Surface description (NRCS NEH, Table 15-3)	Short-grass pasture	Not Used	Not Used	Not Used
7. Flow length, L (ft)	4043			
8. Watercourse slope, s (ft/ft)	0.06618			
9. Average velocity, V (NRCS NEH, Table 15-3)	1.791			
	V=6.962(s)^0.5			

$$T_t = \frac{L}{3600V}$$

T_t = 0.63 hours

Open Channel Flow Properties

Segment ID	CH-1	CH-2	CH-3	CH-4	CH-5
10. Bottom width, B (ft)	10	10			
11. Depth flowing full, D (ft)	2.1	2.6			
12. Channel side slope, z H : 1 V	2	2			
13. Cross sectional area, A (sq ft)	29.82	39.52			
14. Wetted perimeter, P (ft)	19.39	21.63			
15. Hydraulic radius, r = A/P (ft)	1.54	1.83			
16. Channel slope, s (ft/ft)	0.02131	0.00948			
17. Manning's roughness coefficient, n	0.035	0.035			
18. Velocity, V (ft/sec)	8.28	6.20			



$$V = \frac{1.49(r^{2/3})(s^{1/2})}{n}$$

19. Flow length, L (ft)	5380	4940
T_t =	0.18 hours	0.22 hours

$$T_t = \frac{L}{3600V}$$

Results

Time of Concentration =	**1.18**	**hours**	**=**	**70.54**	**minutes**
Lag Time =	**0.71**	**hours**	**=**	**42.32**	**minutes**

Gannett Fleming

Time of Concentration Calculation Summary

Project:	Upper Merion Township SWM		By:	YW	Date: 6/20/2017
Location:	Upper Merion Township, Montgomery County, PA		Checked:	AKS	Date: 6/30/2017
Subwatershed:	Trout Creek W160				

Sheet Flow Properties

Segment ID	SH-1	SH-2
1. Surface description	Woods - Light Underbrush	Not Used
2. Manning's roughness coefficient, n (NRCS NEH,Table 15-1)	0.400	
3. Flow length, L (ft)	100	
4. Two-year 24-hour rainfall, P2 (in) (NOAA HDSC PFDS)	3.26	
5. Land slope, s (ft/ft)	0.01950	

$$T_t = \frac{0.007\,(nL)^{0.8}}{(P2)^{0.5}(s)^{0.4}}$$

T_t = 0.36 hours

Shallow Concentrated Flow Properties

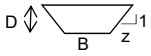
Segment ID	SC-1	SC-2	SC-3	SC-4
6. Surface description (NRCS NEH, Table 15-3)	Short-grass pasture	Not Used	Not Used	Not Used
7. Flow length, L (ft)	2726			
8. Watercourse slope, s (ft/ft)	0.05767			
9. Average velocity, V (NRCS NEH, Table 15-3)	1.672			
	V=6.962(s)^0.5			

$$T_t = \frac{L}{3600V}$$

T_t = 0.45 hours

Open Channel Flow Properties

Segment ID	CH-1	CH-2	CH-3	CH-4	CH-5
10. Bottom width, B (ft)	5	8			
11. Depth flowing full, D (ft)	2.4	2.7			
12. Channel side slope, z H : 1 V	2	2.1			
13. Cross sectional area, A (sq ft)	23.52	36.909			
14. Wetted perimeter, P (ft)	15.73	20.56			
15. Hydraulic radius, r = A/P (ft)	1.49	1.80			
16. Channel slope, s (ft/ft)	0.03782	0.01185			
17. Manning's roughness coefficient, n	0.035	0.035			
18. Velocity, V (ft/sec)	10.82	6.84			
19. Flow length, L (ft)	5142	6715			
Tt =	0.13 hours	0.27 hours			



$$V = \frac{1.49(r^{2/3})(s^{1/2})}{n}$$

$$T_t = \frac{L}{3600V}$$

Results

Time of Concentration =	**1.22**	**hours**	**=**	**72.93**	**minutes**
Lag Time =	**0.73**	**hours**	**=**	**43.76**	**minutes**

Gannett Fleming

Time of Concentration Calculation Summary

Project:	Upper Merion Township SWM		By:	YW	Date: 6/20/2017
Location:	Upper Merion Township, Montgomery County, PA		Checked:	AKS	Date: 6/30/2017
Subwatershed:	Trout Creek W170				

Sheet Flow Properties

Segment ID	SH-1	SH-2
1. Surface description	Short-Grass Prairie	Not Used
2. Manning's roughness coefficient, n (NRCS NEH,Table 15-1)	0.150	
3. Flow length, L (ft)	100	
4. Two-year 24-hour rainfall, P2 (in) (NOAA HDSC PFDS)	3.26	
5. Land slope, s (ft/ft)	0.00390	

$$T_t = \frac{0.007\,(nL)^{0.8}}{(P2)^{0.5}(s)^{0.4}}$$

T_t = 0.31 hours

Shallow Concentrated Flow Properties

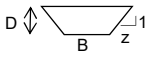
Segment ID	SC-1	SC-2	SC-3	SC-4
6. Surface description (NRCS NEH, Table 15-3)	Pavement and small upland gullies	Short-grass pasture	Not Used	Not Used
7. Flow length, L (ft)	858	722		
8. Watercourse slope, s (ft/ft)	0.01934	0.06371		
9. Average velocity, V (NRCS NEH, Table 15-3)	2.827	1.757		
	V =20.328(s)^0.5	V=6.962(s)^0.5		

$$T_t = \frac{L}{3600V}$$

T_t = 0.08 hours | 0.11 hours

Open Channel Flow Properties

Segment ID	CH-1	CH-2	CH-3	CH-4	CH-5
10. Bottom width, B (ft)	10	15	20	25	
11. Depth flowing full, D (ft)	1.15	1.15	2.2	2.11	
12. Channel side slope, z H : 1 V	1	1	2	2	
13. Cross sectional area, A (sq ft)	12.8225	18.5725	53.68	61.6542	
14. Wetted perimeter, P (ft)	13.25	18.25	29.84	34.44	
15. Hydraulic radius, r = A/P (ft)	0.97	1.02	1.80	1.79	
16. Channel slope, s (ft/ft)	0.04608	0.02007	0.01159	0.00864	
17. Manning's roughness coefficient, n	0.035	0.035	0.035	0.035	
18. Velocity, V (ft/sec)	8.94	6.10	6.78	5.83	



$$V = \frac{1.49(r^{2/3})(s^{1/2})}{n}$$

19. Flow length, L (ft)	4590	2835	3615	3053

$$T_t = \frac{L}{3600V}$$

Tt = 0.14 hours | 0.13 hours | 0.15 hours | 0.15 hours

Results

Time of Concentration =	**1.07**	**hours**	**=**	**64.48**	**minutes**
Lag Time =	**0.64**	**hours**	**=**	**38.69**	**minutes**

Gannett Fleming

Time of Concentration Calculation Summary

Project:	Upper Merion Township SWM		By:	YW	Date: 6/20/2017
Location:	Upper Merion Township, Montgomery County, PA		Checked:	AKS	Date: 6/30/2017
Subwatershed:	Trout Creek W180				

Sheet Flow Properties

Segment ID	SH-1	SH-2
1. Surface description	Short-Grass Prairie	Not Used
2. Manning's roughness coefficient, n (NRCS NEH,Table 15-1)	0.150	
3. Flow length, L (ft)	100	
4. Two-year 24-hour rainfall, P2 (in) (NOAA HDSC PFDS)	3.26	
5. Land slope, s (ft/ft)	0.04020	

$$T_t = \frac{0.007\,(nL)^{0.8}}{(P2)^{0.5}(s)^{0.4}}$$

T_t = 0.12 hours

Shallow Concentrated Flow Properties

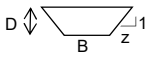
Segment ID	SC-1	SC-2	SC-3	SC-4
6. Surface description (NRCS NEH, Table 15-3)	Short-grass pasture			
7. Flow length, L (ft)	3679			
8. Watercourse slope, s (ft/ft)	0.02786			
9. Average velocity, V (NRCS NEH, Table 15-3)	1.162			
	V=6.962(s)^0.5			

$$T_t = \frac{L}{3600V}$$

T_t = 0.88 hours

Open Channel Flow Properties

Segment ID	CH-1	CH-2	CH-3	CH-4	CH-5
10. Bottom width, B (ft)	5	5	6		
11. Depth flowing full, D (ft)	2	2.3	2.5		
12. Channel side slope, z H : 1 V	2.4	2.2	2.6		
13. Cross sectional area, A (sq ft)	19.6	23.138	31.25		
14. Wetted perimeter, P (ft)	15.40	16.12	19.93		
15. Hydraulic radius, r = A/P (ft)	1.27	1.44	1.57		
16. Channel slope, s (ft/ft)	0.04543	0.02773	0.01340		
17. Manning's roughness coefficient, n	0.035	0.035	0.035		
18. Velocity, V (ft/sec)	10.66	9.02	6.65		



$$V = \frac{1.49(r^{2/3})(s^{1/2})}{n}$$

19. Flow length, L (ft)	3093	3576	2772		
T_t =	0.08 hours	0.11 hours	0.12 hours		

$$T_t = \frac{L}{3600V}$$

Results

Time of Concentration =	**1.31**	**hours**	**=**	**78.49**	**minutes**
Lag Time =	**0.78**	**hours**	**=**	**47.10**	**minutes**

Gannett Fleming

Time of Concentration Calculation Summary

Project: Upper Merion Township SWM
Location: Upper Merion Township, Montgomery County, PA
Subwatershed: Trout Creek W200

By: YW Date: 6/20/2017
Checked: Date:

Flowpath Description:

Sheet Flow Properties

Segment ID	SH-1	SH-2
1. Surface description	Smooth Surface (concrete, asphalt, gravel, or bare soil)	Not Used
2. Manning's roughness coefficient, n (NRCS NEH,Table 15-1)	0.011	
3. Flow length, L (ft)	100	
4. Two-year 24-hour rainfall, P2 (in) (NOAA HDSC PFDS)	3.26	
5. Land slope, s (ft/ft)	0.02610	

$$T_t = \frac{0.007\,(nL)^{0.8}}{(P2)^{0.5}(s)^{0.4}}$$

T_t = 0.02 hours

Shallow Concentrated Flow Properties

Segment ID	SC-1	SC-2	SC-3	SC-4
6. Surface description (NRCS NEH, Table 15-3)	Short-grass pasture	Not Used	Not Used	Not Used
7. Flow length, L (ft)	3872			
8. Watercourse slope, s (ft/ft)	0.01514			
9. Average velocity, V (NRCS NEH, Table 15-3)	0.857			
	V=6.962(s)^0.5			

$$T_t = \frac{L}{3600V}$$

T_t = 1.26 hours

Open Channel Flow Properties

Segment ID	CH-1	CH-2	CH-3	CH-4	CH-5
10. Bottom width, B (ft)	20				
11. Depth flowing full, D (ft)	5.6				
12. Channel side slope, z H : 1 V	1.25				
13. Cross sectional area, A (sq ft)	151.2	0	0	0	0
14. Wetted perimeter, P (ft)	37.93	0.00	0.00	0.00	0.00
15. Hydraulic radius, r = A/P (ft)	3.99	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
16. Channel slope, s (ft/ft)	0.00271	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
17. Manning's roughness coefficient, n	0.035	0.014	0.040	0.040	0.040
18. Velocity, V (ft/sec)	5.57	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
19. Flow length, L (ft)	4726	0	0	0	0
Tt =	0.24 hours	#DIV/0! hours	#DIV/0! hours	#DIV/0! hours	#DIV/0! hours

D, B, z, 1

$$V = \frac{1.49(r^{2/3})(s^{1/2})}{n}$$

$$T_t = \frac{L}{3600V}$$

Results

Time of Concentration =	**1.51**	**hours**	**=**	**90.55**	**minutes**
Lag Time =	**0.91**	**hours**	**=**	**54.33**	**minutes**

Gannett Fleming

Time of Concentration Calculation Summary

Project:	Upper Merion Township SWM		By:	YW	Date: 6/20/2017
Location:	Upper Merion Township, Montgomery County, PA		Checked:	AKS	Date: 6/30/2017
Subwatershed:	Trout Creek W210				

Sheet Flow Properties

Segment ID	SH-1	SH-2
1. Surface description	Smooth Surface (concrete, asphalt, gravel, or bare soil)	Not Used
2. Manning's roughness coefficient, n (NRCS NEH,Table 15-1)	0.011	
3. Flow length, L (ft)	100	
4. Two-year 24-hour rainfall, P2 (in) (NOAA HDSC PFDS)	3.26	
5. Land slope, s (ft/ft)	0.02450	

$$T_t = \frac{0.007\,(nL)^{0.8}}{(P2)^{0.5}(s)^{0.4}}$$

T_t = 0.02 hours

Shallow Concentrated Flow Properties

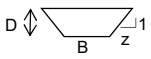
Segment ID	SC-1	SC-2	SC-3	SC-4
6. Surface description (NRCS NEH, Table 15-3)	Short-grass pasture	Short-grass pasture	Short-grass pasture	Not Used
7. Flow length, L (ft)	763	1176	1589	
8. Watercourse slope, s (ft/ft)	0.01755	0.01437	0.02039	
9. Average velocity, V (NRCS NEH, Table 15-3)	0.922	0.834	0.994	
	V=6.962(s)^0.5	V=6.962(s)^0.5	V=6.962(s)^0.5	

$$T_t = \frac{L}{3600V}$$

T_t = 0.23 hours | 0.39 hours | 0.44 hours

Open Channel Flow Properties

Segment ID	CH-1	CH-2	CH-3	CH-4	CH-5
10. Bottom width, B (ft)	35				
11. Depth flowing full, D (ft)	3.6				
12. Channel side slope, z H : 1 V	1.6				
13. Cross sectional area, A (sq ft)	146.736				
14. Wetted perimeter, P (ft)	48.58				
15. Hydraulic radius, r = A/P (ft)	3.02				
16. Channel slope, s (ft/ft)	0.00392				
17. Manning's roughness coefficient, n	0.035				
18. Velocity, V (ft/sec)	5.57				



$$V = \frac{1.49(r^{2/3})(s^{1/2})}{n}$$

19. Flow length, L (ft)	1508				

$$T_t = \frac{L}{3600V}$$

Tt = 0.08 hours

Results

Time of Concentration =	**1.16**	**hours**	**=**	**69.53**	**minutes**
Lag Time =	**0.70**	**hours**	**=**	**41.72**	**minutes**

Gannett Fleming

Upper Merion Township
Montgomery County, PA
Time of Concentration Calculation Summary

Project: Upper Merion Township SWM
Location: Upper Merion Township, Montgomery County, PA
Subwatershed: Abram Creek

By: YW Date: 5/12/2017
Checked: AKS Date: 5/26/2017

Flowpath Description:

Sheet Flow Properties

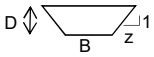
Segment ID	SH-1	SH-2
1. Surface description	Short-Grass Prairie	Not Used
2. Manning's roughness coefficient, n (NRCS NEH,Table 15-1)	0.150	
3. Flow length, L (ft)	100	0
4. Two-year 24-hour rainfall, P2 (in) (NOAA HDSC PFDS)	3.26	0.00
5. Land slope, s (ft/ft)	0.02200	0.00000
$T_t = \frac{0.007\,(nL)^{0.8}}{(P2)^{0.5}(s)^{0.4}}$	T_t = 0.16 hours	#VALUE! hours

Shallow Concentrated Flow Properties

Segment ID	SC-1	SC-2	SC-3	SC-4
6. Surface description (NRCS NEH, Table 15-3)	Short-grass pasture	Pavement and small upland gullies	Short-grass pasture	Pavement and small upland gullies
7. Flow length, L (ft)	1144	919	1417	839
8. Watercourse slope, s (ft/ft)	0.03333	0.02127	0.03200	0.02688
9. Average velocity, V (NRCS NEH, Table 15-3)	1.271	2.965	1.245	3.333
	V=6.962(s)^0.5	V =20.328(s)^0.5	V=6.962(s)^0.5	V =20.328(s)^0.5
$T_t = \frac{L}{3600V}$	T_t = 0.25 hours	0.09 hours	0.32 hours	0.07 hours

Open Channel Flow Properties

Segment ID	CH-1	CH-2	CH-3	CH-4	CH-5
10. Bottom width, B (ft)	10				
11. Depth flowing full, D (ft)	1.03				
12. Channel side slope, z H : 1 V	2				
13. Cross sectional area, A (sq ft)	12.4218	0	0	0	0
14. Wetted perimeter, P (ft)	14.61	0.00	0.00	0.00	0.00
15. Hydraulic radius, r = A/P (ft)	0.85	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
16. Channel slope, s (ft/ft)	0.03971	0.01572	0.00457	0.00457	0.00457
17. Manning's roughness coefficient, n	0.035	0.040	0.040	0.040	0.040
18. Velocity, V (ft/sec)	7.61	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
$V = \frac{1.49(r^{2/3})(s^{1/2})}{n}$					
19. Flow length, L (ft)	949	0	0	0	0
$T_t = \frac{L}{3600V}$	Tt = 0.03 hours	#DIV/0! hours	#DIV/0! hours	#DIV/0! hours	#DIV/0! hours



Results

Time of Concentration =	**0.91**	**hours**	**=**	**54.74**	**minutes**
Lag Time =	**0.55**	**hours**	**=**	**32.85**	**minutes**

Gannett Fleming

Upper Merion Township
Montgomery County, PA
Time of Concentration Calculation Summary

Project:	Upper Merion Township SWM		By:	YW	Date: 5/12/2017
Location:	Upper Merion Township, Montgomery County, PA		Checked:	AKS	Date: 5/26/2017
Subwatershed:	Abram Creek				

Flowpath Description:

Sheet Flow Properties

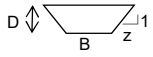
Segment ID	SH-1	SH-2
1. Surface description	Short-Grass Prairie	Not Used
2. Manning's roughness coefficient, n (NRCS NEH,Table 15-1)	0.150	
3. Flow length, L (ft)	100	0
4. Two-year 24-hour rainfall, P2 (in) (NOAA HDSC PFDS)	3.26	0.00
5. Land slope, s (ft/ft)	0.04940	0.00000
$T_t = \frac{0.007\,(nL)^{0.8}}{(P2)^{0.5}(s)^{0.4}}$		
$T_t =$	0.11 hours	#VALUE! hours

Shallow Concentrated Flow Properties

Segment ID	SC-1	SC-2	SC-3	SC-4
6. Surface description (NRCS NEH, Table 15-3)	Pavement and small upland gullies	Short-grass pasture	Short-grass pasture	Pavement and small upland gullies
7. Flow length, L (ft)	1106	1939	0	0
8. Watercourse slope, s (ft/ft)	0.04898	0.03856	#DIV/0!	#DIV/0!
9. Average velocity, V (NRCS NEH, Table 15-3)	4.499	1.367	#DIV/0!	#DIV/0!
	V =20.328(s)^0.5	V=6.962(s)^0.5	V=6.962(s)^0.5	V =20.328(s)^0.5
$T_t = \frac{L}{3600V}$				
$T_t =$	0.07 hours	0.39 hours	#DIV/0! hours	#DIV/0! hours

Open Channel Flow Properties

Segment ID	CH-1	CH-2	CH-3	CH-4	CH-5
10. Bottom width, B (ft)	10				
11. Depth flowing full, D (ft)	1.45				
12. Channel side slope, z H : 1 V	2				
13. Cross sectional area, A (sq ft)	18.705	0	0	0	0
14. Wetted perimeter, P (ft)	16.48	0.00	0.00	0.00	0.00
15. Hydraulic radius, r = A/P (ft)	1.13	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
16. Channel slope, s (ft/ft)	0.01621	0.01572	0.00457	0.00457	0.00457
17. Manning's roughness coefficient, n	0.035	0.040	0.040	0.040	0.040
18. Velocity, V (ft/sec)	5.90	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
$V = \frac{1.49(r^{2/3})(s^{1/2})}{n}$					
19. Flow length, L (ft)	742	0	0	0	0
$T_t = \frac{L}{3600V}$					
Tt =	0.03 hours	#DIV/0! hours	#DIV/0! hours	#DIV/0! hours	#DIV/0! hours



Results

Time of Concentration =	**0.61**	**hours**	**=**	**36.59**	**minutes**
Lag Time =	**0.37**	**hours**	**=**	**21.96**	**minutes**

Gannett Fleming

Time of Concentration Calculation Summary

Project:	Upper Merion Township SWM		By:	YW	Date: 6/20/2017
Location:	Upper Merion Township, Montgomery County, PA		Checked:	AKS	Date: 6/27/2017
Subwatershed:	Frog Run W50				

Sheet Flow Properties

Segment ID	SH-1	SH-2
1. Surface description	Short-Grass Prairie	Not Used
2. Manning's roughness coefficient, n (NRCS NEH,Table 15-1)	0.150	
3. Flow length, L (ft)	100	
4. Two-year 24-hour rainfall, P2 (in) (NOAA HDSC PFDS)	3.26	
5. Land slope, s (ft/ft)	0.04460	

$$T_t = \frac{0.007\,(nL)^{0.8}}{(P2)^{0.5}(s)^{0.4}}$$

T_t = 0.12 hours

Shallow Concentrated Flow Properties

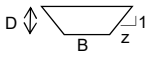
Segment ID	SC-1	SC-2	SC-3	SC-4
6. Surface description (NRCS NEH, Table 15-3)	Grassed waterways	Not Used	Not Used	Not Used
7. Flow length, L (ft)	5062			
8. Watercourse slope, s (ft/ft)	0.05221			
9. Average velocity, V (NRCS NEH, Table 15-3)	3.687			
	V=16.135(s)^0.5			

$$T_t = \frac{L}{3600V}$$

T_t = 0.38 hours

Open Channel Flow Properties

Segment ID	CH-1	CH-2	CH-3	CH-4	CH-5
10. Bottom width, B (ft)	15				
11. Depth flowing full, D (ft)	1.72				
12. Channel side slope, z H : 1 V	2				
13. Cross sectional area, A (sq ft)	31.7168				
14. Wetted perimeter, P (ft)	22.69				
15. Hydraulic radius, r = A/P (ft)	1.40				
16. Channel slope, s (ft/ft)	0.01153				
17. Manning's roughness coefficient, n	0.035				
18. Velocity, V (ft/sec)	5.71				



$$V = \frac{1.49(r^{2/3})(s^{1/2})}{n}$$

19. Flow length, L (ft)	4710				

$$T_t = \frac{L}{3600V}$$

Tt = 0.23 hours

Results

Time of Concentration =	**0.73**	**hours**	**=**	**43.67**	**minutes**
Lag Time =	**0.44**	**hours**	**=**	**26.20**	**minutes**

Gannett Fleming

Time of Concentration Calculation Summary

Project:	Upper Merion Township SWM		By:	YW	Date: 6/20/2017
Location:	Upper Merion Township, Montgomery County, PA		Checked:	AKS	Date: 6/27/2017
Subwatershed:	Frog Run W100				

Sheet Flow Properties

Segment ID	SH-1	SH-2
1. Surface description	Smooth Surface (concrete, asphalt, gravel, or bare soil)	Not Used
2. Manning's roughness coefficient, n (NRCS NEH,Table 15-1)	0.011	
3. Flow length, L (ft)	100	
4. Two-year 24-hour rainfall, P2 (in) (NOAA HDSC PFDS)	3.26	
5. Land slope, s (ft/ft)	0.00710	

$$T_t = \frac{0.007\,(nL)^{0.8}}{(P2)^{0.5}(s)^{0.4}}$$

T_t = 0.03 hours

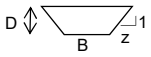
Shallow Concentrated Flow Properties

Segment ID	SC-1	SC-2	SC-3	SC-4
6. Surface description (NRCS NEH, Table 15-3)	Short-grass pasture	Grassed waterways	Not Used	Not Used
7. Flow length, L (ft)	1649	2263		
8. Watercourse slope, s (ft/ft)	0.03727	0.02168		
9. Average velocity, V (NRCS NEH, Table 15-3)	1.344	2.376		
	V=6.962(s)^0.5	V=16.135(s)^0.5		
T_t =	0.34 hours	0.26 hours		

$$T_t = \frac{L}{3600V}$$

Open Channel Flow Properties

Segment ID	CH-1	CH-2	CH-3	CH-4	CH-5
10. Bottom width, B (ft)	20				
11. Depth flowing full, D (ft)	2.18				
12. Channel side slope, z H : 1 V	2				
13. Cross sectional area, A (sq ft)	53.1048				
14. Wetted perimeter, P (ft)	29.75				
15. Hydraulic radius, r = A/P (ft)	1.79				
16. Channel slope, s (ft/ft)	0.00632				
17. Manning's roughness coefficient, n	0.035				
18. Velocity, V (ft/sec)	4.98				
19. Flow length, L (ft)	6118				
Tt =	0.34 hours				



$$V = \frac{1.49(r^{2/3})(s^{1/2})}{n}$$

$$T_t = \frac{L}{3600V}$$

Results

Time of Concentration =	**0.98**	**hours**	**=**	**58.61**	**minutes**
Lag Time =	**0.59**	**hours**	**=**	**35.17**	**minutes**

Gannett Fleming

Time of Concentration Calculation Summary

Project:	Upper Merion Township SWM		By:	YW	Date: 6/20/2017
Location:	Upper Merion Township, Montgomery County, PA		Checked:	AKS	Date: 6/27/2017
Subwatershed:	Frog Run W150				

Sheet Flow Properties

Segment ID	SH-1	SH-2
1. Surface description	Smooth Surface (concrete, asphalt, gravel, or bare soil)	Not Used
2. Manning's roughness coefficient, n (NRCS NEH,Table 15-1)	0.011	
3. Flow length, L (ft)	100	
4. Two-year 24-hour rainfall, P2 (in) (NOAA HDSC PFDS)	3.26	
5. Land slope, s (ft/ft)	0.04220	

$$T_t = \frac{0.007\,(nL)^{0.8}}{(P2)^{0.5}(s)^{0.4}}$$

T_t = 0.01 hours

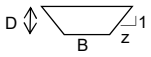
Shallow Concentrated Flow Properties

Segment ID	SC-1	SC-2	SC-3	SC-4
6. Surface description (NRCS NEH, Table 15-3)	Pavement and small upland gullies	Pavement and small upland gullies	Not Used	Not Used
7. Flow length, L (ft)	2545	1353		
8. Watercourse slope, s (ft/ft)	0.01971	0.02243		
9. Average velocity, V (NRCS NEH, Table 15-3)	2.854	3.044		
	V =20.328(s)^0.5	V =20.328(s)^0.5		

$$T_t = \frac{L}{3600V}$$

T_t =	0.25 hours	0.12 hours

Open Channel Flow Properties



Segment ID	CH-1	CH-2	CH-3	CH-4	CH-5
10. Bottom width, B (ft)	20	10			
11. Depth flowing full, D (ft)	2.25	2.06			
12. Channel side slope, z H : 1 V	2	2			
13. Cross sectional area, A (sq ft)	55.125	29.0872			
14. Wetted perimeter, P (ft)	30.06	19.21			
15. Hydraulic radius, r = A/P (ft)	1.83	1.51			
16. Channel slope, s (ft/ft)	0.00733	0.00461			
17. Manning's roughness coefficient, n	0.035	0.013			
18. Velocity, V (ft/sec)	5.46	10.27			

$$V = \frac{1.49(r^{2/3})(s^{1/2})}{n}$$

19. Flow length, L (ft)	2014	2856

$$T_t = \frac{L}{3600V}$$

Tt =	0.10 hours	0.08 hours

Results

Time of Concentration =	**0.57**	**hours**	**=**	**33.94**	**minutes**
Lag Time =	**0.34**	**hours**	**=**	**20.37**	**minutes**

Gannett Fleming

Time of Concentration Calculation Summary

Project:	Upper Merion Township SWM		By:	YW	Date: 6/20/2017
Location:	Upper Merion Township, Montgomery County, PA		Checked:	AKS	Date: 6/27/2017
Subwatershed:	Frog Run W140				

Flowpath Description:

Sheet Flow Properties

Segment ID	SH-1	SH-2
1. Surface description	Woods - Light Underbrush	Not Used
2. Manning's roughness coefficient, n (NRCS NEH,Table 15-1)	0.400	
3. Flow length, L (ft)	100	
4. Two-year 24-hour rainfall, P2 (in) (NOAA HDSC PFDS)	3.26	
5. Land slope, s (ft/ft)	0.01120	

$$T_t = \frac{0.007\,(nL)^{0.8}}{(P2)^{0.5}(s)^{0.4}}$$

T_t = 0.45 hours

Shallow Concentrated Flow Properties

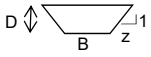
Segment ID	SC-1	SC-2	SC-3	SC-4
6. Surface description (NRCS NEH, Table 15-3)	Short-grass pasture	Pavement and small upland gullies	Not Used	Not Used
7. Flow length, L (ft)	1479	2605		
8. Watercourse slope, s (ft/ft)	0.01703	0.00055		
9. Average velocity, V (NRCS NEH, Table 15-3)	0.909	0.478		
	V=6.962(s)^0.5	V =20.328(s)^0.5		

$$T_t = \frac{L}{3600V}$$

T_t = 0.45 hours | 1.51 hours

Open Channel Flow Properties

Segment ID	CH-1	CH-2	CH-3	CH-4	CH-5
10. Bottom width, B (ft)	10				
11. Depth flowing full, D (ft)	2				
12. Channel side slope, z H : 1 V	1.7				
13. Cross sectional area, A (sq ft)	26.8				
14. Wetted perimeter, P (ft)	17.89				
15. Hydraulic radius, r = A/P (ft)	1.50				
16. Channel slope, s (ft/ft)	0.04005				
17. Manning's roughness coefficient, n	0.035				
18. Velocity, V (ft/sec)	11.15				



$$V = \frac{1.49(r^{2/3})(s^{1/2})}{n}$$

19. Flow length, L (ft)	424				

$$T_t = \frac{L}{3600V}$$

Tt = 0.01 hours

Results

Time of Concentration =	**2.42**	**hours**	**=**	**145.41**	**minutes**
Lag Time =	**1.45**	**hours**	**=**	**87.25**	**minutes**

Gannett Fleming

Time of Concentration Calculation Summary

Project:	Upper Merion Township SWM		By:	YW	Date: 6/21/2017
Location:	Upper Merion Township, Montgomery County, PA		Checked:	AKS	Date: 6/26/2017
Subwatershed:	Matsunk Creek W100				

Sheet Flow Properties

Segment ID	SH-1
1. Surface description	Smooth Surface (concrete, asphalt, gravel, or bare soil)
2. Manning's roughness coefficient, n (NRCS NEH,Table 15-1)	0.011
3. Flow length, L (ft)	100
4. Two-year 24-hour rainfall, P2 (in) (NOAA HDSC PFDS)	3.26
5. Land slope, s (ft/ft)	0.01220

$$T_t = \frac{0.007\,(nL)^{0.8}}{(P2)^{0.5}(s)^{0.4}}$$

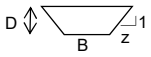
T_t = 0.02 hours

Shallow Concentrated Flow Properties

Segment ID	SC-1	SC-2	SC-3	SC-4
6. Surface description (NRCS NEH, Table 15-3)	Pavement and small upland gullies	Short-grass pasture	Pavement and small upland gullies	Short-grass pasture
7. Flow length, L (ft)	737	941	903	840
8. Watercourse slope, s (ft/ft)	0.00941	0.01895	0.00900	0.04688
9. Average velocity, V (NRCS NEH, Table 15-3)	1.972	0.958	1.928	1.507
	V =20.328(s)^0.5	V=6.962(s)^0.5	V =20.328(s)^0.5	V=6.962(s)^0.5
$T_t = \frac{L}{3600V}$	0.10 hours	0.27 hours	0.13 hours	0.15 hours

Open Channel Flow Properties

Segment ID	CH-1
10. Bottom width, B (ft)	5
11. Depth flowing full, D (ft)	1.1
12. Channel side slope, z H : 1 V	1
13. Cross sectional area, A (sq ft)	6.71
14. Wetted perimeter, P (ft)	8.11
15. Hydraulic radius, r = A/P (ft)	0.83
16. Channel slope, s (ft/ft)	0.01608
17. Manning's roughness coefficient, n	0.035
18. Velocity, V (ft/sec)	4.76



$$V = \frac{1.49(r^{2/3})(s^{1/2})}{n}$$

19. Flow length, L (ft)	1817
$T_t = \frac{L}{3600V}$	Tt = 0.11 hours

Results

Time of Concentration =	**0.79**	**hours**	**=**	**47.52**	**minutes**
Lag Time =	**0.48**	**hours**	**=**	**28.51**	**minutes**

Gannett Fleming

Time of Concentration Calculation Summary

Project: Upper Merion Township SWM
Location: Upper Merion Township, Montgomery County, PA
Subwatershed: Watershed A

By: YW Date: 5/12/2017
Checked: AKS Date: 5/30/2017

Flowpath Description:

Sheet Flow Properties

Segment ID	SH-1	SH-2
1. Surface description	Short-Grass Prairie	Not Used
2. Manning's roughness coefficient, n (NRCS NEH,Table 15-1)	0.150	
3. Flow length, L (ft)	100	0
4. Two-year 24-hour rainfall, P2 (in) (NOAA HDSC PFDS)	3.26	0.00
5. Land slope, s (ft/ft)	0.01550	0.00000
$T_t = \frac{0.007\,(nL)^{0.8}}{(P2)^{0.5}(s)^{0.4}}$	T_t = 0.18 hours	#VALUE! hours

Shallow Concentrated Flow Properties

Segment ID	SC-1	SC-2	SC-3	SC-4
6. Surface description (NRCS NEH, Table 15-3)	Short-grass pasture	Not Used	Not Used	Not Used
7. Flow length, L (ft)	1043	0	0	0
8. Watercourse slope, s (ft/ft)	0.03721	#DIV/0!	0.00000	0.00000
9. Average velocity, V (NRCS NEH, Table 15-3)	1.343			
	V=6.962(s)^0.5			
$T_t = \frac{L}{3600V}$	T_t = 0.22 hours	#VALUE! hours	#VALUE! hours	#VALUE! hours

Open Channel Flow Properties

Segment ID	CH-1	CH-2	CH-3	CH-4	CH-5
10. Bottom width, B (ft)	25	2			
11. Depth flowing full, D (ft)	0.67	1.45			
12. Channel side slope, z H : 1 V	3.33	5.38			
13. Cross sectional area, A (sq ft)	18.244837	14.21145	0	0	0
14. Wetted perimeter, P (ft)	29.66	17.87	0.00	0.00	0.00
15. Hydraulic radius, r = A/P (ft)	0.62	0.80	#DIV/0!	#DIV/0!	#DIV/0!
16. Channel slope, s (ft/ft)	0.01169	0.01478	0.00000	0.00000	0.00000
17. Manning's roughness coefficient, n	0.025	0.035	0.000	0.000	0.000
18. Velocity, V (ft/sec)	4.66	4.44	#DIV/0!	#DIV/0!	#DIV/0!
$V = \frac{1.49(r^{2/3})(s^{1/2})}{n}$					
19. Flow length, L (ft)	4642	3013	0	0	0
$T_t = \frac{L}{3600V}$	Tt = 0.28 hours	0.19 hours	#DIV/0! hours	#DIV/0! hours	#DIV/0! hours

D, B, z, 1

Results

Time of Concentration =	**0.86**	**hours**	**=**	**51.60**	**minutes**
Lag Time =	**0.52**	**hours**	**=**	**30.96**	**minutes**

Gannett Fleming

Time of Concentration Calculation Summary

Project:	Upper Merion Township SWM		By:	YW	Date: 6/20/2017
Location:	Upper Merion Township, Montgomery County, PA		Checked:	AKS	Date: 6/29/2017
Subwatershed:	Gulph Mill Creek W40				

Sheet Flow Properties

Segment ID	SH-1	SH-2
1. Surface description	Short-Grass Prairie	Not Used
2. Manning's roughness coefficient, n (NRCS NEH,Table 15-1)	0.150	
3. Flow length, L (ft)	100	
4. Two-year 24-hour rainfall, P2 (in) (NOAA HDSC PFDS)	3.26	
5. Land slope, s (ft/ft)	0.05330	

$$T_t = \frac{0.007\,(nL)^{0.8}}{(P2)^{0.5}(s)^{0.4}}$$

T_t = 0.11 hours

Shallow Concentrated Flow Properties

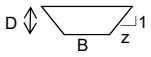
Segment ID	SC-1	SC-2	SC-3	SC-4
6. Surface description (NRCS NEH, Table 15-3)	Short-grass pasture	Pavement and small upland gullies	Short-grass pasture	Not Used
7. Flow length, L (ft)	1122	2417	1495	
8. Watercourse slope, s (ft/ft)	0.14859	0.02568	0.06568	
9. Average velocity, V (NRCS NEH, Table 15-3)	2.684	3.257	1.784	
	V=6.962(s)^0.5	V =20.328(s)^0.5	V=6.962(s)^0.5	

$$T_t = \frac{L}{3600V}$$

T_t =	0.12 hours	0.21 hours	0.23 hours

Open Channel Flow Properties

Segment ID	CH-1	CH-2	CH-3	CH-4	CH-5
10. Bottom width, B (ft)	30	30			
11. Depth flowing full, D (ft)	3.5	3.2			
12. Channel side slope, z H : 1 V	2.1	2			
13. Cross sectional area, A (sq ft)	130.725	116.48			
14. Wetted perimeter, P (ft)	46.28	44.31			
15. Hydraulic radius, r = A/P (ft)	2.82	2.63			
16. Channel slope, s (ft/ft)	0.00689	0.00967			
17. Manning's roughness coefficient, n	0.035	0.035			
18. Velocity, V (ft/sec)	7.06	7.97			



$$V = \frac{1.49(r^{2/3})(s^{1/2})}{n}$$

19. Flow length, L (ft)	6902	4135			
T_t =	0.27 hours	0.14 hours			

$$T_t = \frac{L}{3600V}$$

Results

Time of Concentration =	**1.08**	**hours**	**=**	**64.78**	**minutes**
Lag Time =	**0.65**	**hours**	**=**	**38.87**	**minutes**

Gannett Fleming

Time of Concentration Calculation Summary

Project:	Upper Merion Township SWM		By:	YW	Date: 6/20/2017
Location:	Upper Merion Township, Montgomery County, PA		Checked:	AKS	Date: 6/29/2017
Subwatershed:	Gulph Mill Creek W50				

Sheet Flow Properties

Segment ID	SH-1	SH-2
1. Surface description	Smooth Surface (concrete, asphalt, gravel, or bare soil)	Not Used
2. Manning's roughness coefficient, n (NRCS NEH,Table 15-1)	0.011	
3. Flow length, L (ft)	100	
4. Two-year 24-hour rainfall, P2 (in) (NOAA HDSC PFDS)	3.26	
5. Land slope, s (ft/ft)	0.02030	

$$T_t = \frac{0.007\,(nL)^{0.8}}{(P2)^{0.5}(s)^{0.4}}$$

T_t = 0.02 hours

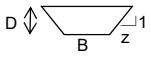
Shallow Concentrated Flow Properties

Segment ID	SC-1	SC-2	SC-3	SC-4
6. Surface description (NRCS NEH, Table 15-3)	Pavement and small upland gullies	Short-grass pasture	Not Used	Not Used
7. Flow length, L (ft)	886	2431		
8. Watercourse slope, s (ft/ft)	0.02626	0.04628		
9. Average velocity, V (NRCS NEH, Table 15-3)	3.294	1.498		
	V =20.328(s)^0.5	V=6.962(s)^0.5		
T_t =	0.07 hours	0.45 hours		

$$T_t = \frac{L}{3600V}$$

Open Channel Flow Properties

Segment ID	CH-1	CH-2	CH-3	CH-4	CH-5
10. Bottom width, B (ft)	20	23	25		
11. Depth flowing full, D (ft)	1.24	1.24	1.47		
12. Channel side slope, z H : 1 V	2	2	2		
13. Cross sectional area, A (sq ft)	27.8752	31.5952	41.0718		
14. Wetted perimeter, P (ft)	25.55	28.55	31.57		
15. Hydraulic radius, r = A/P (ft)	1.09	1.11	1.30		
16. Channel slope, s (ft/ft)	0.02055	0.02925	0.02377		
17. Manning's roughness coefficient, n	0.035	0.035	0.035		
18. Velocity, V (ft/sec)	6.47	7.79	7.82		
19. Flow length, L (ft)	5363	3539	1222		
Tt =	0.23 hours	0.13 hours	0.04 hours		



$$V = \frac{1.49(r^{2/3})(s^{1/2})}{n}$$

$$T_t = \frac{L}{3600V}$$

Results

Time of Concentration =	**0.95**	**hours**	**=**	**56.73**	**minutes**
Lag Time =	**0.57**	**hours**	**=**	**34.04**	**minutes**

Gannett Fleming

Time of Concentration Calculation Summary

Project:	Upper Merion Township SWM		By:	YW	Date: 6/20/2017
Location:	Upper Merion Township, Montgomery County, PA		Checked:	AKS	Date: 6/29/2017
Subwatershed:	Gulph Mill Creek W80				

Flowpath Description:

Sheet Flow Properties

Segment ID	SH-1	SH-2
1. Surface description	Smooth Surface (concrete, asphalt, gravel, or bare soil)	Not Used
2. Manning's roughness coefficient, n (NRCS NEH,Table 15-1)	0.011	
3. Flow length, L (ft)	100	
4. Two-year 24-hour rainfall, P2 (in) (NOAA HDSC PFDS)	3.26	
5. Land slope, s (ft/ft)	0.03320	

$$T_t = \frac{0.007\,(nL)^{0.8}}{(P2)^{0.5}(s)^{0.4}}$$

T_t = 0.02 hours

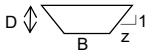
Shallow Concentrated Flow Properties

Segment ID	SC-1	SC-2	SC-3	SC-4
6. Surface description (NRCS NEH, Table 15-3)	Pavement and small upland gullies	Short-grass pasture	Not Used	Not Used
7. Flow length, L (ft)	702	2460		
8. Watercourse slope, s (ft/ft)	0.03824	0.05886		
9. Average velocity, V (NRCS NEH, Table 15-3)	3.975	1.689		
	V =20.328(s)^0.5	V=6.962(s)^0.5		
T_t =	0.05 hours	0.40 hours		

$$T_t = \frac{L}{3600V}$$

Open Channel Flow Properties

Segment ID	CH-1	CH-2	CH-3	CH-4	CH-5
10. Bottom width, B (ft)	25	28	30		
11. Depth flowing full, D (ft)	2.4	2.52	2.48		
12. Channel side slope, z H : 1 V	2	2	2		
13. Cross sectional area, A (sq ft)	71.52	83.2608	86.7008		
14. Wetted perimeter, P (ft)	35.73	39.27	41.09		
15. Hydraulic radius, r = A/P (ft)	2.00	2.12	2.11		
16. Channel slope, s (ft/ft)	0.01010	0.01081	0.01461		
17. Manning's roughness coefficient, n	0.035	0.035	0.035		
18. Velocity, V (ft/sec)	6.80	7.31	8.47		
19. Flow length, L (ft)	5864	3289	2623		
Tt =	0.24 hours	0.13 hours	0.09 hours		



$$V = \frac{1.49(r^{2/3})(s^{1/2})}{n}$$

$$T_t = \frac{L}{3600V}$$

Results

Time of Concentration =	**0.92**	**hours**	**=**	**55.24**	**minutes**
Lag Time =	**0.55**	**hours**	**=**	**33.15**	**minutes**

Gannett Fleming

Time of Concentration Calculation Summary

Project:	Upper Merion Township SWM		By:	YW	Date: 6/20/2017
Location:	Upper Merion Township, Montgomery County, PA		Checked:	AKS	Date: 6/30/2017
Subwatershed:	Gulph Mill Creek W90				

Sheet Flow Properties

Segment ID	SH-1	SH-2
1. Surface description	Short-Grass Prairie	Not Used
2. Manning's roughness coefficient, n (NRCS NEH,Table 15-1)	0.150	
3. Flow length, L (ft)	100	
4. Two-year 24-hour rainfall, P2 (in) (NOAA HDSC PFDS)	3.26	
5. Land slope, s (ft/ft)	0.02180	

$$T_t = \frac{0.007\,(nL)^{0.8}}{(P2)^{0.5}(s)^{0.4}}$$

T_t = 0.16 hours

Shallow Concentrated Flow Properties

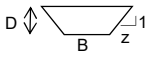
Segment ID	SC-1	SC-2	SC-3	SC-4
6. Surface description (NRCS NEH, Table 15-3)	Pavement and small upland gullies	Short-grass pasture	Not Used	Not Used
7. Flow length, L (ft)	1878	2301		
8. Watercourse slope, s (ft/ft)	0.03318	0.01959		
9. Average velocity, V (NRCS NEH, Table 15-3)	3.703	0.975		
	V =20.328(s)^0.5	V=6.962(s)^0.5		

$$T_t = \frac{L}{3600V}$$

T_t = 0.14 hours | 0.66 hours

Open Channel Flow Properties

Segment ID	CH-1	CH-2	CH-3	CH-4	CH-5
10. Bottom width, B (ft)	15	18	23	23	
11. Depth flowing full, D (ft)	1.82	2.41	2.8	2.78	
12. Channel side slope, z H : 1 V	2	2	2.3	2	
13. Cross sectional area, A (sq ft)	33.9248	54.9962	82.432	79.3968	
14. Wetted perimeter, P (ft)	23.14	28.78	37.04	35.43	
15. Hydraulic radius, r = A/P (ft)	1.47	1.91	2.23	2.24	
16. Channel slope, s (ft/ft)	0.01135	0.00942	0.00443	0.00712	
17. Manning's roughness coefficient, n	0.035	0.035	0.035	0.035	
18. Velocity, V (ft/sec)	5.85	6.36	4.83	6.15	



$$V = \frac{1.49(r^{2/3})(s^{1/2})}{n}$$

19. Flow length, L (ft)	5360	5229	2176	3131
Tt =	0.25 hours	0.23 hours	0.13 hours	0.14 hours

$$T_t = \frac{L}{3600V}$$

Results

Time of Concentration =	**1.70**	**hours**	**=**	**102.14**	**minutes**
Lag Time =	**1.02**	**hours**	**=**	**61.28**	**minutes**

Appendix C-3 - NOAA's Atlas 14 Point Precipitation Frequency Web Data

NOAA Atlas 14, Volume 2, Version 3
Location name: Upper Merion Twp, Pennsylvania, USA*
Latitude: 40.0962°, Longitude: -75.3706°
Elevation: 179.06 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M.Yekta, and D. Riley

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.346 (0.318-0.377)	0.412 (0.379-0.449)	0.483 (0.442-0.525)	0.532 (0.488-0.579)	0.591 (0.538-0.643)	0.631 (0.571-0.686)	0.669 (0.604-0.730)	0.703 (0.630-0.768)	0.741 (0.659-0.813)	0.769 (0.679-0.847)
10-min	0.552 (0.508-0.602)	0.659 (0.606-0.717)	0.773 (0.708-0.842)	0.851 (0.780-0.926)	0.942 (0.858-1.02)	1.00 (0.909-1.09)	1.06 (0.960-1.16)	1.11 (0.999-1.22)	1.17 (1.04-1.29)	1.21 (1.07-1.33)
15-min	0.690 (0.635-0.752)	0.828 (0.762-0.902)	0.978 (0.896-1.06)	1.08 (0.986-1.17)	1.19 (1.09-1.30)	1.27 (1.15-1.38)	1.34 (1.21-1.47)	1.41 (1.26-1.54)	1.48 (1.31-1.62)	1.52 (1.34-1.67)
30-min	0.946 (0.871-1.03)	1.14 (1.05-1.25)	1.39 (1.27-1.51)	1.56 (1.43-1.70)	1.77 (1.61-1.92)	1.92 (1.73-2.08)	2.06 (1.86-2.25)	2.19 (1.96-2.39)	2.35 (2.09-2.58)	2.46 (2.17-2.71)
60-min	1.18 (1.09-1.29)	1.44 (1.32-1.56)	1.78 (1.63-1.94)	2.03 (1.86-2.21)	2.35 (2.14-2.56)	2.60 (2.35-2.83)	2.84 (2.56-3.09)	3.07 (2.75-3.35)	3.37 (2.99-3.69)	3.59 (3.17-3.96)
2-hr	1.41 (1.29-1.55)	1.72 (1.57-1.88)	2.14 (1.95-2.34)	2.46 (2.24-2.69)	2.89 (2.61-3.16)	3.23 (2.90-3.52)	3.56 (3.18-3.89)	3.89 (3.45-4.27)	4.35 (3.81-4.78)	4.69 (4.07-5.17)
3-hr	1.54 (1.41-1.70)	1.87 (1.71-2.06)	2.34 (2.13-2.57)	2.70 (2.45-2.96)	3.18 (2.87-3.48)	3.55 (3.19-3.88)	3.93 (3.50-4.30)	4.31 (3.81-4.73)	4.82 (4.21-5.32)	5.22 (4.51-5.77)
6-hr	1.93 (1.76-2.12)	2.33 (2.13-2.57)	2.90 (2.65-3.19)	3.36 (3.06-3.69)	4.01 (3.61-4.39)	4.53 (4.05-4.95)	5.07 (4.50-5.55)	5.64 (4.95-6.18)	6.43 (5.55-7.09)	7.07 (6.01-7.82)
12-hr	2.34 (2.14-2.60)	2.83 (2.59-3.14)	3.54 (3.23-3.92)	4.14 (3.75-4.57)	5.00 (4.49-5.50)	5.72 (5.09-6.29)	6.50 (5.71-7.16)	7.34 (6.37-8.10)	8.57 (7.27-9.48)	9.58 (7.99-10.6)
24-hr	2.71 (2.49-2.97)	3.26 (3.00-3.58)	4.10 (3.75-4.48)	4.79 (4.37-5.23)	5.78 (5.25-6.30)	6.62 (5.98-7.21)	7.52 (6.76-8.19)	8.49 (7.59-9.24)	9.91 (8.75-10.8)	11.1 (9.69-12.1)
2-day	3.13 (2.86-3.44)	3.78 (3.45-4.15)	4.75 (4.33-5.21)	5.53 (5.03-6.07)	6.65 (6.02-7.27)	7.57 (6.83-8.28)	8.55 (7.67-9.35)	9.59 (8.55-10.5)	11.1 (9.79-12.1)	12.3 (10.8-13.4)
3-day	3.30 (3.02-3.63)	3.98 (3.65-4.37)	4.99 (4.56-5.48)	5.80 (5.29-6.36)	6.96 (6.32-7.62)	7.91 (7.16-8.65)	8.92 (8.03-9.76)	10.0 (8.95-10.9)	11.5 (10.2-12.6)	12.8 (11.2-14.0)
4-day	3.48 (3.19-3.82)	4.19 (3.84-4.60)	5.23 (4.79-5.74)	6.08 (5.55-6.66)	7.27 (6.62-7.96)	8.26 (7.49-9.02)	9.30 (8.39-10.2)	10.4 (9.34-11.4)	12.0 (10.6-13.1)	13.3 (11.7-14.5)
7-day	4.06 (3.76-4.43)	4.87 (4.50-5.32)	6.02 (5.55-6.58)	6.96 (6.41-7.60)	8.30 (7.61-9.05)	9.41 (8.60-10.3)	10.6 (9.62-11.5)	11.8 (10.7-12.9)	13.6 (12.2-14.8)	15.1 (13.4-16.4)
10-day	4.63 (4.30-5.01)	5.53 (5.13-5.98)	6.74 (6.24-7.30)	7.71 (7.13-8.34)	9.06 (8.35-9.79)	10.1 (9.32-11.0)	11.3 (10.3-12.2)	12.4 (11.3-13.5)	14.1 (12.7-15.3)	15.4 (13.8-16.7)
20-day	6.25 (5.84-6.71)	7.42 (6.94-7.96)	8.85 (8.27-9.49)	9.97 (9.30-10.7)	11.5 (10.7-12.3)	12.7 (11.8-13.6)	13.9 (12.8-14.8)	15.1 (13.9-16.1)	16.7 (15.3-17.9)	17.9 (16.3-19.3)
30-day	7.79 (7.36-8.25)	9.18 (8.66-9.72)	10.7 (10.1-11.3)	11.9 (11.2-12.6)	13.4 (12.6-14.2)	14.6 (13.7-15.4)	15.7 (14.7-16.7)	16.9 (15.7-17.9)	18.3 (17.0-19.5)	19.4 (18.0-20.7)
45-day	9.89 (9.39-10.4)	11.6 (11.0-12.3)	13.4 (12.7-14.1)	14.7 (13.9-15.5)	16.3 (15.4-17.2)	17.5 (16.6-18.5)	18.7 (17.6-19.7)	19.8 (18.6-20.9)	21.1 (19.9-22.3)	22.1 (20.7-23.4)
60-day	11.9 (11.3-12.5)	13.9 (13.2-14.6)	15.9 (15.1-16.7)	17.3 (16.5-18.2)	19.1 (18.2-20.1)	20.4 (19.4-21.5)	21.7 (20.5-22.8)	22.8 (21.6-24.0)	24.2 (22.9-25.5)	25.2 (23.8-26.6)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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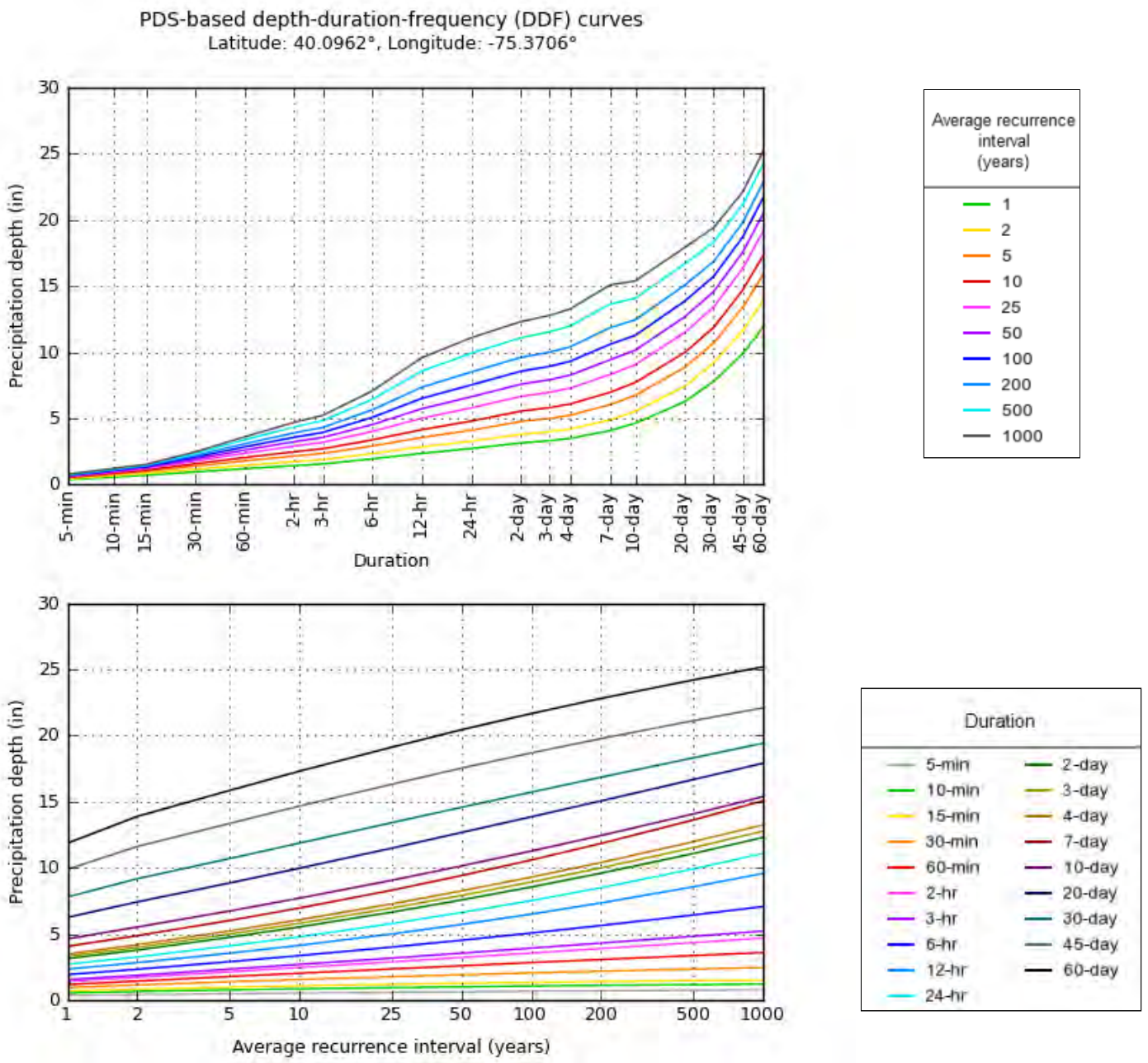
PF graphical



NOAA Atlas 14, Volume 2, Version 3

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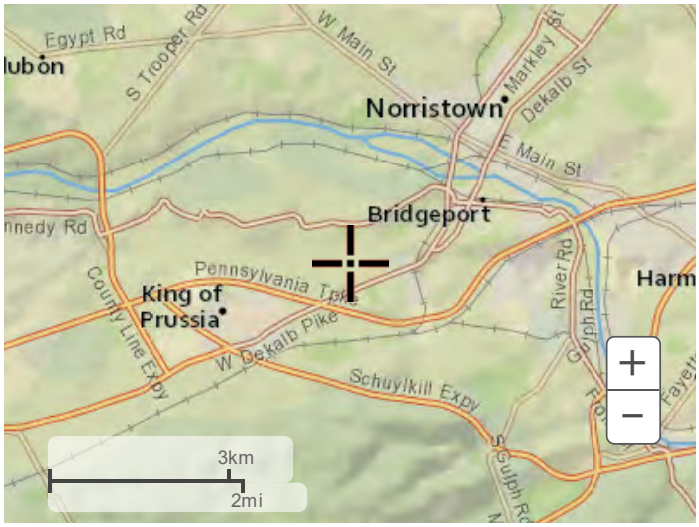
Maps & aerials

Small scale terrain



Large scale terrain

Large scale map

Large scale aerial

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US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Disclaimer

Appendix D – Flooding Concern Area(s) Mapping

Upper Merion Township Problem Flood Areas

Recommended Project Areas

Map 1 of 8

N

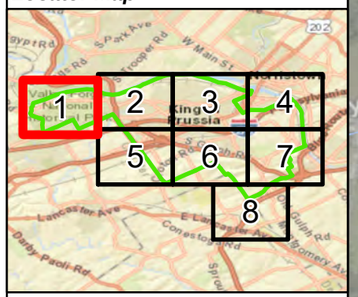
W E

S

0 500 1,000 2,000

Feet

Locator Map



Legend

NHD Flowline

- Artificial Path
- Stream River
- 10 Year Flood Inundation Boundary
- Upper Merion Township Boundary

Gannett Fleming

Date Created: 6/14/2018

Upper Merion Township Problem Flood Areas

Recommended Project Areas

Map 2 of 8

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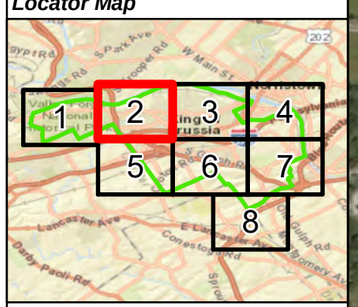
Feet

Locator Map



Legend

- Recommended Projects

NHD Flowline

- Artificial Path
- Stream River
- 10 Year Flood Inundation Boundary
- Upper Merion Township Boundary

Gannett Fleming

Date Created: 6/14/2018

Upper Merion Township Problem Flood Areas

Recommended Project Areas

Map 3 of 8

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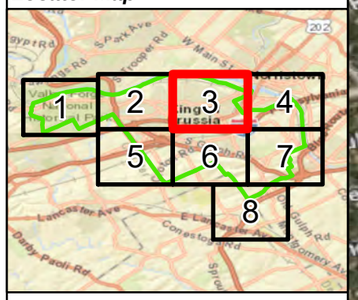
Locator Map



Legend

- Recommended Projects

NHD Flowline

- Artificial Path
- Connector
- Stream River
- 10 Year Flood Inundation Boundary
- Upper Merion Township Boundary

Gannett Fleming

Date Created: 6/14/2018

Upper Merion Township Problem Flood Areas

Recommended Project Areas

Map 4 of 8

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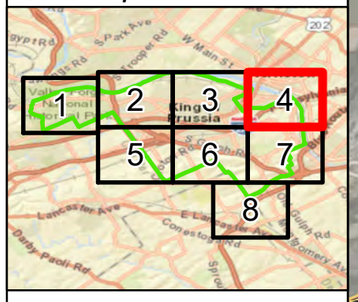
Locator Map



Legend

- Recommended Projects

NHD Flowline

- Artificial Path
- Connector
- Stream River
- 10 Year Flood Inundation Boundary
- Upper Merion Township Boundary

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Upper Merion Township Problem Flood Areas

Recommended Project Areas

Map 5 of 8

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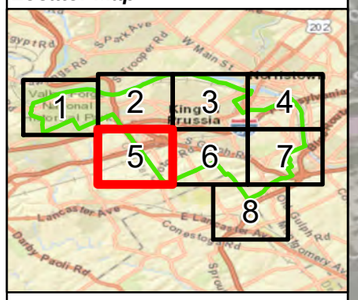
Locator Map



Legend

- Recommended Projects

NHD Flowline

- Artificial Path
- Stream River
- 10 Year Flood Inundation Boundary
- Upper Merion Township Boundary

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Upper Merion Township Problem Flood Areas

Recommended Project Areas

Map 6 of 8

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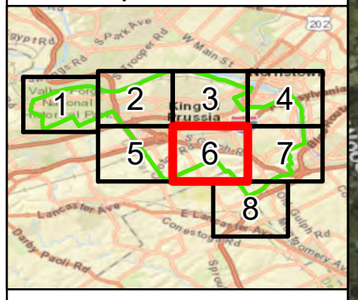
Locator Map



Legend

- Recommended Projects

NHD Flowline

- Artificial Path
- Connector
- Stream River
- 10 Year Flood Inundation Boundary
- Upper Merion Township Boundary

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Upper Merion Township Problem Flood Areas

Recommended Project Areas

Map 7 of 8

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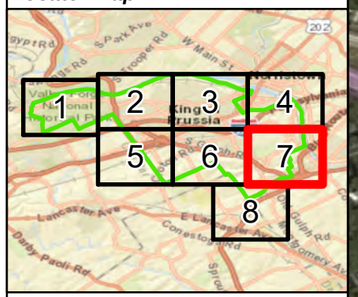
Locator Map



Legend

- Recommended Projects

NHD Flowline

- Artificial Path
- Connector
- Stream River
- 10 Year Flood Inundation Boundary
- Upper Merion Township Boundary

Gannett Fleming

Date Created: 6/14/2018

Upper Merion Township Problem Flood Areas

Recommended Project Areas

Map 8 of 8

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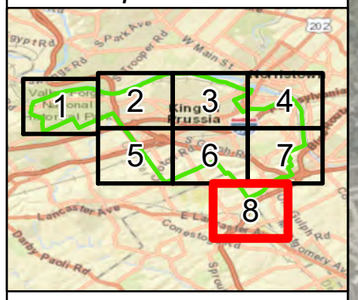
Feet

Locator Map



Legend

- Recommended Projects

NHD Flowline

- Artificial Path
- Stream River
- 10 Year Flood Inundation Boundary
- Upper Merion Township Boundary

Gannett Fleming

Date Created: 6/14/2018

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Gulph Creek

Denbigh Ln

Tory Turn

Conshohocken Station

Woodland Ln

Rock Rose Ln

Pine Tree Rd

Cricket Ln

Hermitage Dr

Biddulph Rd

Montgomery Ave

Woodfield Rd

Firethorn Ln

Panorama Rd

Stoke Rd

Candace Ln

County Line Rd

Radnor Corporate Ct

Patton Ln

Hares Ln

Harford Ln

King of Prussia Rd

Belrose Ln

Glenmary Rd

Matsonford Rd

SEPTA R5-Radnor

Saybrook Rd

N Stoneridge Ln

Stoneridge Ln

Spruce Ln

Balsam Ln

Cedar Ln

Devereux Dr

Lark Ln

Wistar Rd

Claremont Rd

Radnor Way

N Radnor Chester Rd

Rader Rd

High Rd

Hardings Run

Soccer Complex-Villanova University

St Marys Seminary

N Spring Mill Rd

Hillsdale Rd

Ashwood Rd

Broughton Ln

Mill Creek

N Ithan Ave

Curwen Rd

Rosemont Co

E Lancaster Ave

Chew Ln

Browns Run

Villanova University

SEPTA R5-Villanova

Aldwyn Ln

S Ithan Ave

The Pavilion Villanova Stadium

S Spring Mill Rd

Ithan

bing

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Appendix E - List of Recommendations and Corresponding Maps

Appendix E
Upper Merion Township
List of Recommendations

Project Type	LabelID	MapSheet	Number of Sources	1995 Study	2017 Model	Public Survey	EMA Staff	Problem	Recommendations	Notes	Estimated Cost
C	105	6	4	Yes	Yes	Yes	Yes	Insufficient Culvert Capacity on Croton Road near Elementary School	Install a 2'x20' box culvert, adjust road alignment (vertical) and adjust stream banks accordingly.	Must be tied to improvements on Tannery Drive.	$ 850,000.00
C	95	5	1		Yes			Flooding of Tannery Drive	Improve inlet and outlet conditions, stabilize channel banks, maintenance of culvert barrel(s).	This area was observed by results of study and staff.	$ 200,000.00
D	160	7	2	Yes			Yes	Erosion and property flooding between 947 & 961 Trinity road	Stabilize channel; culvert maintenance; larger culvert under SEPTA tracks	Authorization by SEPTA to adjust drainage structures reduces viability of project	$ 20,000.00
E	147	7	4	Yes	Yes	Yes	Yes	Trinity Road - Bridge overtopping, sedimentation, and standing water	Berm to prevent overflow to low point on Ballimingo Road; Replace stone arch with 2 - 11'x8' RCB and evaluate possible need for storage BMP.	Twp. resists replacing Stone arch for historical landmark reasons, need alternate plan	$ 700,000.00
A	36	3	3	Yes		Yes	Yes	Abrams Road Bridge overtopping	Increase Roadway Elevation; grade swale to drain north side of road; improve channel alignment.		$ 100,000.00
A	232	7	1				Yes	Flooding of River Road	Clean out storm water facilities in area. If nothing found, increasing size of culvert should be investigated		$ 360,000.00
E	203	2	2		Yes		Yes	Low ground on Richards Road near N Gulph Road	Install Culvert of adequate size. Elevation of Richards Road just above 10-year floodplain according to model. Can construct levee on west side (2 feet high, approximately 600 feet long)of Richards Road to prevent future flooding of Richards road.	Close proximity to Tref. Twp. reduces priority of this project.	$ 860,000.00
A	161	7	2	Yes			Yes	Street flooding - South Gulph Road	Add inlets and pipes under road to stream		$ 130,000.00
E	229	4	1				Yes	Flooding of River Road near and at underpass of I-276	Construct channel on west side of road. No current stormwater facility in area.		$ 20,000.00
B	135	7	2	Yes			Yes	Street flooding on B Street and Rt. 23	Add 27" pipe under B Street		$ 140,000.00
B	211	5	1				Yes	Flooding on N Gulph Road near I-76 underpass	Clean out storm water facilities in area. If nothing found, increasing size of culvert should be investigated		$ 10,000.00
A	44	3	3	Yes	Yes		Yes	Low Ground at Walker Park	Install levee along east creek bank 2,200 feet from 134 to 125 feet elevation (approximately 5 feet above existing elevation).	Improvements here could push flooding to other less desirable areas	$ 110,000.00
B	127	7	3	Yes	Yes		Yes	Road flooding on River Road between Swedeland Road and 3rd Street	Due to creek dropping elevation prior to River Road, the high velocity of the creek raises the water level over the road level, culvert work alone would not solve issue, would need a detention basin to settle the water prior to culverts.		$ 160,000.00
B	210	5	2			Yes	Yes	Flooding on Guthrie Road	Further investigation Required		N/A
	74	3	2	Yes			Yes	Flooding on East Valley Forge Road	Inlet Maintenance		$ 3,000.00
C	172	6	2	Yes	Yes		Yes	Yerkes and Church Roads - Overtopping due to backwater from railroad and Church Road culverts	Replace culverts under Church Rd and RR Tracks with 5.5' x 26' RCB; replace Yerkes Rd culvert with 4.5' x 27' RCV, increase Yerkes Rd elevation 2 feet; Project is likely more conveyance in nature since the end of line is the existing Quarry (which could receive/control the volume). There is little room in the upper watershed to place any large scale detention facilities.		$ 2,130,000.00
C	179	4	3	Yes	Yes		Yes	Crooked Lane Overtopping	Replace with 6'x13' box culvert		$ 1,010,000.00
D	188	6	2	Yes			Yes	Hughes Park - Street Flooding	Add inlets and piping at Traymore and Schenley, and Traymore and Philadelphia; inlet maintenance		$ 60,000.00
A	208	2	2		Yes		Yes	Insufficient Culvert Capacity under 1st Street and American Avenue	Increase culverts size on 1st Avenue and American Avenue to 20' x 8'		$ 1,800,000.00
A	221	3	3		Yes	Yes	Yes	Low ground in Fire Company parking lot.	Install levee along north stream bank to protect King of Prussia Fire Company building and parking lot (approx. 450 feet at elevation of 143)	Priority is given due to EMS need to access facility. Pushing runoff with levee could impact other sites adversely.	$ 22,000.00
	2	3	2	Yes			Yes	Property and street flooding on Keebler Road	Replace with 54" pipe under Keebler Road, 48" pipe under Springhouse Road		$ 220,000.00

B	17	3	2	Yes			Yes	Property and Regimental Road flooding near Caley Road	Conduct Inlet maintenance; Grade swale and add inlets between Regiment and West Valley Forge/Covered Bridge Road; Property grading to convey flows to existing inlets along Regimental Road between every home.	The school is in the process of rebuilding and new SWM regulations may affect this flooding.	$ 110,000.00
C	89	6	3	Yes	Yes		Yes	Insufficient Culvert Capacity causing flooding on South Gulph Road and Church Road.	Increase culvert on Croton Road to 18'x6' box culvert, increase culvert on Gulph Road to 25' x 6' box culvert, adjust stream banks accordingly.	By field review, opening up culvert could push large volume of water into neighborhood. Study should focus on possible detainment in memorial site.	$ 770,000.00
E	152	8	2	Yes	Yes		Yes	South County Line Road - Culvert overtopping	Replace 2 - 5' x 15' RCB		$ 1,310,000.00
A	235	7	3		Yes	Yes	Yes	Bridge overtopping	Elevate the Jones Road bridge 2 feet	Project expected to be costly.	$ 600,000.00
A	86	6	2	Yes	Yes			Intersection flooding at Colonial and Powderhorn	Replace 18" & 21" pipes with 24" & 30" pipes		$ 20,000.00
D	124	2	2	Yes	Yes			Insufficient Culvert Capacity, low road elevation on W Valley Forge Road from Mancill Mill Road to Trout Creek bridge.	Elevate W Valley Forge Road from the Bridge to approximately 1,000 feet southwest of the bridge. This includes raising the bridge 2 feet and conducting some stream work before the bridge.		$ 870,000.00
B	130	7	2	Yes	Yes			Culvert undersized	Add second 48" pipe to Existing Culvert, add 26 ac/ft. detention basin in lower end of golf course. Note our model does not include a 48" under parking lot, but a swale between properties.		$ 490,000.00
D	141	7	2	Yes	Yes			Intersection 3rd Street and Rt. 23 - street flooding, deep water at culvert near park	Regrade swale further to west side of road; add inlet and a 72" pipe prior to Route 23 and add second 48" pipe under Route 23	Anticipated low priority with lack of residential area nearby.	$ 60,000.00
B	144	7	2	Yes	Yes			Flooding on B Street, erosion and debris build-up upstream of B Street	Add second 48" pipe if all downstream pipes are dual 48" or single 72"		$ 340,000.00
	156	7	2	Yes	Yes			Stream Erosion, deposition and flooding of properties from Garrison to Longview	Construct Detention Basin south of Gypsy Ln		$ 280,000.00
B	170	6	2	Yes	Yes			South Henderson Road/Shoemaker Road - Culvert overtopping/Street Flooding	Replace Ex. Culvert with 4.5'x15.5' Box Culvert	No field investigation, Earth data shows modifications to the region potentially resulting in improvements of the SWM.	$ 1,180,000.00

A Project type is valid as a stand alone project, whose benefit must be evaluated by the Authority.

B Project type where adjacent large scale development project may have significantly altered the topography of the land and included various BMP practices that could have altered perceived (prior) flooding. Given the scale of the watershed modeling effort, additional (more refined) modeling analysis would be required to fully evaluate the effectiveness of the improvements and the potential mitigation of any flooding.

C Project type where improvements for this item are inherently "connected" to another project area and must be completed in conjunction with one another in order to avoid creating augmented flooding by only partially addressing.

D Project type is not a high priority given relatively low return on investment (i.e., investment on this project will reduce flooding, but with limited benefits to the residents.)

E Project type where perceived improvements is a low priority given proximity to adjacent municipality (where either runoff originates or where flooding impacts are observed).

Appendix F - Programmatic Enhancements Topic Papers

Minimum Control Measure Compliance Report

Cooperative Public Education Opportunities Report

BMP Recommendations for New Development, Redevelopment, and Township Projects

Review of Water Quality Monitoring Needs

Subdivision & Land Development Ordinance Revision Recommendations

Good House-Keeping Recommendations

Proposed Stormwater Treatment Practices

Preliminary Stormwater Program Priorities

Pollutant Reduction Plan Review

Upper Merion Township
Stormwater Management Plan
Minimum Control Measure Compliance Report
July 19, 2017

The purpose of this report is to provide Upper Merion Township with an overview of its existing stormwater management program as it relates to the six Minimum Control Measures (MCM) the Township is required to implement under its Municipal Separate Storm Sewer System (MS4) permit. Upper Merion administers activities to achieve the measurable goals associated with each of the six MCMs.

Like many Pennsylvania communities that are regulated under Pennsylvania Department of Environmental Protection's (PADEP) administration of the *General Permit for Stormwater Discharges from MS4s* (PAG-03), Upper Merion Township is transitioning from the 2013 version of the permit (permit # PAG130042, issued 3/16/2013) to an updated version to go into effect in March 2018.

On April 12, 2017 Amec Foster Wheeler submitted a Stormwater Program Questionnaire focusing on elements of the Township's existing stormwater management program and the program's consistency with regulatory standards under the MS4 permit. Township staff provided responses to this Questionnaire during interviews with Township staff on May 1, 2017. Amec Foster Wheeler gained additional information about MS4 compliance activities during site assessments of Township facilities on May 24, 2017; and review of MS4 reporting documents from the Township provided on June 12 and 14, 2017.

This report summarizes the Township's compliance with each MCM in the 2013 version of the PAG-03, as well as the anticipated impacts of the MCMs included in the 2018 permit mandates. By understanding current stormwater compliance activities and the degree to which they achieve compliance under both the 2013 and 2018 versions of the PAG-03, the Township will be able to make decisions on the scope and scale of their future stormwater compliance program. If changes are necessary, local leaders can determine how to make changes that meet compliance responsibilities as well as other goals of the community.

This Report provides a compliance summary of each MCM, organized by the Best Management Practices (BMP) associated with each as defined by PADEP.

MCM 1 – Public Education and Outreach on Stormwater Impacts

BMP #1 – *Develop, implement, and maintain a written Public Education Outreach Program (PEOP).*

Current Activities
The Township prepared a written PEOP in May 2014 and revised it in March 2016. This PEOP outlines the ways in which the Township plans to educate the public and make them aware of the impacts of illicit discharges to waterways. The PEOP contains overall goals and objectives, target audiences, and strategies for public education. It briefly describes the Township's intentions to publish and distribute material related to stormwater and illicit discharges to the community, keep target audience lists updated, and distribute stormwater information with township permits.

In 2016, the Township targeted on a plan for the restaurants and retail stores at the King of Prussia mall as part of their coordination with the Schuylkill Action Network. The goal of this effort was to increase awareness of the connection between storm drains and streams and to suggest specific actions business owners could take to protect local streams.

In 2016, the Township coordinated with the Montgomery County Conservation District on a successful environmental education grant application to install stream crossing signs, mark storm drains, and distribute pollution prevention information.

Recommendations
- Define measurable goals – The goals and strategies outlined in the Township's PEOP should be expanded upon and developed to:
    - Focus on a set of pollutants that are of concern in local water bodies;
    - Focus on specific audiences for targeted education (see BMP #2);
    - Establishing a goal for each public education strategy;
    - Define a timeline for achieving each measurable goal;
    - Quantify the resources needed to pursue goals; and
    - Identify the individual or office that is responsible for action to pursue the measurable goals.
- Review and update the PEOP – Revisions to the PEOP should be performed annually to reflect the progress made toward measurable goals and help the Township direct personnel and resources where most effective at educating the public about the specific stormwater issues facing Upper Merion.
- Pursue partnerships – Upper Merion's goal to educate the public on water quality and management responsibilities are shared with other organizations in the region. The PEOP should include a method for communication with these organizations and share resources to expand their reach. Examples of potential partnerships are identified below in the *Cooperative Public Education Opportunities Report*.

BMP #2 – *Develop and maintain a list of target audience groups that are present within the areas served by the Township's MS4.*

Current Activities
The Township has a general list of target audiences and resources for identifying and contacting these groups in their PEOP. Target audiences includes homeowners associations, business owners, schools, and local community organizations. Resources for populating these lists include property records, the Township Environmental Advisory Council (EAC) and the King of Prussia Business District.

Recommendations

- Specifically define target audiences – The PEOP should address the potential water quality impacts of a broad variety of audiences. Targeting specific messages to defined population sectors (i.e. ethnic, minority, and low-income communities; educational institutions; neighborhood and community groups; and businesses and industries) would address the varying perspectives that exist in the Township. Targeted education to be considered for addition into the PEOP could include:
    - Printing posters and brochures in more than one language;
    - Door hangers distributed through specific neighborhoods or districts that may be the source of pollutants of concern; and
    - Letters to business in specific areas or of specific types with information about good housekeeping practices.

BMP #3 – *Publish a newsletter, pamphlet, flyer, or website that includes stormwater educational information and the Township's program.*

Current Activities

The Township regularly includes information pieces in editions of all three of the Township's newsletters (*E-Newsletter*, *Township Lines*, and *Community Connections*). Through these newsletters, the Township is able to release information pertaining to yard waste, recycling events, tree planting events, stream cleanup events, littering, maintenance to street inlets, and maintenance to street inlets, among other things. For example, the Township's *E-Newsletter* of December 2, 2016, contained an article titled "Winter Stormwater Tips" and the October 3, 2014 issue included a link to an updated list with information regarding free local recycling events.

The Township maintains a Municipal Industrial Pretreatment Program (MIPP)/MS4/Stormwater Management Page on the municipal website that provides details about MIPP/MS4, MIPP ordinances, an environment response plan, MS4 program resources, and contact information for the MIPP/MS4 administrator.

Recommendations

- Select specific messages – To address Upper Merion's pollutants of concern as defined in the PEOP, the Township should post and publish articles that directly address the water quality issues facing the Township. Articles may be selected from clearinghouses of material managed by USEPA or PADEP or written by Township staff, EAC members, or solicited from the general public.
- Aggregate publications – In addition to posting links to relevant stormwater articles from the *E-Newsletter*, *Township Lines*, and *Community Connections*, the Township could add articles to its stormwater website from other sources. Such a collection of information would serve as a more comprehensive educational resource to the public. This website would allow the Township to track the number of hits on stormwater education links and serve as a way to organize information prior to preparing annual reports. Development of this resource requires periodic monitoring of articles published in the region surrounding Upper Merion.

BMP #4 – *Distribute stormwater educational materials to the target audience groups.*

Current Activities

In addition to regularly including information in the Township's newsletters, the Township distributes informational pamphlets and brochures at the Township's Earth Day Celebration.

Additionally, informational posters are on display in the lobby of the Township building, and stormwater educational slides occasionally circulate on the local television station UMGA-TV.

Recommendations

- Targeted distribution – Goals for distribution of educational materials to target audiences should be documented in the PEOP and reviewed regularly. These distribution tools should vary depending on the method best suited for that particular target audience. The Township should annually measure the efficiency of the method of distribution to each target audience and revise as necessary.

MCM 2 – Public Involvement/Participation

BMP #1 – *Develop, implement, and maintain a written Public Involvement and Participation Program (PIPP).*

Current Activities

The Township prepared a written PIPP in May 2014 and revised it in April 2016. This PIPP outlines the ways in which the Township plans to promote public involvement and participation in stormwater management decisions. The PIPP contains overall goals and objectives and potential strategies for promoting public involvement and participation. It briefly describes the Township's intentions to develop participation programs through various partnerships with adjacent municipalities and local organizations and associations, the creation of volunteer programs, and open access to public meetings. The Township's PIPP outlines goals encouraging broad use of rain barrels on private property and participation in stream clean-ups and tree planting events. Several aspects of the Township's PIPP overlap with the Township's PEOP.

Recommendations

- Define measurable goals – The goals and strategies outlined in the Townships PIPP should be expanded and developed to:
    - Promote opportunities to participate in decisions related to implementation of the MS4 permit;
    - Expand interaction with local groups with similar water quality goals;
    - Make water quality reports available to the general public; and
    - Define a timeline for achieving each measurable goal.
- Annually review the PIPP – It is best practice to review and revise the PIPP regularly to reflect the progress made toward increasing the public's involvement in the Township's stormwater program. These revisions will identify actions that support the PIPP and allow the Township to direct resources where most effective at encouraging the public's involvement. This review should evaluate the PIPP's consistency with the PEOP.
- Provide access to reports – In addition to the links currently on the MIPP/MS4/Stormwater Management Page on the Township's municipal website, the Township should upload MS4 status reports to its website for public review. Postings could include a map of the MS4, the PIPP, the PEOP, and the Township's MS4 compliance timeline.
- Routinely communicate with partners – The Township is located in a region with multiple organizations whose natural resource protection mission overlaps with Upper Merion, such as surrounding municipalities, the Upper Merion School District, and the Upper Merion EAC. Regional groups such as the Schuylkill River Heritage Conservancy, the Delaware Riverkeeper Network, the Pennsylvania Council of Trout Unlimited, and the Valley Forge National Park implement program elements that share water quality goals with Upper Merion. The Township should formalize communication with these groups. Increased communication would help to raise awareness among residents of regional water quality activities and promote greater involvement in stormwater projects sponsored by other organizations. Regular communication could expand awareness of Upper Merion's stormwater management program and water quality activities to a larger audience.

BMP #2 – *Solicit input from the public on the Township's Stormwater Management Ordinances, Standard Operating Procedures (SOPs), and Pollutant Reduction Plans (PRPs) prior to adoption.*

Current Activities

The Township's Board of Supervisor (BOS) and EAC meetings are generally open to the public; the meeting dates are posted on the Township's website and in all three of the Township's newsletters. The EAC regularly discusses stormwater issues at their meetings. Both the BOS and EAC use the Township website for routine communications with the public, and meeting minutes are available on the Township's website.

Recommendations

- Engage diverse audiences – Involving a diverse cross-section of the community provides the potential for input on a variety of concerns and ideas during the Township's stormwater program review and development process. The Township may find success with attracting participation by direct invitation to specific stakeholders and target audiences, requesting their attendance and input.
- Use alternative advertising methods – Since there may be a large sector of the population who does not read the local press, watch the Township's local television station, or visit the Township's website, the audience reached using current methods may be limited. Advertising meetings of the BOS, EAC, or other public events via social media, radio spots, postings at bus stops, using multilingual announcements, and door-to-door visits to increase public involvement in Township stormwater management activities.

BMP #3 – *Regularly solicit public involvement and participation from target audience groups.*

Current Activities

Several MS4-related activities have been planned with the intent of soliciting public involvement and participation, such as stream cleanups, tree plantings, and rain barrel seminars. Specifically, on May 2, 2015, the Township's EAC sponsored a stream clean-up with 64 volunteers, and on May 14, 2016, over 30 attendees helped clean up Township parks and streams through the Upper Merion Clean-Up.

Recommendations

- Invite target audiences – To increase participation in stormwater involvement opportunities, the Township should utilize the target audience list developed for the PEOP and specifically invite members of those target audiences. Invitations personalized by the Township may include a specific request to the invitee to send representatives from their organization to the Township event. These forums could be an opportunity where the Township could gain input on water quality and Green Infrastructure priorities.
- Name unnamed tributaries – The US Board on Geographic Names defines a process for naming unnamed streams. The Township could promote an event to solicit names for unnamed streams to raise awareness of the stream, its drainage area, and its water quality status. Once named, the Township could follow through with clean-up activities or water quality monitoring programs that would engage the public as partners in protecting the newly named tributary.
- Invest in partnerships – Forming and strengthening partnerships with other local entities may allow the Township to tap into partners' existing programs to cost-effectively expand the awareness of the number and variety of educational events available to the community. By building these partnerships, the Township could collaborate on activities already performed by local partners and invest in advertising that promotes those activities. Examples of potential partnerships are identified below in the *Cooperative Public Education Opportunities Report*.

MCM 3 – Illicit Discharge Detection and Elimination (IDD&E)

BMP #1 – *Maintain a written program to detect and eliminate illicit discharges into the MS4.*

Current Activities
The Township prepared a written Program for the Detection, Elimination and Prevention of Illicit Discharges in July 2013 and revised it in October 2013, November 2013, and April 2016. This program outlines procedures for the Township's plans to identify sources of, and consequentially eliminate, illicit discharges. It briefly describes the Township's procedures for identifying priority areas, screening outfalls, identifying the source of any detected illicit discharges, assessing the potential for illicit discharges, gaining access to private properties to inspect outfalls, and program documentation, evaluation, and assessment.

Recommendations
- Identify priority areas – The Township has performed inspections for over ten years under BMP #4 (described below) and could develop a map of where dry weather flows have occurred and where illicit discharges have been reported. Outfalls within areas of the Township experiencing more frequent illicit discharge activity are targets for increased inspections.
- Annually review the written Program for the Detection, Elimination, and Prevention of Illicit Discharges – It is best practice to review and revise the written program regularly, including standard operating procedures, to reflect the progress made toward the detection and elimination of illicit discharges into the MS4. These revisions will identify actions that support the written program and allow the Township to direct resources where most effective at detecting and eliminating illicit discharges.

BMP #2 – *Maintain a map showing location of all outfalls.*

Current Activities
The Township maintains a map of outfalls to receiving waters. The Township updated its map of its MS4 boundary and outfalls in April 2016; this map presents 259 outfalls.

Recommendations
- Confirm regulated outfalls – The MS4 progress report submitted in 2016 states that 253 outfalls are under the jurisdiction of the MS4 permit. The MS4 permit includes a definition of outfall that links to the federal Clean Water Act. Each of the outfalls currently identified by the Township should be evaluated with respect to the Clean Water Act definition to determine which outfalls are regulated by the Township's MS4 permit, which are fully the responsibility of a private property owner, and which are the responsibility of another permittee (i.e. PennDOT or an industrial NPDES-permitted discharger). For example, Outfall TCI002 discharges to the Trout Creek near Toys R Us. Future mapping may reveal that the storm sewer system serving this location is wholly on private property and does not intersect with the Township's right of way, therefore eliminating it from the Township's responsibility to manage under the MS4 permit. The list should also include points at which Upper Merion's MS4 discharges to another MS4.

  Upon refinement of the list of outfalls regulated under the Township's MS4 permit, the Township will know which outfalls to inspect over the course of the permit cycle, have a better-defined MS4 drainage area, and have a more precisely-calculated sediment load discharging to local water bodies.

- Periodic update of outfall map – As inspections occur and property owners develop and redevelop their parcels, outfalls may be added, removed, or improved. The Township should develop a system to track any new outfalls or changes to existing outfalls. This tracking process should document if the outfall is a privately-owned feature or if it should be associated with the Township's MS4 permit. Updates to the Township's GIS database could be performed quarterly or annually, depending on the pace of revisions being submitted to the Township. The Township could develop a feature of this map specifying where dry weather flows have occurred and where illicit discharges have been reported.

BMP #3 – *Maintain a map showing the entire storm sewer collection system, including privately owned components.*

Current Activities
The map described under BMP #2 displays watershed boundaries, streams, and surface and underground detention basins. The Township is currently adding more detail to the existing maps of the stormwater conveyance network. This next phase of map revision is anticipated to be completed time for the submittal of the MS4 application in September 2017.

Recommendations
- Mapping update – Adding features such as manholes, stormwater inlets, and piping to the Township's maps will help complete the map of the stormwater conveyance network. Such a comprehensive map aids in the investigation of the source of an illicit discharge into the MS4, track the course of spills that may occur, and inform infrastructure management decisions. The map should include a suite of attributes that allows the Township to facilitate efficiency when complying with MS4 standards, planning inspection schedules, facilitating operations and maintenance, responding to citizen complaints, and setting priorities for stormwater feature replacement and capital projects. The spatial data and attribute information should include the following for each feature:
    - Connectivity to an outfall;
    - Ownership and maintenance responsibility;
    - Construction material;
    - Current condition;
    - Inspection schedule;
    - Maintenance record; and
    - Photos.

    Field observations of elevation and size of pipes and swales would provide the Township with even greater information that could be used to create hydrologic models of the system and better understand pinch points and necessary system upgrades.
- Identify private features – Of the features already mapped, many of them are located on private property. However, the Township has not distinguished between private and public stormwater management infrastructure. The Township should document which features are private, which property owners have maintenance responsibilities, and where the Township holds the right of access to inspect or take remedial action on failing structures.
- Identify PennDOT and industrial features – The Township should identify features that convey stormwater owned and/or managed by PennDOT. The Township should identify facilities discharging under the authority of PADEP through an industrial stormwater discharge NPDES permit. This ownership information can support policy development that assigns long-term operations and maintenance responsibility for stormwater infrastructure.

- Regularly update GIS database – The Township should annually update the GIS database to ensure the location and other data associated with all mapped stormwater features are current and accurate.

BMP #4 – *Conduct dry weather screenings of MS4 outfalls.*

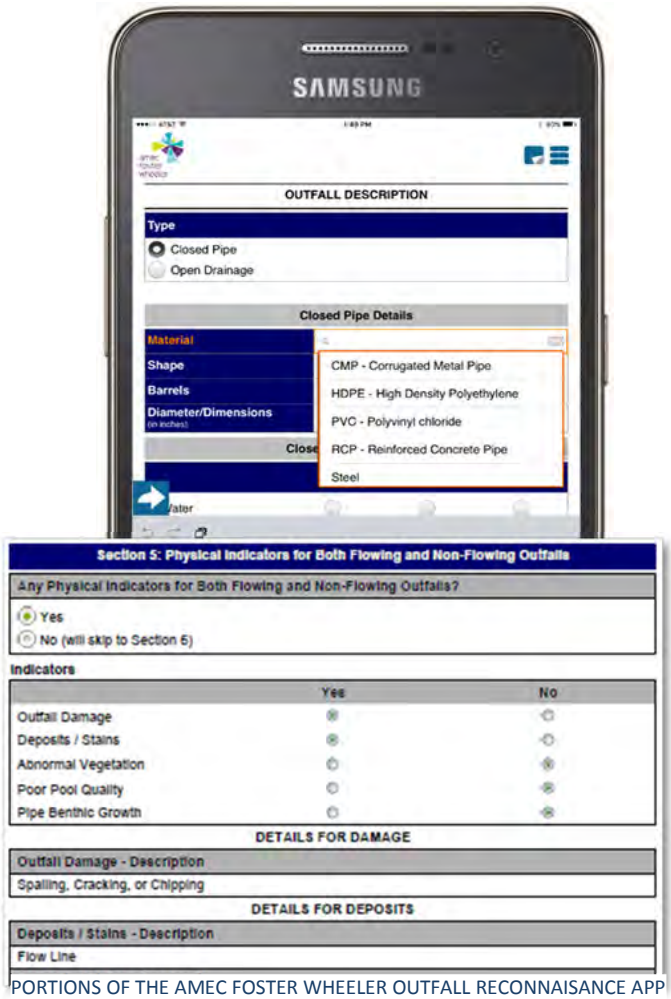
Current Activities

The Township's MS4 progress report covering the period of March 2014 to March 2016 documents that the Township screened 22% of 253 outfalls, or 56 outfalls, in that two-year period. The 2016 MS4 Outfall Screening Report stated that 105 outfalls were screened in March 2016.

The Township's MS4 progress report covering the period of March 2016 to March 2017 documents screening of 63% of 253 outfalls, or 159 outfalls, in that one-year period. Eighty-four of these outfalls screenings took place in February 2017 as documented in the 2017 MS4 Outfall Screening Report. During this series of screenings, 12 dry weather flows were investigated the source of non-stormwater discharge. When a dry weather flow is discovered, the Township obtains a sample for laboratory testing. If a suspected illicit discharge is recognized in the field, the Township field inspector obtains photographs and samples for laboratory testing. The Township documented structural issues with outfalls when found.

Recommendations

- Data recording – The Township has Outfall Reconnaissance Inventory/Sample Collection Field Sheets gathered as an attachment to their MS4 Annual Progress Report. The Township should consider aggregating all records in an online database that would help facilitate the Township in measuring progress of screening all the regulated outfalls in the 2013 to 2018 permit term.
- Mobile data collection – The Township's current method of screening includes the following steps: (1) define list of outfalls to be evaluated, (2) perform field observations and take photos, (3) organize observation data sheets and photos, and (4) summarize paper forms in an annual report. This process is vulnerable to error as information is transferred multiple times. Further, the information gathered has no GPS reference to assure accuracy or aid in tracking efforts.



PORTIONS OF THE AMEC FOSTER WHEELER OUTFALL RECONNAISANCE APP AND RESULTING INSPECTION REPORT

Instead, the Township should consider mobile data collection that uses smartphone or tablet applications to collect data in the field, including photographs, feature conditions, maintenance needs, and more. The collection tool can be customized for input of specific observations (weather, color, sheen, odor, etc.) as well as additional fields for entry of additional observations. Mobile data collection enables the field inspector to upload observations directly to a GIS for immediate review and quality control. This process allows the Township to standardize observation input, saves data entry time, and limits transcription errors.

- Stream assessment – During the course of periodic dry weather flow screenings, the Township could consider performing additional review of stream health. These assessments could help the Township identify areas of the stream that may be actively eroding and threatening infrastructure, that are susceptible to illegal dumping, or that may have degraded habitat.

BMP #5 – *Enact a Stormwater Management Ordinance to implement and enforce prohibition of non-stormwater discharges to the MS4.*

Current Activities
The Township implemented an ordinance in February 2014 that prohibits non-stormwater discharges; this ordinance was submitted to the DEP. The ordinance has been enforced, and notices of violations have been issued to those responsible for violations. According to the Township's Program for the Detection, Elimination and Prevention of Illicit Discharges, the property owner and/or operator of the use on the property which is suspected of being the source of the illicit discharge is contacted by the Township with the intent of eliminating the illicit discharge; if the illicit discharge continues, the Township will take further action.

Recommendations

- Consistency with Model Ordinance – Upper Merion's Chapters 140A and 140B both address *Stormwater, Grading, and Erosion Control.* Specifically, Article VI of each chapter lists prohibited discharges from the MS4 to surface waters and defines allowable non-stormwater discharges. These articles are generally consistent with the PADEP's 2022 Model Ordinance. The Township should perform a thorough review of its ordinances and the PADEP model and make necessary changes by the regulatory due date of September 2022.
- Track waivers – The Township is required to notify PADEP of the approval of any waiver it grants to applicants for Township permits for an exception to the non-stormwater discharge provisions of the Ordinance. The Township should track these waivers to summarize in the MS4 Annual Report.

BMP #6 – *Educate the public about the program to detect and eliminate illicit discharges.*

Current Activities
The Township is required to reach out to the public to educate them about the IDD&E program. The Township is consistent with this education outreach requirement by including IDD&E related information in the educational materials discussed under MCM 1.

Recommendations

- Create education resources – Creating an easy process for the public to detect and report illicit discharges helps educate the public on illicit discharges; for example, the Township

can add a guide for detecting and reporting illicit discharges to the MIPP/MS4/Stormwater Management page on their municipal website.

- Targeted education – Education efforts related to preventing illicit discharges could be directed more specifically to property owners in those locations that have historically high incidents of illicit discharges or dry weather flows. Targeted education could include:
    - Press releases to local newspapers and throughout the Township's social media;
    - Widely-distributed information on proper waste management, including announcements of household hazardous waste collection activities;
    - Door hangers distributed through specific neighborhoods; and
    - Targeted letters to business in specific areas or of specific types with information about good housekeeping practices.
- Staff training – The Township should conduct training for field personnel in the recognition and reporting of illicit discharges. Training should be applicable to the staff's role implementing the IDD&E program and the types of illicit discharges they may encounter based on their specific job responsibilities.
- Storm drain marking – Storm drain marking, which informs the public that discharges to storm drains flow to local surface water, is a popular way for communities to educate and involve the public, as well as reduce illegal dumping. The Township should consider further expanding partnerships with local volunteer groups to add markers or stenciling to storm drains.

MCM 4 – Construction Site Stormwater Runoff Control

Current Activities
Upper Merion is currently relying on Pennsylvania's statewide program for stormwater discharges associated with construction activities, satisfying the four BMPs associated with the 2013 version of the MS4 permit for this MCM. The Montgomery County Conservation District is delegated by PADEP to administer regulations associated with Chapter 102 *Erosion and Sediment Control* of the Pennsylvania Code across the County. Upper Merion and the Conservation District communicate regarding earth disturbance activities during the process of land development.

Recommendations
As the Township transitions to the 2018 version of the MS4 permit, the Township should continue to rely on PADEP's program for issuing NPDES permits, formally communicate with the Conservation District regarding responsibilities for overseeing land disturbance activities, and implement the following BMPs as defined in the updated permit. Formal communication could be documented in a Memorandum of Understanding with the Conservation District that specifies responsibilities and expectations for reporting and notification of erosion control inspections and enforcement.

- BMP #1 – *Withhold issuance of building permits to those proposing earth disturbance activities requiring an NPDES permit until coverage is authorized.*

- BMP #2 – *Notify the PADEP or the Conservation District of applications for a Township permit proposing greater than one acre of earth disturbance.*

- BMP #3 – *Enact, implement, and enforce an ordinance to require the implementation and maintenance of erosion controls.*

MCM 5 – Post-Construction Stormwater Management in New Development and Redevelopment

PADEP reorganized the six BMPs comprising this MCM in the 2013 version of the MS4 permit into three BMPs for the 2018 version. The concepts of BMPs #1, 2, and 3 as defined below for the 2013 version are now incorporated into BMP #1 of the 2018 version. BMP #1 will require each MS4 permittee to enact and enforce an ordinance that defines standards for post-construction stormwater management. BMPs #2 and 3 of the new permit are generally consistent with BMPs #5 and 6 of the old permit. The current BMPs from the 2013 permit are discussed below. The recommendations section for this MCM address the 2018 version of the three BMPs for MCM 5.

BMP #1 – *Develop a written procedure describing implementation of this MCM.*

BMP #2 – *Require structural and/or non-structural practices that minimize water quality impacts from new development and redevelopment.*

BMP #3 – E*nsure that controls are installed to prevent water quality impacts.*

Current Activities
Upper Merion is currently relying on Pennsylvania's statewide program for post-construction stormwater management associated with development activities for BMPs #1, 2, and 3 associated with this MCM under the 2013 version of the MS4 permit.

BMP #4 – *Enact, implement, and enforce an ordinance to address post-construction stormwater runoff from new development and redevelopment.*

Current Activities
The Township maintains two chapters in its code that address *Stormwater, Grading and Erosion Control*. Chapter 140A regulates residential development; Chapter 140B regulates multifamily, commercial, industrial and institutional development. These chapters address post-construction runoff from development projects and submitted to the PADEP with a letter from an official certifying its enactment on February 20, 2014.

BMP #5 – *Develop and implement measures to encourage the use of Low Impact Development.*

Current Activities
The MS4 progress report submitted to PADEP in 2016 states that progress toward the measurable goal to enact an ordinance to promote Low Impact Development is not applicable.

BMP #6 – *Ensure adequate operation and maintenance of post-construction stormwater management BMPs.*

Current Activities
The Township revised its *Operation, Maintenance, Inspection, and Repair Program* for stormwater facilities in April 2016. This program states general goals for inspection of roadways; storm sewer inlets, channels, culverts, outfalls; and stormwater basins, to promote adequate function. Program activities include street sweeping, inlet cleaning and rebuild, pipe replacement, and leaf collection. The Township inspects three Township-owned structural stormwater management features annually and takes corrective action as necessary.

The Township has identified 30 post-construction stormwater BMPs that have been constructed and maintains in an inventory that includes location, specifications, and status.

Recommendations

- Consistency with Model Ordinance – The Township should perform a thorough review of its ordinances and the PADEP model and make necessary changes by the regulatory due date of September 2022 in order to comply with BMP #1 of the 2018 version of MCM 5. This will include the requirement associated with BMP #2 of the 2018 version of the MS4 permit that states that permittees shall enact ordinances to encourage and expand the use of Low Impact Development in new development and redevelopment.
- Public BMP inventory – As part of its current mapping efforts, the Township should update its list of stormwater BMPs located at Township facilities. Examples of the revisions that should be made to this list are discussed in the Good House-Keeping Recommendations dated June 15, 2017.
- Operation of public BMPs – The Township should develop a maintenance plan for each publicly-owned stormwater structure that manages rate and/or volume of stormwater discharge. The maintenance plan should include an inspection cycle, maintenance schedule with specific activities, and responsible parties so that the structure operates as designed.
- Private Storm Sewer and BMP Monitoring Program – The Township has a list of 31 detention basins; five of which are owned by the Township. However, the Township does not actively manage or update this list of stormwater management controls that were likely installed as a condition of the Township's land development plan approval. The Township should perform a complete inventory of privately-owned stormwater management structures and define a process for adding new structures constructed during the land development process. This inventory should focus on controls that are associated with *NPDES Permits for Stormwater Discharges Associated with Construction Activities* approved since March 10, 2003.

  Once structures are identified, located, and spatially connected to an outfall to a waterbody on the MS4 map (see Mapping Update recommendation under MCM 3, BMP #3), the Township should gather attribute data for each, including:
  - Type of stormwater control
  - Date of construction
  - Ownership
  - Status of Township rights to access, inspect, and/or repair
  - Status of an operation and maintenance plan or agreement
  - Inspection schedule and responsibility
  - Date of last inspection
  - Current condition and operation
  - Completed and planned corrective actions

  Where the Township does not have rights to access stormwater controls on private property, the Township should also develop a process to communicate with the property owner about their responsibilities for operations and maintenance of the structure. If appropriate, the Township can pursue access rights to inspect the structure, enter into a maintenance agreement with the property owner, or establish a process by which the property owner certifies the structure is properly functioning.

MCM 6 – Pollution Prevention / Good Housekeeping

See Good House-Keeping Recommendations dated June 15, 20

Upper Merion Township
Stormwater Management Plan
Cooperative Public Education Opportunities Report
July 19, 2017

The following organizations and partnerships are active in the Upper Merion region providing outreach and education activities related to environmental awareness and water quality stewardship. Each organization has defined target audiences for delivering specific messages to inform the public about opportunities individuals have to take on behaviors to protect water quality.

As the Township further develops its Public Education and Outreach Program (PEOP) and Public Involvement and Participation Program (PIPP), these organizations, in addition to the Township's own Environmental Advisory Council (EAC), should be consulted for opportunities to partner on the pursuit of shared water quality goals. The Township may wish to formalize communication and partnerships with select groups where target audiences defined in the PEOP and PIPP overlap. Strategic partnerships could efficiently enable the Township to raise awareness among residents of regional water quality activities and promote greater involvement in stormwater projects sponsored by other organizations. Similarly, promotion of the Township's water management efforts by partner organization could also broaden awareness of Upper Merion's stormwater management program and water quality activities to a greater audience.

- Trout Unlimited – The Valley Forge chapter of Trout Unlimited primary mission is to protect the major watersheds of Chester County, including the Valley Creek as it flows through Upper Merion in Montgomery County. It promotes watershed protection, a stream inspection program, fly fishing, and floodplain restoration. The chapter coordinates a trout raising program for school children in the region and has open monthly meetings at the Grange Hall in Phoenixville.
- Green Valleys Watershed Association – The Green Valleys Association focuses its water quality assessment, restoration, education, and advocacy efforts on northern Chester County watersheds, extending to the Valley Creek. They sponsor stream clean-ups, nature camps, and nature classes.
- Valley Creek Restoration Partnership – Consisting of five non-profit organizations in the region (Green Valleys Association, Open Land Conservancy, West Chester Fish, Game & Wildlife Assoc. and the League of Women Voters), this affiliation aims to protect and improve the Valley Creek watershed. Affiliated members include local municipalities, Chester County offices, the National Park Service, Valley Forge Middle School, and five Philadelphia area colleges and universities.
- Valley Forge National Historical Park – A member of the Valley Creek Restoration Partnership, Park Service exhibits provide historical context for how the Schuylkill River and Valley Creek in Upper Merion were used as a resource to the local economy in the 17th and 18th Centuries.
- Riverbend Environmental Education Center – Located in Gladwyne along the Schuylkill River, Riverbend's website states that its mission is "to teach environmental principles to children in Southeastern Pennsylvania." Programs include camps, nature clubs, and scout programs.
- Schuylkill Center for Environmental Education – The Schuylkill Center provides outreach and education opportunities for all ages from its location on Hagy's Mill Road in Philadelphia. Target audiences include teachers, school environmental clubs, and birders.
- Neighboring communities – Each of Upper Merion's municipal neighbors (Lower Merion, Tredyffrin, Radnor, Norristown, Lower Providence, East Norriton, West Norriton,

Norristown, Bridgeport, and West Conshohocken), as well as Montgomery County, manages their own compliance with their MS4 permit. This includes development, implementation, and regular review of a PEOP and PIPP. Communities in Southeastern Pennsylvania commonly work together on shared outreach and education programs, and could be an opportunity for communities in the Lower Schuylkill watershed.

- Schuylkill Action Network – This partnership of local watershed organizations, businesses, academic institutions, local, state, and federal governments, and water suppliers is administered by the Partnership for the Delaware Estuary. Objectives of the partnership include improving watershed health, improving the public's perceived value of the River, and improve drinking water safety.
- Delaware Riverkeeper – The Riverkeeper serves the Delaware River watershed which flows through New York, Pennsylvania, New Jersey, and Delaware. The network acts on both regional and local issues that could impact water quality in the watershed. The network hosts an annual Watershed Congress that could be advertised to Upper Merion's target audience groups to increase public involvement and participation.
- Upper Merion Area School District – The School District's Director of Curriculum & Instruction has a focus on S.T.E.M Education (Science Technology Engineering Mathematics). The Director states the School District's intent to seek out partnerships that provide opportunities for applying S.T.E.M. education in the community.

Upper Merion Township
Stormwater Management Plan

BMP Recommendations for New Development, Redevelopment, and Township Projects

July 20, 2017

This report summarizes the evaluation and approach in developing a list of preferred stormwater management Best Management Practices (BMP), whose implementation will help Upper Merion Township meet its pollutant reduction goals. The recommended BMPs presented for consideration by the Township provide the best combination of the following desirable characteristics:

- Pollutant reduction efficiency;
- Cost of implementation; and
- Cost of maintenance.

Like other municipalities in the Commonwealth of Pennsylvania, Upper Merion Township faces stormwater challenges associated with compliance with Pennsylvania Department of Environmental Protection's (PADEP) Municipal Separate Storm Sewer System (MS4) Permit. To comply with the MS4 permit, the Township is tasked with developing Pollutant Reduction Plans (PRP) to reduce sediment discharging from their MS4 to all of the Township's streams designated as impaired from suspended solids or siltation. The June 26, 2017 version of PADEP's MS4 Requirements Table lists 5 stream systems impaired by these pollutants (Trout Creek, Gulph Creek, Crow Creek, Unnamed Tributaries to the Schuylkill River, and Matsunk Creek).

Stormwater management BMPs are widely recognized as effective measures for improving water quality as well as managing the quantity of discharges. In May 2016, PADEP released a *BMP Effectiveness Values* (3800-PM-BCW0100m) table to provide guidance to MS4s developing and implementing PRPs and Total Maximum Daily Load (TMDL) Plans to comply with the National Pollutant Discharge Elimination System (NPDES) permit requirements. The *BMP Effectiveness Values* table describes several types of BMPs including the pollutant removal effectiveness. Evaluation included the information provided in the *BMP Effectiveness Values* table as well as additional BMP data from other resources to establish a recommended list of BMPs for consideration by the Township. The recommended BMPs provide valuable information for use during the review of development projects as well as in evaluation of Township-sponsored capital projects, focusing on achievement of PRP goals.

Approach

The approach began with the selection of a large sample of BMPs for evaluation. The types of BMPs selected can be implemented on private parcels, public right-of-way (ROW), or both. The primary resource for the selection of the BMPs was the PADEP's *BMP Effectiveness Values* table. Additional BMPs were selected from the City of Philadelphia's *Green Streets Design Manual* (2014). The *BMP Effectiveness Values* table provides the pollutant removal effectiveness for sediment, total Nitrate (TN) and total Phosphorous (TP). Additional pollutant removal effectiveness values for fecal coliform and metals were obtained from the *BMP Selection Guide* (Table 4.1.3-1) of the 2016 edition of the *Georgia Stormwater Management Manual* (Volume 2: Technical Handbook). The Georgia *BMP Selection Guide* provides some of the most current data available for the cost considerations for the implementation and maintenance of various BMPs.

Using the BMP data obtained from the two tables (Pennsylvania and Georgia) referenced above, criterion for establishing a *BMP Effectiveness Score* was created. This criterion assigns points to each category of pollutant reduction effectiveness values. The points assigned for each category

were weighted to reflect the importance of a specific pollutant to Upper Merion Township's pollutant reduction goals. Per the current MS4 permit, the major pollutant of concern for the Township is sediment. Therefore, sediment removal effectiveness values were designated highest point scores. Table 1 below summarizes our criteria for assigning points to the different pollutant reduction effectiveness values. For example, a BMP stated to be able to remove 70% of sediment and 20% of TN would score 8 points using this weighting system. This point system was developed based on our understanding of Upper Merion's priorities. Factor weighting can be adjusted to result in alternative rankings and relative scores to reflect input from future studies on costs and pollutant removal effectiveness or to reflect changes in Township goals.

Table 1. Pollutant Removal Effectiveness Scoring Chart

BMP Pollutant Removal Effectiveness Value	Sediment	Total Nitrogen	Total Phosphorous	Fecal Coliform	Metals
if > 80%	10	5	5	3	3
if 60% - 80%	7	3	3	2	2
if 40% - 60%	5	2	2	1	1
if 10% - 40%	2	1	1	0.5	0.5
if 0 – 10%	0	0	0	0	0

Cost considerations were also a critical contributing feature to establishing the *BMP Effectiveness Score*. The Georgia *BMP Selection Guide* table provides ratings for construction costs and maintenance burden. The ratings are high, medium, and low, and represent typical consolidated costs per impervious acre treated. Table 2 below summarizes our criterion for assigning points based on cost considerations. To support these rankings, we also consulted a Mid-Atlantic publication, *Costs of Stormwater Management Practices in Maryland Counties*, prepared for the Maryland Department of the Environment Science Services Administration by Dennis King and Patrick Hagan.

Table 2. Cost Scoring Chart

Costs Per Impervious Acre Treated	Construction or Implementation	Maintenance Burden
High	0	0
Medium-High	2	2
Medium	5	5
Low	10	10

We considered runoff reduction potential in establishing the *BMP Effectiveness Score*. The runoff reduction potential ratings are either 'yes' or 'no'. We assigned a score of 3 points for BMPs that provide runoff reduction ('yes') and zero points for BMPs that do not reduce runoff ('no'). The scores assigned for runoff reduction are weighted Upper than scores for pollutant removal and cost scores. This accounts for the fact that runoff reduction/infiltration potential are the primary drivers for the Township's BMP program. Therefore, for our scoring we assumed that runoff reduction points/score are integrated in the pollutant reduction scores.

Results and Conclusion

The *BMP Effectiveness Score* provides a measure for choosing preferred BMPs that we suggest the Township promote for implementation in the municipality. Based on the criterion explained in

the Approach section above, the BMPs with the highest *BMP Effectiveness Score* provide the best combination of water quality improvements and cost-effectiveness. Table 3 below shows results for the highest rated BMPs. The Township's opportunities to promote the use of these preferred BMPs at specific locations towards specific water quality goals will be discussed with Township leadership in future deliverables: the SALDO Revisions Recommendations and the Infrastructure Prioritization.

Attachment A graphically presents the scoring for all BMPs evaluated. Note that the BMPs with medium scores (yellow, with score range of 15 -21) should be considered on a case-by-case basis. The medium-score BMPs include green street measures that provide good pollutant removal efficiencies; however, since the size of the drainage areas that they treat is typically limited, their costs per impervious acre treated are relatively high.

Attachment A contains a graphic that demonstrates the BMPs evaluated against their corresponding BMP Effectiveness Score. The graph is color-coded red, yellow, and green to represent BMPs with low, medium and high scores respectively. The BMP Effectiveness Score summary table is also provided within Attachment A.

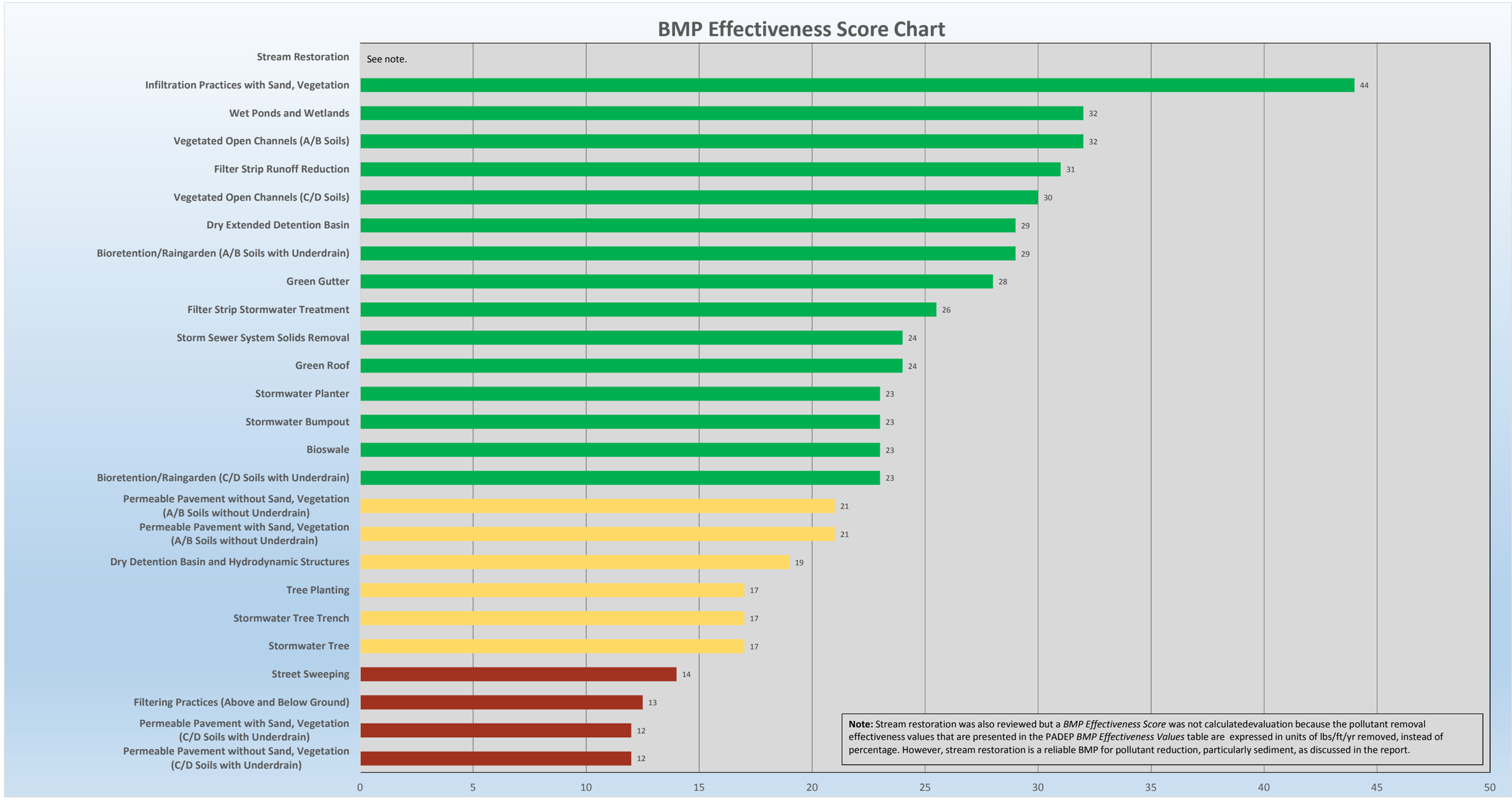
Attachment B provides a summary table of the advantages, disadvantages, and photo examples of each BMP.

Stream restoration was reviewed but was not included on the *BMP Effectiveness Score* evaluation, because the pollutant removal effectiveness values that are presented in the PADEP *BMP Effectiveness Values* table are not expressed as percentage like the other BMPs listed. These values are listed in units of lbs/ft/yr removed. Stream restoration is a reliable BMP for pollutant reduction, particularly sediment. Also, per the Executive Summary 1 (ES-1) table of the *Cost of Stormwater Management Practices in Maryland Counties* draft final report, construction costs (per impervious acre treated) for stream restoration is typically less than the average cost for typical stormwater BMPs implemented in urban settings. Therefore, stream restoration should be considered for implementation by the Township.

Table 3. BMP Effectiveness Score - Highest Rated BMPs

BMP	BMP Effectiveness Score
Infiltration Practices with Sand and Vegetation	44
Wet Ponds and Wetlands	32
Vegetated Open Channels (A/B Soils)	32
Filter Strip Runoff Reduction	31
Vegetated Open Channels (C/D Soils)	30
Dry Extended Detention Basin	29
Bioretention/Raingarden (A/B Soils with underdrain)	29
Green Gutter	28
Filter Strip Stormwater Treatment	26
Storm Sewer System Solids Removal	24
Green Roof	24
Stormwater Planter	23
Stormwater Bumpout	23
Bioswale	23
Bioretention/Raingarden (C/D Soils with underdrain)	23

Attachment A
BMP Effectiveness Score Chart and Table


BMP Effectiveness Score Chart
Stream Restoration
See note.
Infiltration Practices with Sand, Vegetation
44
Wet Ponds and Wetlands
32
Vegetated Open Channels (A/B Soils)
32
Filter Strip Runoff Reduction
31
Vegetated Open Channels (C/D Soils)
30
Dry Extended Detention Basin
29
Bioretention/Raingarden (A/B Soils with Underdrain)
29
Green Gutter
28
Filter Strip Stormwater Treatment
26
Storm Sewer System Solids Removal
24
Green Roof
24
Stormwater Planter
23
Stormwater Bumpout
23
Bioswale
23
Bioretention/Raingarden (C/D Soils with Underdrain)
23
Permeable Pavement without Sand, Vegetation (A/B Soils without Underdrain)
21
Permeable Pavement with Sand, Vegetation (A/B Soils without Underdrain)
21
Dry Detention Basin and Hydrodynamic Structures
19
Tree Planting
17
Stormwater Tree Trench
17
Stormwater Tree
17
Street Sweeping
14
Filtering Practices (Above and Below Ground)
13
Permeable Pavement with Sand, Vegetation (C/D Soils with Underdrain)
12
Permeable Pavement without Sand, Vegetation (C/D Soils with Underdrain)
12
0
5
10
15
20
25
30
35
40
45
50
Note: Stream restoration was also reviewed but a BMP Effectiveness Score was not calculatedevaluation because the pollutant removal effectiveness values that are presented in the PADEP BMP Effectiveness Values table are expressed in units of lbs/ft/yr removed, instead of percentage. However, stream restoration is a reliable BMP for pollutant reduction, particularly sediment, as discussed in the report.

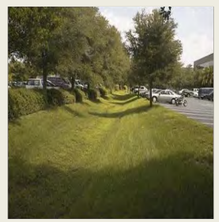
BMP Name	Sediment Removal (%) / Water Quality Benefit / BMP Effectiveness	TN Removal (%)	TP Removal (%)	Fecal Coliform*** (%)	Metals*** (%)	Runoff Reduction	Parcels / Implementation Areas	Public R-O-W / Implementation Areas	Construction Costs / Cost Considerations	Maintenance Burden	BMP Effectiveness Score
Infiltration Practices with Sand, Vegetation*	95	85	85	100	100	Yes	◊		Medium	Low	44
Vegetated Open Channels (A/B Soils)*	70	45	45	0	0	Yes	◊	◊	Low	Low	32
Wet Ponds and Wetlands*	60	20	45	0	0	Yes	◊		Low	Low	32
Filter Strip Runoff Reduction*	56	20	54	0	0	Yes	◊		Low	Low	31
Vegetated Open Channels (C/D Soils)*	50	10	10	0	0	Yes	◊	◊	Low	Low	30
Bioretention/Raingarden (A/B Soils with Underdrain)*	80	70	75	90	95	Yes	◊		Medium-High	Medium	29
Dry Extended Detention Basin*	60	20	20	0	0	No	◊		Low	Low	29
Green Gutter**	80	60	60	80	0	Yes	◊	◊	High	Low	28
Filter Strip Stormwater Treatment*	22	0	0	0	40	Yes	◊		Low	Low	26
Green Roof***	80	50	50	0	0	Yes	◊		High	Low	24

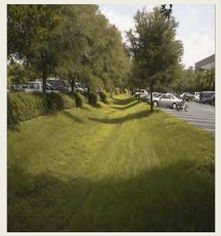
BMP Name	Sediment Removal (%) / Water Quality Benefit / BMP Effectiveness	TN Removal (%)	TP Removal (%)	Fecal Coliform*** (%)	Metals*** (%)	Runoff Reduction	Parcels	Public R-O-W	Construction Costs / Cost Considerations	Maintenance Burden	BMP Effectiveness Score
							Implementation Areas				
Storm Sewer System Solids Removal*	80	50	50	0	0	Yes	◊		Medium	Medium	24
Bioretention/Raingarden (C/D Soils with Underdrain)*	55	25	45	90	95	Yes	◊		Medium-High	Medium	23
Bioswale*	80	70	75	0	0	Yes	◊	◊	Medium-High	Medium	23
Stormwater Bumpout**	80	60	60	80	0	Yes		◊	High	Medium	23
Stormwater Planter **	80	60	60	80	0	Yes		◊	High	Medium	23
Permeable Pavement with Sand or Vegetation * (A/B Soils without Underdrain)	85	80	80	0	60	Yes	◊	◊	High	High	21
Permeable Pavement without Sand or Vegetation * (A/B Soils without Underdrain)	85	75	80	0	60	Yes	◊	◊	High	High	21
Dry Detention Basin and Hydrodynamic Structures*	10	5	10	0	0	No	◊		Medium	Low	19

BMP Name	Sediment Removal (%) / Water Quality Benefit / BMP Effectiveness	TN Removal (%)	TP Removal (%)	Fecal Coliform*** (%)	Metals*** (%)	Runoff Reduction	Parcels	Public R-O-W	Construction Costs / Cost Considerations	Maintenance Burden	BMP Effectiveness Score
							Implementation Areas				
Stormwater Tree**	20	10	15	0	0	Yes		◊	High	Low	17
Stormwater Tree Trench**	20	10	15	0	0	Yes		◊	High	Low	17
Tree Planting*	20	10	15	0	0	Yes	◊	◊	Low	N/A	17
Street Sweeping*	9	3	3	0	0	No		◊	Low	N/A	14
Filtering Practices (Above and Below Ground)*	80	40	60	40	50	No	◊		High	High	13
Permeable Pavement without Sand and Vegetation * (C/D Soils with Underdrain)	55	10	20	0	60	Yes	◊	◊	High	High	12
Permeable Pavement with Sand and Vegetation * (C/D Soils with Underdrain)	55	20	20	0	60	Yes	◊	◊	High	High	12
Stream Restoration *	44.88 lbs/ft/yr	0.075 lbs/ft/yr	0.068 lbs/ft/yr	0	0	No	◊		High	Low	#N/A

* Listed on PADEP's BMP Effectiveness Values Charts
** BMPs listed by City of Philadelphia Green Streets Design Manual 2014
***Data Source - 2016 Georgia Stormwater Management Manual – Volume 2:Technical Handbook

Attachment B
BMP Summary Table

Practice	Description	Advantages	Disadvantages
Stream Restoration	An annual mass nutrient and sediment reduction credit for qualifying stream restoration practices that prevent channel or bank erosion that otherwise would be delivered downstream from an actively enlarging or incising urban stream. Applies to 0 to 3rd order streams that are not tidally influenced. If one of the protocols is cited and pounds are reported, then the mass reduction is received for the protocol. 	• Can restore the biological integrity of stream segments • Can be aesthetically pleasing	• Space limitations can make impractical • Requires expensive grading and the removal of trees • May experience failure if volume/ velocity issues not addressed
Infiltration Practices with Sand, Vegetation*	A depression to form an infiltration basin where sediment is trapped and water infiltrates the soil. No underdrains are associated with infiltration basins and trenches, because by definition these systems provide complete infiltration. Design specifications require infiltration basins and trenches to be built in good soil, they are not constructed on poor soils, such as C and D soil types. Engineers are required to test the soil before approval to build is issued. To receive credit over the longer term, jurisdictions must conduct yearly inspections to determine if the basin or trench is still infiltrating runoff. 	• High pollutant removal. • Can be located in tight spaces or along the edge of parking lots • Can be used in place of gutter system along road • Reduces runoff • Medium Cost • Low maintenance burden	• Implement only on Parcels • Must have permeable soils • Subject to clogging • Can be less aesthetically pleasing
Wet Ponds and Wetlands	"A water impoundment structure that intercepts stormwater runoff then releases it to an open water system at a specified flow rate. These structures retain a permanent pool and usually have retention times sufficient to allow settlement of some portion of the intercepted sediments and attached nutrients/toxics. Until recently, these practices were designed specifically to meet water quantity, not water quality objectives. There is little or no vegetation living within the pooled area nor are outfalls directed through vegetated areas prior to open water release.Nitrogen reduction is minimal." 	• Reduces runoff • Low Cost • Low maintenance burden • Low maintenance burden • Aesthetically pleasing	• Low pollutant removal • Implement only on parcels • Requires space for permanent pool
Vegetated Open Channels (A/B Soils)	Open channels are practices that convey stormwater runoff and provide treatment as the water is conveyed, includes bioswales. Runoff passes through either vegetation in the channel, subsoil matrix, and/or is infiltrated into the underlying soils. This BMP has no underdrain and is in A or B soil. 	• Reduces Runoff • Implement on both parcels and public right of way • Low cost • Low maintenance burden • Easy to incorporate into design • Used for water quality by infiltration • Can be used instead of curb and gutter in residential areas	• Relatively low pollutant removal • Requires permeable soils • Not for use in steep terrain • Takes up more space than other techniques

Practice	Description	Advantages	Disadvantages
Filter Strip Runoff Reduction	Urban filter strips are stable areas with vegetated cover on flat or gently sloping land. Runoff entering the filter strip must be in the form of sheet-flow and must enter at a non-erosive rate for the site-specific soil conditions. A 0.4 design ratio of filter strip length to impervious flow length is recommended for runoff reduction urban filter strips. 	• Reduces runoff • Low cost of implementation • Low maintenance burden	• Average pollutant removal efficiency • Implement only on parcels • Requires flat or gently sloping land
Vegetated Open Channels (C/D Soils)	Open channels are practices that convey stormwater runoff and provide treatment as the water is conveyed, includes bioswales. Runoff passes through either vegetation in the channel, subsoil matrix, and/or is infiltrated into the underlying soils. This BMP has no underdrain and is in C or D soil. 	• Reduces Runoff • Implement on both parcels and public right of way • Low cost • Low maintenance burden • Easy to incorporate into design • Used for water quality by infiltration • Can be used instead of curb and gutter in residential areas	• Relatively low pollutant removal • Requires permeable soils • Not for use in steep terrain • Takes up more space than other techniques
Dry Extended Detention Basin	Dry extended detention (ED) basins are depressions created by excavation or berm construction that temporarily store runoff and release it slowly via surface flow or groundwater infiltration following storms. Dry ED basins are designed to dry out between storm events, in contrast with wet ponds, which contain standing water permanently. As such, they are similar in construction and function to dry detention basins, except that the duration of detention of stormwater is designed to be longer, theoretically improving treatment effectiveness. 	• Low cost of implementation • Low maintenance burden	• Relatively low pollutant removal • No runoff reduction
Bioretention/ Rain Gardens (A/B soils with Underdrain)	An excavated pit backfilled with engineered media, topsoil, mulch, and vegetation. These are planting areas installed in shallow basins in which the storm water runoff is temporarily ponded and then treated by filtering through the bed components, and through biological and biochemical reactions within the soil matrix and around the root zones of the plants. This BMP has an underdrain and is in A or B soil.  	• High pollutant removal efficiency • Reduces runoff • Aesthetically pleasing and may be used as a landscaping feature • Medium costs for maintenance	• Medium-high implementation costs • Better suited for parcels and public ROW • Treats relatively small drainage areas • Precise installation procedure required ensure proper functioning

Practice	Description	Advantages	Disadvantages
Green Gutter	A green gutter is a narrow and shallow landscaped strip along a street's curb line. It is designed to manage stormwater runoff by placing the top of the planting media in the green gutter lower than the street's gutter elevation allowing stormwater runoff from both the street and sidewalk to flow directly into the green gutter. An elevated curb can be used along the street side of the green gutter with openings along its length to allow runoff to flow into the green gutter. Green gutters can be designed to infiltrate and/or flow to the existing storm sewer. The system attenuates stormwater flows, provides storage and, in some cases, infiltration and evapotranspiration. In flow-through green gutters, overflow runoff can be conveyed to the existing storm drain system, either through an underdrain tied to the existing storm drain system, or as shallow concentrated flow that is conveyed downstream to an existing inlet. 	• Effective pollutant removal • Reduces runoff • Implement on both parcels and public right of way • Low maintenance burden • Aesthetically pleasing • May be used as a landscaping feature • Good for urban areas	• High cost • Treats small drainage areas
Filter Strip Stormwater Treatment	Urban filter strips are stable areas with vegetated cover on flat or gently sloping land. Runoff entering the filter strip must be in the form of sheet-flow and must enter at a non-erosive rate for the site-specific soil conditions. A 0.2 design ratio of filter strip length to impervious flow length is recommended for stormwater treatment urban filter strips. 	• Reduces Runoff • Low cost • Low maintenance burden	• Low pollutant removal • Implement only on parcels • Requires flat or gently sloping land
Storm Sewer System Solids Removal	This BMP (also referred to as "Storm Drain Cleaning") involves the collection or capture and proper disposal of solid material within the storm system to prevent discharge to surface waters. Examples include catch basins, stormwater inlet filter bags, end of pipe or outlet solids removal systems and related practices. Credit is authorized for this BMP only when proper maintenance practices are observed (i.e., inspection and removal of solids as recommended by the system manufacturer or other available guidelines). 	• Reduces Runoff • Medium cost • Medium maintenance burden	• Relatively low pollutant removal • Implement only on parcels • Implement only on Parcels • Requires disposal of materials within system • Can become clogged if not properly maintained
Green Roof	Green roofs (also known as vegetated roofs or eco-roofs) represent an alternative to traditional impervious roof surfaces. They typically consist of underlying waterproofing and drainage materials and an overlying engineered growing media that is designed to support plant growth. Stormwater runoff is captured and temporarily stored in the engineered growing media, where it is subjected to the hydrologic processes of evaporation and transpiration, with any excess runoff conveyed back into the storm drain system. This allows green roofs to provide measurable reductions in post construction stormwater runoff rates, volumes, and pollutant loads on development sites. 	• Reduces runoff • Low maintenance burden once established • Secondary benefits include improved air quality and reduced heating/cooling bills • Aesthetically pleasing. • Can be installed in any urban area. • Does not take up land space	• High cost • Possibility of leakage • Best for new construction or replacement of entire roof system • Vegetation requires maintenance while being established • Relatively low pollutant removal

Practice	Description	Advantages	Disadvantages
Stormwater Planter	A stormwater planter is a specialized, landscaped planter installed in the sidewalk area and designed to manage stormwater runoff. Runoff is routed to the planter by setting the top of the planting media in the planter lower than the street's gutter elevation and connecting the planter to one or more inlets (types vary), allowing stormwater runoff from the street to flow into the planter. Runoff from the adjacent sidewalk can flow directly into the stormwater planter from the surface. Plantings are incorporated within the facility to provide uptake of water and pollutants. Though stormwater planters can be designed in a variety of shapes and sizes, they are typically rectangular in form with vertical sidewalls on all four sides and an open bottom. 	• Effective pollutant removal • Reduces runoff • Medium maintenance burden • Easy to incorporate and can be used to retrofit streets and parking lots • Small area need for installation • Aesthetically pleasing	• Small drainage area • Implement on public right of way only • High Cost • Requires consistent maintenance (i.e. vegetation replacement, grooming) • Does not provide flood control
Stormwater Bumpout	A stormwater bump-out is a landscaped curb extension that extends the existing curb line into the cartway. It is designed to manage stormwater runoff by setting the top of the planting media in the bump-out lower than the street's gutter elevation and connecting the bump-out to one or more inlets (types vary), which allows stormwater runoff from the street to flow into the bump-outs. Runoff from the adjacent sidewalk can flow directly into the stormwater bump-out from the surface. They are designed to capture, slow, and infiltrate stormwater within a planted area or subsurface stone bed. Landscape plantings within the curb extension effectively take up some of the stormwater through their root systems. The remaining stormwater is temporarily stored within the curb extension until it either infiltrates or drains back to the sewer. In mid-block bump-outs, overflow exits through an opening on the downstream side, and flows into a nearby storm drain inlet. 	• Effective pollutant removal • Reduces runoff • Medium maintenance burden • Easy to incorporate and can be used to retrofit streets and parking lots • Small area need for installation • Aesthetically pleasing	• Small drainage area • Implement on public right of way only • High Cost • Requires consistent maintenance (i.e. vegetation replacement, grooming) • Does not provide flood control
Bioswale	With a bioswale, the load is reduced because, unlike other open channel designs, there is now treatment through the soil. A bioswale is designed to function as a bioretention area.  	• High pollutant removal efficiency • Reduces runoff • Applicable on both parcels and public ROW • Medium costs for maintenance • Easy to incorporate into site design • Can be used instead of curb and gutter in residential areas	• Medium-high implementation costs • Not for use in steep terrain • Precise installation procedure required ensure proper functioning
Bioretention/ Raingarden (C/D Soils with Underdrain)	An excavated pit backfilled with engineered media, topsoil, mulch, and vegetation. These are planting areas installed in shallow basins in which the storm water runoff is temporarily ponded and then treated by filtering through the bed components, and through biological and biochemical reactions within the soil matrix and around the root zones of the plants. This BMP has an underdrain and is in C or D soil.  	• High pollutant removal efficiency • Reduces runoff somewhat • Aesthetically pleasing • May be used as a landscaping feature • Medium costs for maintenance	• Medium-high implementation costs • Better suited for parcels and public ROW • Treats relatively small drainage areas • Precise installation procedure required ensure proper functioning

Practice	Description	Advantages	Disadvantages
Permeable Pavement with Sand or Vegetation **(A/B Soils without Underdrain)**	Pavement or pavers that reduce runoff volume and treat water quality through both infiltration and filtration mechanisms. Water filters through open voids in the pavement surface to a washed gravel subsurface storage reservoir, where it is then slowly infiltrated into the underlying soils or exits via an underdrain. This BMP has no underdrain, has sand and/or vegetation and is in A or B soil. 	• Effective pollutant removal • Reduces runoff • Implement on both parcels and public right of way • Does not take up additional land space • Good for churches and secondary parking areas that are not used frequently • Reduces impervious area of site	• High cost • High maintenance burden • Easily clogged or compacted • Inappropriate for high traffic areas • Requires permeable soils or the installation of under-drain
Permeable Pavement without Sand or Vegetation **(A/B Soils without Underdrain)**	Pavement or pavers that reduce runoff volume and treat water quality through both infiltration and filtration mechanisms. Water filters through open voids in the pavement surface to a washed gravel subsurface storage reservoir, where it is then slowly infiltrated into the underlying soils or exits via an underdrain. This BMP has no underdrain, no sand or vegetation and is in A or B soil. 	• Same as “Permeable Pavement with Sand or Vegetation”	• Same as “Permeable Pavement with Sand or Vegetation”
Dry Detention Basin and Hydrodynamic Structures	Dry Detention Ponds are depressions or basins created by excavation or berm construction that temporarily store runoff and release it slowly via surface flow or groundwater infiltration following storms. Hydrodynamic Structures are devices designed to improve quality of stormwater using features such as swirl concentrators, grit chambers, oil barriers, baffles, micropools, and absorbent pads that are designed to remove sediments, nutrients, metals, organic chemicals, or oil and grease from urban runoff.	• Low maintenance burden • Medium costs for implementation	• Poor pollutant removal efficiency • No runoff reduction • Suitable for parcels and not public ROW
Tree Planting	The BMP effectiveness values for tree planting are estimated by DEP. DEP estimates that 100 fully mature trees of mixed species (both deciduous and non-deciduous) provide pollutant load reductions for the equivalent of one acre (i.e., one mature tree = 0.01 acre). The BMP effectiveness values given are based on immature trees (seedlings or saplings); the effectiveness values are expected to increase as the trees mature. To determine the amount of pollutant load reduction that can credited for tree planting efforts: 1) multiply the number of trees planted by 0.01; 2) multiply the acreage determined in step 1 by the pollutant loading rate for the land prior to planting the trees (in lbs/acre/year); and 3) multiply the result of step 2 by the BMP effectiveness values given. 	• Reduces Runoff • Implement on both parcels and public right of way • Low Cost • Low maintenance burden	• Low pollutant removal • Need land to plant and grow trees

Practice	Description	Advantages	Disadvantages
Stormwater Tree Trench	A stormwater tree trench is a subsurface trench installed in the sidewalk area that includes a series of street trees along along a section or the total length of the subsurface trench. It is designed to manage stormwater runoff by connecting the subsurface trench to one or more inlets (types vary), which allows runoff from the street and sidewalk to flow into the subsurface trench. The runoff is stored in the empty spaces between the stones or other storage media in the trench, watering the trees and slowly infiltrating through the trench bottom. If the capacity of the system is exceeded, stormwater runoff can bypass the storm drain entirely and flow into an existing inlet downstream or through an underdrain system connected to the storm drain network. The surface above the trench and surrounding the street trees is restored to the elevation of the surrounding surfaces. 	• Same as Stormwater Tree	Same as Stormwater Tree
Stormwater Tree	"A stormwater tree is a street tree planted in a specialized tree pit installed in the sidewalk area. It is designed to manage stormwater runoff by placing the top of the planting media in the tree pit lower than the street's gutter elevation and connecting the tree pit to an inlet (types vary), which allows stormwater runoff from the street into the tree pit. Runoff from the adjacent sidewalk can flow directly into the tree pit from the sidewalk surface. Multiple tree pits can be designed in series to maximize the potential for stormwater capture and treatment. Stormwater will either infiltrate or drain to a connection to the storm sewer network. If the stormwater tree is at capacity, runoff can bypass the stormwater tree inlet and enter other downstream SMPs or a downstream storm drain." 	• Reduces Runoff • Low maintenance burden	• Small drainage area • Implement on public right of way only • High Cost • Low pollutant removal • Does not provide flood control
Street Sweeping	Street sweeping must be conducted 25 times annually. Only count those streets that have been swept at least 25 times in a year. The acres associated with all streets that have been swept at least 25 times in a year would be eligible for pollutant reductions consistent with the given BMP effectiveness values. 	• Low Cost	• Low pollutant removal • No runoff reduction • Implement only on public right of way • Requires purchase and maintenance of trucks • Must be conducted 25 times a year
Filtering Practices (Above and Below Ground)	Practices that capture and temporarily store runoff and pass it through a filter bed of either sand or an organic media. There are various sand filter designs, such as above ground, below ground, perimeter, etc. An organic media filter uses another medium besides sand to enhance pollutant removal for many compounds due to the increased cation exchange capacity achieved by increasing the organic matter. These systems require yearly inspection and maintenance to receive pollutant reduction credit. 	• Effective pollutant removal • May be used in urban areas • May be located under parking areas • May be used to treat up to 20 acres of drainage area	• No runoff reduction • High cost of implementation • High maintenance burden

Practice	Description	Advantages	Disadvantages
Permeable Pavement without Sand and Vegetation **(C/D Soils with Underdrain)**	Pavement or pavers that reduce runoff volume and treat water quality through both infiltration and filtration mechanisms. Water filters through open voids in the pavement surface to a washed gravel subsurface storage reservoir, where it is then slowly infiltrated into the underlying soils or exits via an underdrain. This BMP has an underdrain, has sand and/or vegetation and is in A or B soil.  	• Reduces runoff • Implement on both parcels and public right of way • Does not take up additional land space • Reduces impervious area of site • Good for churches and secondary parking areas that are not used frequently	• Relatively low pollutant removal • High cost • High maintenance burden • Easily clogged or compacted • Inappropriate for high traffic areas • Requires permeable soils or the installation of an under-drain
Permeable Pavement with Sand and Vegetation **(C/D Soils with Underdrain)**	Pavement or pavers that reduce runoff volume and treat water quality through both infiltration and filtration mechanisms. Water filters through open voids in the pavement surface to a washed gravel subsurface storage reservoir, where it is then slowly infiltrated into the underlying soils or exits via an underdrain. This BMP has an underdrain, has sand and/or vegetation and is in C or D soil. 	• Reduces runoff • Implement on both parcels and public right of way • Does not take up additional land space • Reduces impervious area of site • Good for churches and secondary parking areas that are not used frequently	• Relatively low pollutant removal • High cost • High maintenance burden • Easily clogged or compacted • Inappropriate for high traffic areas • Requires permeable soils or the installation of an under-drain
Stream and Headwaters Restoration	Various techniques used to restore degraded streams or headwaters damaged by excessive volume and velocity of stormwater. 	• Can restore the biological integrity of stream segments. • Can be aesthetically pleasing.	• Space limitations can make impractical. • Often requires extensive grading and the removal of trees. • May experience failure if volume/velocity • issues are not addressed.

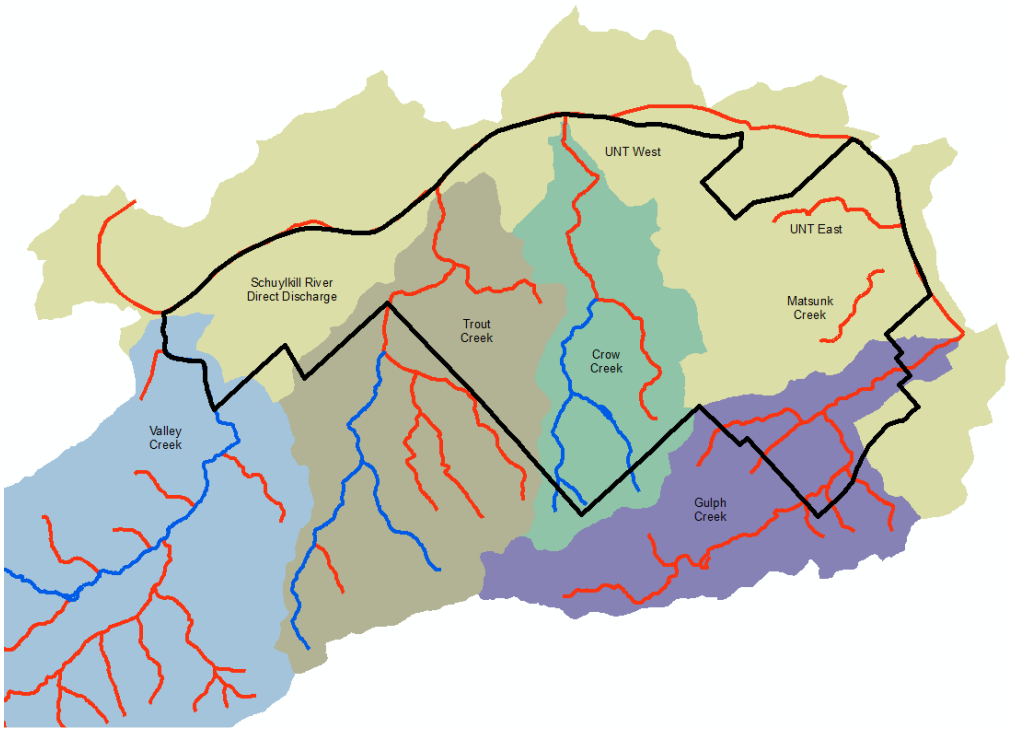
Upper Merion Township
Stormwater Management Plan
Review of Water Quality Monitoring Needs
October 30, 2017

Amec Foster Wheeler developed this review of water quality monitoring needs to help Upper Merion Township understand the scope, extent, and timeline associated with a program that quantitively evaluates the degree of impairment of local streams. The intent of this preliminary approach is to outline a Monitoring Program that the Township can use to collect qualitative and quantitative data about the biological, chemical, and physical properties of Upper Merion's impaired streams. Once collected, water quality data can be used to inform the Township's decisions on actions to improve water quality and address regulatory requirements. This preliminary approach is the basis of a final Monitoring Plan that the Township could formalize and implement if desired.

Introduction

Upper Merion Township has an existing Pollutant Reduction Plan (PRP) that was developed to comply with the Pennsylvania Department of Environmental Protection (PADEP) Municipal Separate Storm Sewer System (MS4) Permit. The PRP and MS4 Permit focus on specific measures to operate the storm sewer system and maintain or improve water quality in receiving waters. Upper Merion Township has five stream systems (Crow, Gulph, Matsunk, Trout, and Valley Creeks) that generally flow from south to north to the Schuylkill River. These stream segments are shown in **Figure 1**. The red streams are impaired; the blue segments attain water quality consistent with their use as designated by PADEP. All of the red streams (with the exception of the Schuylkill River) are impaired by sediment, but some are also impaired for pathogens, metals, and polychlorinated biphenyls (PCBs). These impairments are summarized in *303(d) List Summary* submitted by Amec Foster Wheeler to the Township on August 8, 2017.

Figure 1. Stream Impairments in Upper Merion



Sediment Impairments

PADEP defines sediment as the primary pollutant of concern in Upper Merion's waterways that is resulting in poor water quality. Erosion of sediment from the landscape and from streambanks occurs in a natural system with little or no development. In a natural system, the rate and amount of erosion is controlled by the parent materials of the soil, climate, topography, and vegetative cover. Stream systems are often able to accept these inputs of sediment without negative impact, and sediment transport occurs throughout the stream system. When land use and drainage patterns are changed through development, however, the rate of stormwater runoff and erosion often accelerates. This acceleration can cause greater volumes of sediment to wash off the landscape and can cause the velocity of water to become erosive, eroding the streambanks themselves. Sediment depositing on streambeds impacts the habitat of fish and benthic community (i.e. insects, mussels) and changes the stream morphology (shape and distribution of materials). Suspended sediment in the water column impacts water temperature and light penetration and carries nutrients that promote excessive vegetation growth (e.g., algae) that reduces oxygen in the water body.

Upper Merion submitted a PRP to PADEP in September 2017 focused on sediment as a condition of the Township's MS4 Permit. The PRP states the Township's commitment to reduce the discharge of sediment from its MS4 to local streams by 10% through 2023, as required by the MS4 Permit.

Other Causes of Stream Impairment

In addition to sediment, PADEP lists three other pollutants impacting specific water bodies in Upper Merion, as outlined below:

- Schuylkill River - The River is impaired by PCBs. Upper Merion has developed *Pollutant Control Measures for Waters Impaired by Priority Organic Compounds* to comply with the MS4 Permit. No further action is required by Upper Merion Township.
- Valley Creek - In addition to sediment, this stream is impaired by pathogens and PCBs. PCBs are being addressed through the V*alley Creek PCB Total Maximum Daily Load* that focuses on an upstream point source of pollution. Since the watershed for this stream is completely within Valley Forge National Park in Upper Merion, no action is required by Upper Merion to manage pathogens to this stream.
- Gulph Creek - PADEP defines metals as an impairment of the Gulph Creek, but does not identify sources. The Monitoring Program discussed herein identifies a process for collecting more data to begin establishing an in-stream baseline and identification of potential sources for this pollutant.

Existing Data

PADEP provides records of surface water quality sampling at 20 locations within Upper Merion Township through their eMapPA web portal (**Figure 2**). Chemical and physical water quality sampling results are provided online for several of these locations. PADEP's Assessment Section Chief within the Water Quality Division states that sampling points are determined using observation of changes in land use using aerial photography and known sources of discharge of pollutants to a water body. PADEP's determination of whether or not a stream meets water quality standards is reliant on assessment of benthic macro-invertebrate communities. Results from the assessment of macro-invertebrates are sometimes coupled with field measurements of water chemistry and physical parameters to define if the stream is attaining water quality standards. For streams that are not directly assessed, PADEP makes assumptions based on 1) the attainment status of nearby streams that have been sampled and 2) predominant land use and land use intensity in the watershed. PADEP maintains an assessment methodology webpage that defines their sampling standards.

Figure 2. Water Quality Sampling in Upper Merion.

Stream	# of Locations	Sampling Dates
Valley Creek	4	1998, 2012
	4 additional sample locations associated with a pollution incident are recorded in 2014.	
Trout Creek	3	2000, 2015
Crow Creek	5	2000, 2015
UNT West	0	
UNT East	0	
Matsunk Creek	1	2000
Gulph Creek	3	2000, 2017

Scope of Monitoring Program

The intent of a Monitoring Program designed to inform water resource decisions in Upper Merion would address four primary questions:

1. What are the baseline conditions and most significant sources of sediment in Crow Creek, Gulph Creek, Matsunk Creek, and Trout Creek?
2. What are the baseline conditions and potential sources of metals in Gulph Creek?
3. Are there other factors or sources of uncontrolled stormwater runoff that may be impacting water quality?
4. To what extent are the sources of these pollutants the Township's responsibility under the MS4 Permit or otherwise?

Answers to these questions will guide Township officials on how to direct resources to achieve an efficient water quality and stormwater management program to effectively address problem areas.

This Monitoring Program approach lays out a process for answering these questions. The intent is to define where there is shared responsibility for sources of pollutants and establish a target (i.e. habitat value, sediment discharge reduction) so that local streams can meet water quality standards. Then the Township can propose a timeline and set of partnerships to achieve water quality standards. Measurable goals will enable Township leadership to dedicate resources and track progress.

Currently, Upper Merion is required to reduce sediment discharge by 10% and provide preliminary reporting on potential sources of PCBs. It is unclear, however, what PADEP may require in the next MS4 Permit cycle beginning in 2023. For example, the next MS4 permit could include increases in the sediment reduction goal, specific actions to address metals and PCBs, or identification of other pollutants of concerns that require a PRP. This emphasizes the need to develop a better understanding of the current status of impaired waters and the actions that may be necessary to improve water quality.

The following recommended five-step process will help Upper Merion begin to develop baseline information, trends in water quality, and an understanding of pollutant sources to support the Township's water quality improvement approach:

- Task 1. Desktop Analysis of Potential Pollutant Sources
- Task 2. Field Reconnaissance
- Task 3. Formalize Monitoring Program Goals
- Task 4. Select Monitoring Parameters, Frequency, and Locations
- Task 5. Implement Monitoring Program

Each of these tasks is discussed in more detail below. *Note: Valley Creek is located within Valley Forge National Park, which does not discharge through the Township's MS4. Water quality improvements, therefore, are not the responsibility of Upper Merion Township and monitoring is not proposed for the Valley Creek stream system at this time.*

Task 1. Desktop Analysis of Potential Pollutant Sources

This task involves reviewing available data, reports, and maps to prepare a consolidated map that illustrates the presence of impairments, past pollutant sources, known pollutant sources, and potential pollutant sources. Once collected, features on this map could be analyzed to prioritize the greatest current threats to water quality. The results can be weighted to create a "hot spot map" showing where land use, infrastructure, physical settings, or other activities may have the biggest impact on stream health. This map should include the following (with potential data sources noted):

- Land use intensity and impervious area (USGS National Land Cover Database)
- High potential pollutant load sites, such as gas stations, salvage yards, landscaper yards, gravel pits, industrial sites, large parking lots or high traffic areas (parcel data)
- Facilities with surface water discharge permits (PADEP eFacts and eMap tools)
- Past industrial land uses that could be sources of PCB
- MS4 outfalls (Township MS4 map)
- Steep slopes and soil types (PA DCNR and NRCS)
- Development in the floodplain (parcel data)
- Current earth disturbance permits (Township records)
- Stream impairments (PADEP 303(d) list)
- History of illicit discharge (MS4 records)
- Existing stream gauges (USGS, NOAA)
- Past sampling location and water quality data (PADEP, Lower Merion Conservancy, Tredyffrin Township)
- Existing stormwater controls (Township records)

Results of this analysis should result in a broad spectrum of preliminary goals to help direct the collection of field information in Task 2. Goals would be revised and formalized in Task 3.

Task 2. Field Reconnaissance

Following the desktop analysis, a field reconnaissance effort should be completed to field verify hot spots and observe stream conditions. Ideally, all 50-plus miles of stream should be walked to inventory the overall health and identify areas of concern. Resources and access, however, may limit the number of miles that can be assessed. Therefore, the base map created in Task 1 can be used to prioritize individual segments. To standardize and streamline the data collection process, mobile data collection tools can be used to automatically upload data to a GIS database with photos and observations that are georeferenced. Data collection activities should be performed when conditions are relatively similar; avoiding stream walks immediately after large storm events and occurring in the same season so vegetation can be observed and compared. The data collection effort may include, but not be limited to, the following observations:

- Excessive sedimentation and gravel bars that appear to be recently formed
- Degree of stream channelization
- Eroding stream banks and degree of bank cutting or stream channelization
- Scour at culverts, outfalls, and around bridges

- Point sources of pollution
- Exposed infrastructure (storm sewer, sanitary sewer, bridge abutments)
- Odor, sheen, surfactants (bubbles), or color
- Encroachment from land use and historic structures
- Major inflows of stormwater
- Effluent discharges from facilities or properties
- Non-point sources of pollution
- Illicit discharges
- Dumping and trash
- Runoff from irrigation and properties with managed turf
- Type and condition of vegetation (e.g., distressed vegetation)
- Width and condition of riparian buffer

Tools already exist to assist communities organize observations. The *Rapid Stream Assessment Methodology* developed by the U.S. Fish and Wildlife Service is a useful tool for determine the restoration potential of specific stream segments. Similarly, U.S. EPA's *Rapid Bioassessment Protocols* provides a way for communities to compare stream segment health to help set priorities for action.

Task 3. Formalize Monitoring Program Goals

Following the results of Task 2, the Township should more clearly define and document the goals of the Monitoring Program. These goals should be measurable and include site specific locations that will be the focus of subsequent investigations and the Monitoring Program. ~~G~~oals can be specific to a stream segment, a drainage area, or Township-wide, and may include the following:

- Identify the most actively eroding stream banks.
- Identify stream segments with the highest sediment load potential based on soil type, slopes, and intensity of development.
- Identify stormwater outfalls to the stream that are known or suspected to have high sediment loads based on previous observations.
- Identify and prioritize the known or most likely sources of sediment loads or causes of stream bank erosion.
- Identify stream segments with the greatest biological diversity of benthic macro-invertebrates as an indicator of stream health.

Having clear Monitoring Program goals is critical to developing a Monitoring Program that provides valuable information to support the Township's stormwater program elements such as improving water quality.

Task 4. Select Monitoring Parameters, Frequency, and Locations

The results of Tasks 1 through 3 and understanding of monitoring needs will shape the water quality Monitoring Program for the Township. The monitoring parameters, frequency, and locations depend on the Township's priorities and available resources to support monitoring activities. The Monitoring Program would potentially include the following elements:

1. Prioritize watersheds to focus initial efforts. By starting with one or two watersheds instead of the entire Township, local leaders will be able to refine the monitoring program.
2. Select monitoring locations that are secure, allow for access, and are consistent with the locations and features that will support data collection objectives.
3. Select the instruments that are appropriate to collect samples, monitor in-stream parameters, or methods for observations.

    - Bottles for collecting grab samples for total suspended solids (TSS) and metals analysis
    - Sampling stations with continuous monitoring instruments for select parameters (e.g., turbidity sensor and data logger) or composite sampling instruments for rain event sampling
    - Macro-invertebrate survey devices
    - Pins and stakes for tracking stream bank erosion or mass wasting
    - Field testing kits and hand-held instruments (e.g., turbidity meter) for stormwater outfalls and in-stream grab samples (e.g., sample jars and Imhoff cone)
    - Local weather stations, if needed due to the span of monitoring locations
4. Define the frequency and timing of various sampling and monitoring activities
    - Dry weather monitoring (grab samples)
    - Rain event thresholds and antecedent conditions
    - Daily, weekly, monthly, or quarterly by parameter (continuous monitoring)
5. Define timespan of each monitoring activity to distinguish trends in water quality changes or observations over time. To achieve meaningful results that inform decisions on selection of capital improvements within a drainage area, monitoring timelines may need extend over multiple years.
6. Develop standard operating procedures (SOPs) for monitoring activities.
7. Prepare a health and safety plan for all Monitoring Program activities.
8. Define required resources and personnel.
9. Install monitoring equipment and mark monitoring locations
10. Define monitoring equipment inspection and maintenance activities.
11. Define a process for reviewing the quality and consistency of monitoring activities, as well as the triggers that would initiate changes to the Monitoring Program.

The following factors should be analyzed to support and inform the selection of monitoring parameters, frequency, and locations. The Monitoring Program would likely include documentation of how each of these factors and variables could affect observations; and steps necessary to integrate these impacts into the process of analyzing data.

- Weather Conditions: Sediment samples will be higher after storm events. For moderate rain events, samples taken during the first flush may be higher than several hours into a storm. For more intense rain events, sediment samples collected hours into the storm may include sediment mobilized during active stream bank erosion.
- Seasonal Timing: Monitoring performed in the winter may show higher levels of salt from road treatments and sediment loads from areas with less vegetation.
- Drainage Area Size and Land Use: Land use intensity and drainage network characteristics are important to understand the watershed response during precipitation events.
- Representative Sampling: The program should consider if drainage areas in the Township are similar enough that sampling results in one could be applied to another. This is an assumption that could be made early on in the program, or evolve as water quality data is collected and analyzed.
- Maintenance of Stormwater Controls: The Township tracks several dozen stormwater controls on both private and public property. If these controls are not functioning, there may be measurable downstream effects.
- Proposed Stormwater Controls. The Township PRP lists a set of stormwater controls to reduce sediment discharge. The monitoring program could include monitoring locations to

observe any benefit to water quality from the function of these structures, as well as other constructed as part of land development projects.

- Temporary Conditions: Monitoring downstream of an active construction project may result in higher sediment loads and skew the monitoring data. Testing of fire suppression systems or hydrant flushing and discharge to streams may also affect monitoring results.
- Background Sediment Loads: The Township will need to begin developing a better understanding of the background sediment loads that would exist through natural processes and the amount the streams are able to assimilate and still meet their designated use. The Township should consider monitoring of reference streams for comparison purposes.

Task 5. Implement Monitoring Program to Support Stormwater Program Decision-Making

The Township can then begin the process of monitoring streams to establish its own baseline for water quality and assess trends over time. This baseline could inform a proposal to PADEP to support water quality targets on a Township-defined timeline that is 1) consistent with the intent of the Township's MS4 permit and 2) customized to local conditions in Upper Merion.

Water quality data collected by Upper Merion can be used to build public support for the Township's decisions for large stormwater capital projects, changes in land development regulations, or new MS4 operations and maintenance activities. As capital improvements are completed and the Township provides a new level of stormwater management service, the monitoring results would be useful to evaluate whether Township resources are being directed appropriately and efficiently. Upper Merion leadership can then adjust the Monitoring Program and the stormwater program to adapt to changing Township priorities, shifts in water quality trends, or progress towards stated goals.

Upper Merion Township
Stormwater Management Plan
SALDO Revision Recommendations
October 18, 2017

This report has been prepared to identify potential revisions to the Township's land use policy and regulations that could improve the design of stormwater management features proposed during the land development plan review process.

The Subdivision and Land Development Ordinance (SALDO) includes minimum standards for how site improvements are designed. However, just as importantly, the SALDO defines the process of designing and laying out a land development plan.

Upper Merion's SALDO (Chapter §145 of Upper Merion's code) provides Design Standards for proposed land developments (Article III) and a list of Plan Requirements necessary to include in a proposal package for submittal to the Township for review (Article IV). Stormwater-related requirements in the Township's SALDO primarily focus on landscaping standards (§145.24.1). The SALDO refers applicants to the Township's design standards for stormwater management controls in the two-part Stormwater, Grading and Erosion Control Ordinance (Stormwater Ordinance) (Chapters §140A and §140B). The Zoning Ordinance (Chapter §165) provides standards for developing in the Floodplain Conservation District (Article XXXII) and impervious surface coverage caps that apply to land use in specific zoning districts.

Upper Merion is considering how to update land use regulations to improve the municipality's stormwater conveyance and management infrastructure through the land development process. There are several key drivers for promoting stormwater management above the typical standards included in Pennsylvania's model stormwater ordinance. These drivers include the Municipal Separate Storm Sewer System (MS4) permit under the National Pollutant Discharge Elimination System (NPDES), flood protection, environmental issues, and the desire for the quality of life and economic development aspects of green developments.

Upper Merion's current land use standards include stormwater management provisions that can support water quality through the development process. However, the Township could benefit from expanding the use of Green Stormwater Infrastructure (GSI), Low Impact Development (LID), and over-control of runoff rates and volumes in development and redevelopment projects. Promotion of these concepts will support the pursuit of community goals for water quality compliance, environmental protection, and community development.

Upper Merion's MS4 Responsibility

Specifically, Minimum Control Measure (MCM) 5 *Post-Construction Stormwater Management in New Development and Redevelopment* of the 2018 version of the Township's MS4 permit will require the Township to:

- *Enact, implement and enforce an ordinance to require post-construction stormwater management from new development and redevelopment projects, including sanctions for non-compliance.*
- *Develop and implement measures to encourage and expand the use of Low Impact Development in new development and redevelopment. Measures should also be included to encourage retrofitting Low Impact Development (LID) into existing development.*

- *Enact ordinances consistent with LID practices and repeal sections of ordinances that conflict with LID practices. Submission of an ordinance that is consistent with DEP's 2022 Model Stormwater Management Ordinance will satisfy this BMP.*

MCM 5 maintains the requirement to include LID concepts in land use regulations from the 2013 version of the MS4 permit. For the 2018 version, PADEP has offered a Model Stormwater Management Ordinance as sample language of how permittees can update their land use regulations to comply with their permit responsibilities. PADEP expects Upper Merion to adopt an acceptable version of this Model Ordinance, which also includes prohibitions for non-stormwater discharges from the MS4 (MCM 3) and erosion controls at construction sites (MCM 4), by 2022.

Ordinance Overview

Upper Merion's land use policies and regulations addressing stormwater management are contained within a handful of policy documents and regulations (Comprehensive Plan, Zoning Ordinance, SALDO, Stormwater Ordinance) that were reviewed for this report. Impervious surface caps are included in the Zoning Ordinance; general land development standards, the plan review process, and natural area protection provisions are included in the SALDO; and specific stormwater management design elements are included in the two-part Stormwater Ordinance. Upper Merion anticipates completion of its Comprehensive Plan in 2018, continuation of zoning workshops with the Board of Supervisors in 2018, and a consideration of an update to the SALDO using a model template over the next two years. In addition to these policies and regulations, activities performed by property owners that do not qualify as land development but exceed 250 square feet of new impervious surface, will trigger the need for a *Stormwater, Grading and Erosion Control Permit*.

A cohesive set of municipal stormwater management regulations for land development integrates both stormwater quality and quantity management. The Township's policies must be aligned with the local drivers (regulatory, environmental, flood protection, etc.). Regulations should provide clear guidance to developers on standards for improvements. And every aspect of plan review, plan approval, construction inspection, and long-term stormwater facility operation and maintenance should be clearly stated.

The following sections ask questions about the Township's current land use policies and regulations. Answers to these questions will help identify potential revisions to the Township's code that support Upper Merion's stormwater management strategy.

On October 12, 2017, Nathan Walker and Kobby Addo-Boateng from Amec Foster Wheeler joined Robert Loeper and Kyle Brown from the Planning and Development Division of the Township Public Works Department to discuss the preliminary version of the Recommended SALDO Updates Report (9/21/2017). This document reflects the feedback provided by the Township staff and their priorities that we discussed.

This is only the beginning of the process toward establishing an effective set of stormwater management standards that pursue Upper Merion's goals. Once concepts are prioritized for inclusion in the Township code or as a matter of administrative practice, effort is required to tailor each concept into a regulation or incentive that best meets Township goals. It will be advantageous to employ a stepwise method of integrating the highest priority stormwater management elements into the land development permitting process. Such an approach, will allow land development stakeholders, the public, and Township staff time to:

- Adequately identify and understand stormwater management drivers;

- Determine appropriate levels of regulation;
- Calculate the administrative cost of implementing new policies and regulations;
- Remove impediments to implementing GSI/LID; and
- Include possible incentives and regulatory changes.

Administration and Policy

- **How will the public accept GSI/LID concepts?** The challenge of expanding the use of GSI/LID and understanding potential effects on developers, local governments, and the general public is a topic of great interest and a priority for communities throughout the United States. Integrating GSI/LID requirements into local standards and then promoting implementation requires local municipalities to be proactive in addressing how changes will affect the multiple groups of stakeholders across the community. Therefore, communities adding GSI/LID elements to their land use planning often establish public education and outreach programs. Such a program in Upper Merion could be appropriately branded to program goals, and should be inclusive of the multiple target audiences, both internal (staff, Planning Commission, elected officials, etc.) and external (i.e. developers, institutions, civic and business associations, and the general public). A GSI/LID Public Education and Outreach strategy that communicates the pros and cons of GSI/LID elements could be developed in conjunction with the Township's MS4 Public Education and Outreach requirements.

- **Are definitions and standards consistent between ordinances?** As an example, the definition for *Impervious Surface* differs between the PADEP Model Ordinance, the SALDO, the Zoning Ordinance, and the Stormwater Ordinance. Such inconsistency leaves the definition open for interpretation and can result in issues for the Township when communicating and enforcing standards. The Township's intent to develop a separate definitions section applicable across chapters of the code would help achieve this consistency.

- **Is there a formal ordinance review and update process?** Consider defining a schedule to assess if plan review and design standards in the Township code are consistent with community development and environmental stewardship goals.

- **Should as-builts be required of completed stormwater infrastructure?** The Township SALDO requires applicants to create as-built drawings of developments whenever funds are held in escrow (§145.31.1). The SALDO specifically requires as-built drawings for landscaping, telecommunications, and sanitary sewer extensions. The Township's definition of an As-Built Plan generally includes 'utilities,' but is not specific to stormwater. The Township should clarify that the requirement for developers to submit as-built CAD files includes stormwater management features so they can be added into the Township's GIS database. As-builts for stormwater management features treating greater than a Township-defined land area threshold or with complex installation or maintenance requirements should be prioritized.

- **Who follows up on approved operations and maintenance (O&M) agreements?** The Stormwater Ordinance (§140A.25 and §140B.26) requires the property owner to record an operation and maintenance plans for the stormwater facilities to be privately owned. Property owners are also required to provide the Township with a conservation easement to enable inspections by the Township. These standards apply to any subdivision, land development, or activity requiring a stormwater permit. The Township should assign staff

to track the plans, including any agreements and easements held with private landowners, and ensure they are being followed as approved. Information about each agreement (including past agreements maintained in paper format) should be maintained in a GIS database that includes the following attributes:

- Relationship to an NPDES permit for earth disturbance;
- Location of each stormwater control;
- Link to the approved plan and agreement;
- Schedules for inspection and maintenance; and
- The Township's right of access.

- **Does a Municipal Stormwater Maintenance Fund exist?** Pennsylvania's model Act 167 ordinance includes a section that allows municipalities to require developers that are installing stormwater storage facilities to pay into such a fund to defray costs of periodic inspections and maintenance expenses for up to ten years. The Township should consider codifying this requirement and linking the contribution to the extent of the stormwater management services the feature provides and anticipated maintenance costs. Examples of Pennsylvania municipalities that utilize this provision are Radnor Township (§245-39), Swarthmore Borough (§1459.072), and Cheltenham Township (290-18).

- **Are waivers to stormwater management standards tracked?** PADEP requires a report of the number and type of waivers associated stormwater standards granted by each MS4 permittee to permit an exception to the non-stormwater discharge provision required by the MS4 permit (MCM 3, BMP #5). The Stormwater Ordinance considers waivers on a case by case basis "to permit reasonable utilization of property in substantial conformance" with the ordinance (§140A.23 and §140B.24). A waiver report should be created for submittal to PADEP and to allow the Township to review specific sections of the ordinances for which waivers are commonly sought.

- **Is a fee in lieu of stormwater management an acceptable alternative?** The Township provides developers with an option to offer a fee in lieu of stormwater management instead of requiring structural controls that serve small areas of impervious surface (§140B-13.A). The developer is required to show that installation of stormwater controls to meet all the stormwater management requirements is not feasible on-site. The program allows a developer to pay the Township the amount that would have been necessary to install the necessary stormwater controls. These funds are used to support the Township's stormwater program. The Township should consider increasing the fee paid in lieu of stormwater management by adding the cost of maintenance and inspection that would have been the responsibility of the property owner if the stormwater controls were constructed. The Township solicitor should be consulted on this matter.

Permit Applicability

- **Are permit thresholds appropriate?** The Township requires applicants for a building permit, a land development permit (§140B.5), or a Stormwater, Grading and Erosion Control Permit for construction of a single-family house, twin, or townhome (§140A.5), to propose stormwater controls. The Township provides calculation sheets and standard design drawings for dry wells and rain gardens to assist applicants required to manage only small amounts of runoff. If less than 250 square feet of impervious surface are proposed, the project is exempt from the requirement to detain stormwater runoff, although an application is still required to be submitted. The Township should review the types of permit applications received to evaluate whether this 250-square foot threshold should be

modified or if the $400 fee associated with the Class A permit is appropriate. This analysis should include a review of the following as they relate to small stormwater controls:

- Use of the standard details by applicants;
- Quality of design and installation;
- Cost of design and installation;
- Demand for acreage for stormwater management;
- Inspection and maintenance responsibilities; and
- Function lifespan of the control.

- **Is repaving earth disturbance or land development?** Repaving an existing parking lot may include simple top-coating, milling to the sub-base, or excavation to the sub-grade and full-depth replacement. The Township should consider classifying certain parking lot rehabilitation or upgrade activities as regulated earth disturbances that trigger the need for construction of new stormwater controls.

- **When can an improvement qualify as *de minimis*?** Improvements may qualify as a land development or exceed the current 250 square foot earth disturbance threshold, but site characteristics and potential for runoff may not justify a fully engineered solution. For instance, the improvement may discharge to an existing and sufficient stormwater control and not require added control. The Township should enable property owners to request *de minimis* exemptions from stormwater management when they meet certain conditions. Township decisions should be based on consistent application of policy.

Design Process

- **How are site design decisions documented?** A municipality's SALDO provides the standards for design improvements associated with land developments. Just as importantly, the SALDO provides the process for how land development proposals are designed, submitted, and reviewed. Upper Merion's SALDO provides applicants with general direction on how to design land developments (§145-25). The Township should consider adding direction in to the SALDO to guide applicants through a process that includes prioritization of site features to be protected, assessment of the impact of proposed land developments on sensitive features, discussion of alternatives site improvements considered, and rationale for decisions made about site layout and stormwater controls used. An outline of the process that could be documented in the SALDO should be consistent with the Supervisor's current plan review process occurring during their workshop meetings.

- **Should stormwater management near sources of contamination be more protective?** Neither the Stormwater Ordinance nor the SALDO define standards to require applicants to identify hotspots within a project area that could contribute to pollution of water resources. Hotspots could be gas stations or industrial sites where improper stormwater management could transport pollutants via runoff to surface water or groundwater. The SALDO or the Stormwater Ordinance could include provisions requiring applicants to identify these areas and plan site layouts and stormwater management features in such a way as to prevent discharge of pollutants. Similarly, the Township could consider adding runoff management standards in areas know to be susceptible to high rates of streambank erosion or contributors of sediment to local water bodies. The Township may be able to seek out model ordinances that address these issues that they can adapt to meet local objectives.

- **Could incentives promote enhanced stormwater management?** The Township already promotes the use of LEED standards by allowing developments earning Silver or Gold designation to reduce their minimum green area, increase their building height, and increase their residential density (§165.106). The Township could also promote the use of LID techniques, GSI practices, and over-control of stormwater using a similar set of incentives that offer applicants greater options for developing their site. The Township's current incentive program has not yet been utilized by developers; incentives offered to promote stormwater management must provide measurable benefits and return on investment for the applicant if implemented.

- **How can the Township promote favored stormwater management BMPs?** The *BMP Recommendations for New Development, Redevelopment, and Township Projects* (July 20, 2017) provides scoring of BMPs based on their ability to meet the Township's water resource management goals for sediment reduction and annual maintenance. During the land development application process, the Township should direct applicants toward these preferred stormwater controls as appropriate. A stormwater management design manual can address all aspects of stormwater management controls, before, during, and after construction on a land development site. The stormwater management design manual could serve to inform applicants of the Township's preferred methods for managing stormwater, such as daylighting streams, the use of GSI/LID, and designs proven to be practical from an operations and maintenance perspective. A specific focus of such a manual should be alternatives to groundwater infiltration in karst geology.

- **How can the Township promote favored locations for BMPs?** Applicants submitting a land development plan or permit application describe areas to be utilized for stormwater management. However, no standards are included on preferred locations for these controls. The Township should consider adding statements to encourage the installation of stormwater management infrastructure on areas of the site that are most conducive to infiltration, could help to manage off-site runoff, utilize green space, or avoid excessive grading. If there are specific areas the Township believes are well-suited for stormwater, these could be included on the Township's Official Map or listed in a design manual.

<u>Stormwater Management and Conveyance Design</u>

- **Does oversight occur at the critical stages of installation?** Section 102.8 of PADEP's Erosion and Sediment Control regulations require a licensed professional to be present during the implementation of critical stages of installation of post-construction stormwater management features. The Township should define a process with the Township engineer and the County Conservation District to document this construction oversight for projects operating under an NPDES permit for earth disturbance associated with construction activities.

- **How are sediment reduction calculations documented?** The Township should consider requesting that developers provide them with calculations that support required sediment reductions to local water bodies. The series of calculations could include:
    1. The existing sediment discharge flowing via stormwater runoff from the site proposed for development,
    2. The reduction achieved by new BMPs installed during the land development process, and
    3. The value of any sediment reduction achieved above the minimum required that could be applied to the Township's sediment reduction goals.

- **Should different water quality standards apply to different watersheds?** The Township may wish to apply different water quality treatment standards to specific watersheds to address specific sources of pollution or flooding and promote preferred stormwater controls based on the land use, soils, and topography. The water quality volume required to be treated could be higher in districts where water quality is poor. Rationale for setting different standards for water quality treatment in different watersheds could be based on actual in-stream water quality data or on land cover, tree canopy, or impervious surface measurements. More stream health and water quality data would be needed to develop these standards.

Parking and Transportation

- **Do street, curb, and sidewalk standards enable flexibility for installation of stormwater BMPs in the right of way?** The Township establishes minimum street widths (§145.9), requires curbs on all streets except next to large lots with deep setbacks, and generally mandates that sidewalks are to be located as far as practicable from the curb (§145.12). The Township should consider amending these standards to provide flexibility for the implementation of GSI/LID features to treat stormwater within the right of way. Smaller paving widths, the ability to avoid installation of curbs, and standards for green space between the road and the sidewalk will allow for GSI elements like vegetated swales and tree trenches to be installed in the public right of way, while also providing traffic calming and heat island reduction benefits. The Township should review existing right of way widths and streetscapes and prioritize opportunities for GSI installation. In addition, the Township should consider creating technical guidance or a stormwater management design manual for GSI right of way design (e.g. GSI/LID typical details including curb turnouts, bioretention bumpouts, etc.)

- **Can the Township's parking calculations flex to allow for reductions in required spaces?** The Township provides tools for property owners to establish shared parking arrangements, hold parking in reserve, or submit a request to reduce the number of minimum parking spaces (§165.191.B.7). These tools allow property owners the opportunity to shrink their impervious surface footprint. The Township should review shared parking arrangements, parking in reserve agreements, and reduced parking requests, to calculate the number of parking spots that have been avoided. This analysis and review of ratios may reveal which land uses have parking ratios that are too high. Revisions to parking ratios may give property owners flexibility in land use decisions which could lead to measurable reductions in impervious surface.

- **Do parking lot design standards allow for GSI installation?** Upper Merion includes its parking lot landscaping standards in the SALDO (§145.24.1.D). Standards include ratios of trees to parking spaces and placement of planting islands and strips. The Township should consider amending design standards to ensure landscaped areas associated with parking lots are large enough to accommodate GSI and to promote the use of depressed landscaped areas and rain gardens so they can receive and treat stormwater. A design manual presenting the Township's preferred method for managing stormwater could also be effective.

Land Cover, Land Use, and Landscaping

- **Are impervious surface caps consistent with stormwater management goals?** If the Township proceeds with mapping impervious surfaces, they can assess each parcel's

consistency with impervious surface caps established by individual zoning districts. These regulatory caps and measure of actual impervious surface can be reviewed against the presence of downstream water quality impairments addressed in the Township's Pollutant Reduction Plan. The calculation of sediment discharge from existing impervious surface and impervious surface constructed at the greatest potential build-out condition of the zoning district could show how existing land use regulations affect stream health. The Township could consider amending the Zoning Ordinance by revising impervious surface caps, adding incentives to encourage property owners to reduce or disconnect existing impervious surface, or adding incentives to voluntarily remain under a lower impervious surface threshold when improving a property.

- **Do the regulations provide guidance to promote GSI?** The Zoning Ordinance includes standards for landscaping in stormwater basins (§145.24.1.F), but not smaller features such as rain gardens, seepage beds, or infiltration swales, which are common practice in Upper Merion. The Township ordinances or a stormwater design manual could provide design standards, landscaping standards, and planting lists for use in GSI/LID features. Design standards and a list of preferred stormwater control alternatives are critical for areas underlain by karst geology that can cause sinkholes as included in the Township's Appendix B of the Stormwater Ordinance.

- **How does the Township code promote vegetated riparian buffers?** The SALDO prohibits vegetation removal within the riparian corridor unless specifically permitted by the Township (§145.24.1.C). The Township should consider using land use regulations to improve the water quality function of stream buffers, either integrated into the Flood Conservation District in the Zoning Ordinance (or as a separate overlay as an alternative). These standards could include:
    - Standards for restoration following development;
    - Preferred plant lists;
    - Minimum canopy density;
    - Mandatory inspection cycles; and
    - Long-term vegetation management plans.

- **Does the Property Maintenance ordinance deter GSI?** The Township Property Maintenance Ordinance (Chapter 127) prohibits any "grass or weeds or any vegetation whatsoever" from exceeding six inches in height. Exceptions are made for edible and ornamental plants. To promote the establishment of native grasses and soils that can infiltrate stormwater, the Township should consider revising this ordinance by adding provisions for vegetation necessary as part of the design of a stormwater management control.

Upper Merion Township
Stormwater Management Plan
Good House-Keeping Recommendations
June 15, 2017

The purpose of this report is to document observations of the good housekeeping program and pollution prevention practices performed by Township personnel at municipal facilities, and make recommendations to support compliance with the current and upcoming versions of the Municipal Separate Storm Sewer System (MS4) Permit.

Compliance with Minimum Control Measure (MCM) 6 *Pollution Prevention and Good Housekeeping*, as defined by Pennsylvania Department of Environmental Protection's (PADEP) 2018 MS4 Permit, requires permitted municipalities to implement both programmatic and operational activities. Programmatically, the Township is responsible to comply with each of the three Best Management Practices (BMP) defined within MCM 6. Operationally, the Township must implement site-specific activities at individual municipal facilities to prevent the discharge of pollutants via stormwater runoff to local water bodies.

On May 24, 2017, Nathan Walker and Ghazoll Motlagh from Amec Foster Wheeler joined the Upper Merion Public Works Department Director and Stormwater Manager on site visits to five Township facilities. The Public Works maintenance facility, salt shed, Heuser Park, Nor-View Farm, and Township administration building facility were selected because the activities performed at these facilities have the potential to contaminate stormwater runoff. Site evaluations focused on the good-housekeeping standards as defined in MCM 6. A photolog of some of the observation made during the site visits is attached.

The Township's current compliance activity and recommendations for each of the BMPs included in MCM 6 are listed below. The brief summaries of current activities for each of the three BMPs in MCM 6 are followed by recommendations for future implementation and observations and recommendations for each of the five municipal facilities visited.

BMP #1 – Inventory of Potential Pollutant Sources - *Maintain an inventory of all operations owned or operated by the Township that have the potential for generating pollution in stormwater runoff to the MS4.*

Current Activities
The Township's MS4 progress report for the period from March 2014 through March 2016 states the Township completed a review of its inventory of facilities and activities owned or operated by the Township that have the potential for generating stormwater runoff. The three locations are the pond at the Township building, the stormwater detention feature at the Mancill Mill Rd salt shed, and the stormwater conveyance features near the Trout Run Water Pollution Control Center (WPCC).

Recommendations
- Inventory of municipal facilities – The Township should expand the inventory of Township facilities or activities it owns or operates prior to submittal of the upcoming Notice of Intent (NOI) for the 2018 version of the MS4 permit. The list of facilities and activities should include the facilities visited during the May 24, 2017 site visits. From this list, the Township should document which, if any, facilities are covered under another permit or regulatory program that

requires stormwater management and water quality protection (such as the WPCC or the compost facility in the de-silting basin next to Heuser Park).

- Prioritized facility inventory – The potential for generating pollution that may be carried by stormwater runoff to surface water is higher at some municipal sites than others. The Township should prioritize facilities into tiers based on their potential to pollute stormwater runoff to support site inspection schedules and pollution prevention activities.
- Inventory of municipal stormwater storage or treatment units – The Township should create an inventory of Township-owned and operated structural stormwater management structures such as basins, infiltration/filtering structures, level spreaders, and rain gardens. This inventory should include information on shared responsibility with landowners to manage and maintain these features. Features preliminarily identified during the May 24 site visits include the following:
    - 2 detention structures at Mancill Mill Rd salt shed
    - 3 level spreaders at Heuser Park
    - 1 infiltration basin at Heuser Park
- Annual inventory review – The MS4 permit requires the Township to annually review the inventory of municipal facilities and the potential for activities performed there to pollute. This review should be added to the Township's annual compliance schedule.

BMP #2 - Written Operations and Maintenance Program - *Develop, implement, and maintain a written program for all operations that could contribute to the discharge of pollutants.*

Current Activities

The Township updated its *Operation, Maintenance, Inspection, and Repair Program* in April 2016. Program elements include statements on inspection, operation, and maintenance of the stormwater management and conveyance system; vehicle maintenance; and program documentation.

The Township's 2016 MS4 progress report submitted to PADEP presents the Township's inspection of the three municipal operations and facilities that the Township identified in BMP #1 that could contribute to the discharge of pollutants from the MS4. Elements of the inspections included observations about the presence of debris, water discoloration, odor, and sheen.

The Township has posted Standard Operating Procedures (SOP) for vehicle and equipment washing and fueling at the police station and the Public Works maintenance facility.

Recommendations

- Management practices, policies, and procedures – The Township's general pollutant reduction program includes some formalized SOPs, but not a complete set that addresses the various operations that could discharge pollutants to the MS4 from municipal facilities. SOPs to be added to the updated Operations and Maintenance Program may include processes for handling and storing de-icing material, maintenance of stored vehicles, waste management, oil water separator maintenance, material/manure storage, scrap metal storage, and procedures for protecting interior drains to surface water. SOPs should provide best practices that address safe handling of potential pollutants, be regularly reviewed, and serve as the subject of personnel training modules.
- Maintenance activities, schedules and inspections – Using the prioritized inventory of municipal facilities updated under BMP 1, the Township should develop a written schedule of equipment maintenance and site inspections. The frequencies of the inspection cycle may occur monthly,

quarterly, or annually, depending on the potential for contamination of stormwater runoff. Inspections could include use of site-specific checklists to observe secondary containment structures; waste handling and management procedures; stormwater inlets within the public right-of-way; nozzles, hoses, and ports at municipal fueling stations; spill kit locations and contents; and erosion controls at soil and material stockpiles.

- Controls for reducing pollution of stormwater runoff – During inspections, the Township may discover new potential sources of pollution requiring new controls, existing controls that require maintenance or update, or the need to revise SOPs. The Township should formalize the process for logging amendments or corrective actions necessary to reduce stormwater pollution or eliminate the discharge of pollutants from municipal facilities. The process should identify responsible parties and appropriate timelines for completion of corrective actions.
- Procedures for the disposal of waste – Municipal facilities can become a depository for a wide variety of waste materials. These can include municipal waste, recyclables, accumulated sediments, yard waste, street sweepings, and household hazardous waste. The Township should include in their SOPs the protocols for categorizing, sorting, storing, and disposing of these materials in a way that prevents discharge of pollutants via stormwater.

BMP #3 – Employee Training Program - *Maintain an employee training program to further the goal of preventing/reducing the discharge of pollutants to the MS4.*

Current Activities

The Township updated its *Municipal Employee Stormwater Pollution Prevention Education and Training Plan* in April 2016. Township personnel participate in training sessions facilitated by the MS4 Coordinator to review the SOPs for Vehicle & Equipment Cleaning and Vehicle & Equipment Fueling.

Recommendations

- Identification of staff with stormwater responsibilities – The Township should identify those municipal staff and contractors whose responsibilities include activities that are stormwater related. Individuals include Public Works staff, code enforcement staff, emergency responders, and administrators taking public complaints.
- Targeted messages – The Township should identify specific training topics for staff that are appropriate for the job duties. Topics could include how to respond to spills, illicit discharge detection, or proper erosion control practices. In addition, training session topics should be developed to address the findings of site inspections and recent corrective actions and be consistent with the Public Education and Outreach Program (MCM 1). Sources of training materials and modules could be federal, state or local agencies, local conservation organizations, or professional associations.
- Review of training program – The training program should be reviewed annually to update the list of appropriate personnel and the content of training modules.
- Record training events – Records of the list of stormwater related topics presented through the year should be maintained, as well as the list of the staff and contractors that participated in training. Changes made to the training program as part of an annual review should be recorded and kept on file.

Township Public Works Maintenance Facility – *466 E Church Road*

Current Activities

This facility occupies approximately 3.5 acres and houses the Highway Division. The Township Police have an indoor shooting range at the location. Activities include storage of de-icing material, fleet maintenance, storage for the Parks & Recreation Department, storage of salt spreaders and herbicide sprayers, a vehicle fueling station, scrap metal storage, and stone, sand, and mulch storage. Approximately 20 Township staff operate out of the facility.

Recommendations

- Vegetation management – The facility discharges runoff to the swale located to the west of the facility at several locations, both via overland flow and through outfalls from the storm sewer system. The Township should manage vegetation around discharge points so that staff can respond to spills, monitor discharge, and inspect for scour and soil stability.
- Spill Prevention, Control, and Countermeasure Plan – The Township stores approximately 1,000 gallons of oil products in 55 gallon drums at the facility. In addition, the Township maintains two 4,000-gallon fuel tanks that serve the Township fleet. To comply with the Spill Prevention, Control, and Countermeasure (SPCC) Rule of the Clean Water Act, the Township should develop a SPCC Plan to document pollution controls and formalize a program of review and revision.
- Secondary containment for MgCl2/brine tanks – The tanks holding magnesium chloride and rock salt brine are located directly adjacent to the wetland that discharges to the north. In addition to the SOP associated with de-icing material (BMP #2), the Township should consider adding a curb system that would help control spills or a full secondary containment for these structures.
- Dumpster – The dumpster storing office waste and general trash next to the material storage bins is uncovered, exposed to precipitation, and is leaching fluid on the pavement of the yard. All dumpsters should be covered and maintained in good condition so that they do not discharge pollutants.
- Abandoned storage tanks – Two abandoned storage tanks were found in the swale to the west of the facility. The Township should communicate with the adjacent landowner, investigate if these tanks are their responsibility, and take action accordingly.

Mancill Mill Road Salt Shed – *Mancill Mill Road*

Current Activities

The Township stores de-icing material at this 2.2-acre facility in a 6,000 SF salt shed and in an approximately 2,000-gallon brine tank. Other features at the site include a gravel parking lot, two hydraulically connected stormwater retention basins, and a vacant office shed. The Township may periodically store materials such as stone, soil, or sand on the gravel lot a temporary basis.

Recommendations

- Vegetation management – The vegetation in the two stormwater controls does not allow for easy access for inspection or to evaluate pollutants that may flow in runoff. The Township should periodically clear and manage vegetation to enable access, maintain soil stability, and prevent clogging of the outlet structures.
- Secondary containment for brine tank – The tank holding rock salt brine are located upslope of the stormwater basin that discharges to the east. In addition to the SOP associated with de-icing material (BMP #2), the Township should consider adding a curb system that would help control spills or a full secondary containment for this structure.

Heuser Park – *W Beidler Road*

Current Activities

Heuser Park consists of 30 acres of managed, active recreation parkland. It also includes trail access to the Schuylkill River and adjacent woodlands. The Township maintains a rain barrel education exhibit at the central park building. The Township provides a station where residents can come and pick up mulch that has been processed at the adjacent composting facility. Stormwater from the active parkland and parking lots is managed by an infiltration basin at the northwest corner of the site and through a series of level spreaders along the trail link to the Schuylkill River Trail. Level spreaders discharge runoff to the woodlands to the north.

Recommendations

- Soil and mulch piles – The mulch pile near Beidler Road and the baseball infield soil stockpile in the parking lot are potentially sources of sediment to local water bodies. In addition to the SOP associated with material storage (BMP #2), the Township should control runoff from these sources by proper location of soil away from concentrated flow of runoff, regular street sweeping, and diversion of runoff from entering the stockpile areas.
- Vegetation management – The vegetation around the outlet structures of the infiltration basin, the vegetated swales, and the level spreaders should be more actively managed. Management will allow for access for inspection or to evaluate pollutants that may flow in runoff, maintain soil stability, and prevent clogging of the outlet structures. The Township should review the operations and maintenance plan for these features to make sure they continue to function as designed. This may be aided by markers placed on outlet structures to make the features easier to locate during inspections.
- Stormwater conveyance features – A series of swales run parallel to the Schuylkill River Trail as it travels west of Heuser Park to the wastewater treatment plant. It is unclear if these features were designed to manage stormwater rate or volume or if they simply convey water through the trail corridor. The Township should identify if there is a formal maintenance plan for these features and maintain vegetation so that runoff flows towards the River and does not cause erosion.

NorView Farm Park – *N Henderson Road*

Current Activities

The Township exhibits farm animals at this approximately 9.5-acre facility. Vendors operating at the facility include an ice-cream store, spring water dispensary, and a garden supply store/greenhouse. The Township stores rain barrels at the facility for distribution during public stormwater education activities. The Township sponsored an artwork event associated with storm drains near the greenhouse.

Recommendations

- Manure and material management – As part of the material handling and storage SOP (BMP #2), the Township should consider pollution control measures such as vegetated filter strips, diversion berms, vegetated swales, or curbing to prevent manure leachate, mulch, soil, animal bedding, greenhouse waste, and other material from discharging to the MS4 or local water bodies.
- Dumpster – The lid to one of the dumpsters storing general trash next at the facility was open and exposed to precipitation. This could allow water to wash through the dumpster and discharge leachate into the MS4. All dumpsters should be covered and maintained in good condition so that they do not discharge pollutants.

Township Building – *175 W Valley Forge Road*

Current Activities

The Township Building includes administrative offices, the library, walking trails, and the police station on the approximately 17-acre site. Walking trails include a station for distributing dog-waste bags. The police fueling station includes a spill kit and a SOP for fueling operations.

Recommendations

- Pond management – The pond receives runoff from the surrounding neighborhood and the Township Building and parking lot. Water flows through the pond to discharge at a dam to the southwest. It is unclear if this pond was designed to control peak stormwater rate and volume as a stormwater BMP, or if it only serves as a recreational/aesthetic feature. The Township should review the purpose of the pond and determine its function as a stormwater control practice. Once determined, sediment, vegetation, inflow structures, and the outlet structure should be managed consistent with this design.
- Parking lot inlets – The storm drains serving the parking lot and police station are clogged with leaves, sediment, and debris. It appears that water quality inlet bags were inserted into the inlets to prevent sediment discharge into the pond. In one case, it was observed that water was prevented from entering the storm drain from the collected debris, jumping the curb and eroding portions of the lawn area before discharging to the pond. Material should be removed to allow the inlets to convey runoff properly. The Township should consider an operations and maintenance program for these inlets that may include continuation of the water quality inlet bags or more regular catch basin clean out.
- Interior floor drain – A grate exists within the police garage designed to capture water and snowmelt from police vehicles and discharge to the pond. The Township should communicate to the Police Department that this drain is meant only for stormwater and that other materials should not be discharged to the pond through this feature. Vehicles stored in the garage should be properly maintained and no vehicle maintenance should occur in the garage to prevent fluids from discharging to the pond.

Photo 1

Heuser Park – Baseball infield soil storage and erosion

Photo 2

Heuser Park – Overgrown vegetation at storm sewer headwall along vegetated swale adjacent to parking lot

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Blue Bell, Pennsylvania 19422

PROCESSED GM
DATE June 7, 2017

PHOTOGRAPHIC LOG

Upper Merion Township
Stormwater Good Housekeeping
Comprehensive Stormwater Management Plan
Upper Merion, PA

Photo 3

Heuser Park – Overgrown vegetation headwall at end of infiltration basin

Photo 4

Heuser Park – Partially filled culvert from localized erosion and sediment discharge

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PROCESSED GM
DATE June 7, 2017

PHOTOGRAPHIC LOG

Upper Merion Township
Stormwater Good Housekeeping
Comprehensive Stormwater Management Plan
Upper Merion, PA

Photo 5

Mancill Mill Rd – Overgrown vegetation within lower stormwater basin adjacent to salt shed

Photo 6

Mancill Mill Rd – Overgrown vegetation within upper stormwater basin adjacent to parking lot

Photo 7

NorView Farm Park – Animal waste being discharged in stormwater runoff at this inlet adjacent to pastures

Photo 8

NorView Farm Park – Manure Pile located in pasture

Photo 9

NorView Farm Park – Open dumpster in parking lot adjacent to greenhouse

Photo 10

Township Building and Police Fueling Station – Clogged inlet filters requiring maintenance and leading to overland flow and erosion

Photo 11

Township Building – Clogged inlet filters requiring maintenance and leading to overland flow and erosion

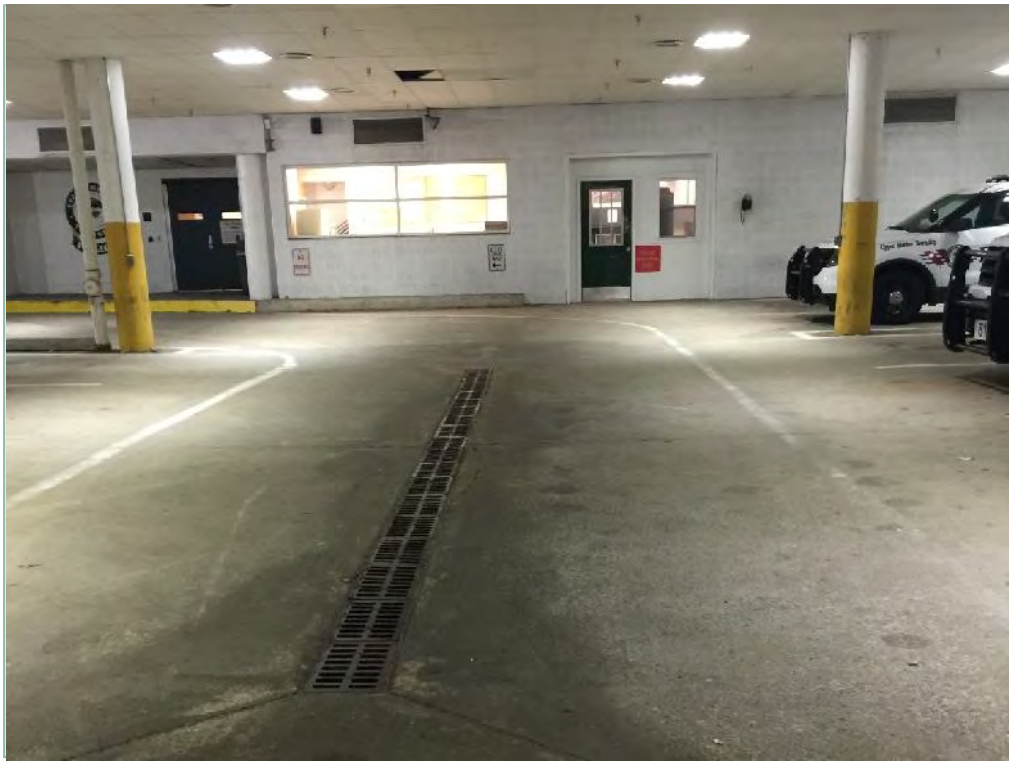

Photo 12

Township Building and Police Fueling Station – Interior floor drain for ice and snow serving garage and vehicle storage discharges to pond

Photo 13

Township Garage - Uncovered dumpster leaking fluids to the MS4

Photo 14

Township Garage – Diesel and gasoline tanks, 4,000 gallons each

Photo 15

Township Garage – De-icing fluid transfer hoses and nozzles

Photo 16

Township Garage – Tanks stored inside and away from doors. Some tanks stored on containment pallets

Photo 17

Township Garage – Abandoned oil/fuel tanks in streambed/wetlands along western property line

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PROCESSED GM
DATE June 7, 2017

PHOTOGRAPHIC LOG

Upper Merion Township
Stormwater Good Housekeeping
Comprehensive Stormwater Management Plan
Upper Merion, PA

Upper Merion Township
Stormwater Management Plan
Proposed Stormwater Treatment Practices
April 20, 2018

One of the general recommendations to be incorporated into the upcoming Stormwater Management Plan for Upper Merion Township will be to **continue existing stormwater services**. These existing services include activities that support the Township's efforts to protect public safety, property, and the environment. Specific stormwater management activities already performed by the Township include compliance with the Township water quality permit, administration and enforcement of land use and development regulations, and operations and maintenance of the storm sewer network.

The Stormwater Management Plan will include recommendations on capital investments, providing a **prioritized list of capital improvements** recommended to mitigate flooding at problem areas identified across the Township. These prioritized project areas were identified through input from the public, Township staff, Authority members, emergency services personnel, historic documents, and a detailed watershed model of select portions of the Township. The list of capital projects will include conceptual costs for implementation and a timeline for completion of the highest priority projects.

This report defines a third type of recommendation to be included in the Stormwater Management Plan. In addition to continuation of existing services and recommendations for investment in capital projects, the Stormwater Management Plan will recommend the **addition of stormwater treatment activities** necessary to protect water quality, efficiently manage infrastructure, and mitigate flooding. Some of these activities are an expansion of the Township's current stormwater services; others are entirely new. The intent of these stormwater treatment recommendations, identified through discussions with Township leadership, is to establish comprehensive, proactive, and efficient stormwater runoff management services.

Table 1 presents the set of new activities recommended for inclusion into the Stormwater Management Plan, many similar in nature to the services required to operate the sanitary collection system and treatment works. They are either current activities recommended for significant expansion; or new services altogether. The activities in Table 1 are organized by Cost Center. Cost Centers provide a focus on the fundamental services, not by the current organizational structure of Township departments. Use of Cost Centers is helpful in communicating the services to the community, stakeholders, and decision makers, as well as for developing a compelling case for how changes could occur.

Some **Critical Program Elements** are identified in Table 1 that are generally associated with the Municipal Separate Storm Sewer System (MS4) permit. The MS4 permit authorizes the discharge of stormwater by Upper Merion from the publicly owned storm sewer collection system to local water bodies. Through the MS4 permit, PADEP defines standards for stormwater discharge and assigns Upper Merion a set of Minimum Control Measures (MCM) to protect water quality. In addition to compliance with the permit, these critical activities are fundamental to efficient management of stormwater to protect public safety, property, and the environment. The critical program elements to be recommended in the Stormwater Management Plan include the following.

- Determine the extent of stormwater conveyance and management infrastructure that is the responsibility of Upper Merion;
- Fully implement the six MCMs defined in PADEP's 2018 version of the MS4 permit;
- Document Upper Merion's role reviewing the function of existing stormwater control structures in the Township; and

- Define an MS4 Infrastructure Maintenance Plan to direct Upper Merion's resources to where they can be most effective in reducing pollutants from the discharge.

Table 1 also defines elective (or non-critical) stormwater management activities. These are not explicitly required for MS4 discharge permit compliance or system operations, but are recommended best practices. They are important for supporting the Township's goal of providing comprehensive, proactive, and efficient stormwater management services.

Table 1 also presents a preliminary estimate of the level of effort needed to perform each task. Some of these new activities are presented as an annually reoccurring service; other services will be performed once. Effort is categorized by suggested Township department or shown as an estimated cost of service by contracting. For the critical activities recommended to be performed on an annual basis it is estimated that approximately 210 hours of effort are required each year. This effort, summarized in **Table 2**, is in addition to current effort for stormwater services already provided by Upper Merion. If Upper Merion were to perform all recommended activities in Table 1 on an annual basis, it is estimated that 550 hours of effort would be required each year.

These proposed stormwater activities are based on current understanding of regulations and infrastructure condition. As Upper Merion implements its Stormwater Management Plan and the program matures, capital projects, services, and priorities will need to be adjusted as more information is captured about the Township's stormwater responsibilities and the condition of the infrastructure network.

Table 1. New Stormwater Treatment Practices

Cost Center	Activity/Project	Critical Program Element	Description / Cost Assumptions	Annual Activity	Estimated Hours					Contract Service Cost
					Planning	Public Information	Code Enforcement	Public Works	Admin.	
MS4 Permit Compliance	Perform annual review of each MCM implementation strategy defined in the MS4 discharge permit.	✓	Annually review and update the written implementation plan for all 6 MCMs. Formalize the process of collecting and organizing information from various Township offices about activities that fulfil MCM responsibilities.	✓	40	20	10	10		
		✓	Post the current version of the complete MS4 compliance strategy and supporting documentation on the Township website for public reference. Offer opportunity for the public to comment during the annual review process and document input received.	✓		10				
	Formally document Township Conservation District responsibilities for enforcing erosion control measures during earth disturbance activities associated with land development.		Prepare a Memorandum of Understanding with the Conservation District (CD) defining roles for inspecting earth disturbance activities, clarifying the responsibility of the CD for MS4 discharge permit compliance. Establish a point of contact with the Conservation District and periodically review reports of their inspections of construction sites in Upper Merion.	✓			20			
	Review and update the inventory of stormwater quality, rate, and volume controls in Upper Merion (both public and private) and establish\implement an inspection protocol.	✓	Review approved land development plans, Conservation District records (approx. 100 NPDES general construction permits), and aerial photographs to develop an inventory of stormwater quality treatment, flow rate, and volume controls constructed in the Township. Prepare a GIS database that spatially locates each structure.		120					
		✓	Assume 150 stormwater quality treatment, flow rate, and volume controls currently exist in the Township. Prepare inspection protocol and perform field observation of four structures per day by two personnel. Make use of mobile data collection technology that uploads observations of location, type, ownership, and condition.		20		600			
		✓	Update the database of stormwater quality treatment, flow rate, and volume controls annually, adding newly constructed controls, inspection reports, and new attributes as they become available.	✓	20					
		✓	Annually perform inspections of 20% of the stormwater controls installed as part of a development requiring an NPDES earth disturbance permit. Evaluate for their ability to be retrofitted to enhance their capacity to remove additional amounts of sediment. Assume inspection and report generation of 3 structures per day by 2 personnel.	✓			100			
	Update the defined planning area of the Pollutant Reduction Plan (PRP), considering regulated outfalls, stream impairments, and the extent of PADEP's legal authority.		Contract watershed planning service to refine PRP using the most appropriate PRP planning area boundary, parsing land area where appropriate and advantageous to the Township.		10					$25K
	Expand stormwater education and public engagement beyond the minimum standard of MCM 1 and MCM 2 to: ⁾ Identify target audiences and specific educational messages. ⁾ Routinely communicate with partners and invest in partnerships with the public and organizations.		Prepare strategy to engage the public and seek input on Township water resource management priorities. Include outreach to conservation groups, civic associations, and adjacent municipalities to partner on water quality education sessions, stream clean-ups, and other projects.			20		20		
			Implement the public outreach and education campaign.	✓	10	10		40		
	Develop standard operating procedures, maintenance schedules, and site inspection protocols for stormwater management practices at municipal facilities.		Draft and formalize 6 to 8 standard operating procedures for Public Works operations and include into the Township's program of training modules.			10		20		
			Perform quarterly inspections of all municipal facilities to ensure compliance with good house-keeping standards and operating procedures.	✓				20		

Cost Center	Activity/Project	Critical Program Element	Description / Cost Assumptions	Annual Activity	Estimated Hours					Contract Service Cost
					Planning	Public Information	Code Enforcement	Public Works	Admin.	
Operations and Maintenance	Define the boundaries of Upper Merion's MS4 compliance responsibility. Review the Township's list of storm sewer outfalls and determine if ownership belongs to Upper Merion, PennDOT, Montgomery County, or a private landowner for point of discharge.	✓	Assume approx. 250 outfalls currently exist in the Township, perform desktop review of 90% to determine responsible party. Perform field observations for remaining 10%.		40		40			
	Develop an MS4 Infrastructure Maintenance Plan	✓	Set measurable goals for system cleaning, inlet and pipe replacement/ repair, and pre- and post-storm response activities to promote long-term function of the stormwater flow control, conveyance and treatment system.					40		
	Add detail to the storm sewer map, including each feature's location, type, condition, size, material, elevation, and maintenance history.		Annually collect attributes for 10% of the Township's surface stormwater conveyance and management features (inlets, manholes, swales). Assume 360 features at 30 features per day by 2 personnel.	✓	20		100	100		
			Annually perform televideo assessment of 5% of the Township's storm sewer pipes. Assume 2.5 miles of storm sewer inspected annually at $7/LF.	✓	20					$100K
Land Use Regulations	Complete prioritized revisions of select land use regulations.		Priority land use regulations changes include: ⎩ Establish a Municipal Stormwater Maintenance Fund for funds held, in escrow and paid by the land owner/developer for the Township to inspect privately-owned stormwater quality treatment, flow rate, and volume controls approved as part of the land development process. ⎩ Apply thresholds of impervious area and/or earth disturbance to the site improvement process that trigger the appropriate degree of detail of stormwater controls as part of an application package submitted to the Township for approval. ⎩ Update the landscaping standards that specify plantings for parking lots, stormwater basins, vegetated swales, and rain gardens. ⎩ Review right of way standards to expand their ability to serve as a location for stormwater management infrastructure.		80		10			$10K
Planning and Administration	Prepare a Green Stormwater Infrastructure (GSI) Plan and accompanying Stormwater Design Manual		Elements of the GSI Plan that communicates the Township's preference for managing stormwater could include: ⎩ Prioritized installation of GSI elements at specific Township facilities; ⎩ Operations and maintenance standards for Township-owned GSI system; ⎩ Prioritized opportunities for integrating GSI into Township, County, and PennDOT right of way; ⎩ Preferred methods for designing, locating, installing, inspecting, and maintaining stormwater management infrastructure linked to land development regulations; ⎩ Incentives offered to private property owners to encourage investment in GSI (grants, loans, flexibility within land development regulations, etc.); ⎩ Method for gaining public input to the Township's GSI objectives; ⎩ Identified specific locations on private properties ideally suited for regional GSI elements; and ⎩ The Township's partnership strategy to work on private properties, including access, cost sharing, and maintenance agreements.		40	20			20	$100K
	Evaluate the costs and benefits of a stream quality monitoring program		Consider the cost and benefits of a stream quality monitoring program to gain understanding of the current status of priority impaired streams, the actions that may be necessary to improve water quality, and the Township's options for negotiating the terms of MS4 permit compliance with regulators.							$20K
Capital Projects	Establish, review, and annually update a Stormwater Capital Improvement Plan.		Include projects in a Stormwater Capital Improvement Plan and review priorities annually. Projects should include flood mitigation projects, priority projects from the GSI Plan, and projects included in the PRP.		10			10	10	

Table 2. Summary of Estimated Effort for New Stormwater Treatment Practices

	Planning	Public Inform.	Code Enforcmnt.	Public Works	Admin.	Contract Service Cost
Annual Effort - Total	**110**	**40**	**230**	**170**	**0**	**$100K**
Critical Program Element	60	30	110	10	0	0
Elective Program Element	50	10	120	160	0	$100K
One-Time Activities - Total Effort	**320**	**50**	**650**	**90**	**30**	**$155K**
Critical Program Element	180	0	640	40	0	0
Elective Program Element	140	50	10	50	30	$155K

Upper Merion Township
Stormwater Management Plan
Preliminary Stormwater Program Priorities
March 13, 2018

On January 17, 2018 Gannett Fleming and Amec Foster Wheeler met with staff from Upper Merion's Public Works Department and Public Information Office to discuss the Township's stormwater program goals. The discussion informed a preliminary set of prioritized capital projects to address flooding and drainage issues, as well as prioritized activities related to stormwater permit compliance, infrastructure operations and maintenance, and planning activities.

Table 1 below provides a preliminary prioritization of the recommended stormwater activities, organized by four Cost Centers. Centers are utilized to assist in thinking through the elements of the current stormwater program and to organize the desired fundamental services of the future program, while not limiting the discussion to the current organizational structure of Township departments. By organizing Upper Merion's costs into these categories, stormwater management activities, available funding sources, fund utilization, and organizational responsibilities in implementation of stormwater services can be fully represented. Use of Cost Centers is helpful in communicating the existing program to the community, stakeholders, and decision makers, as well as for developing a compelling case for the Township's preferred change to the program.

Table 1. Preliminary Stormwater Program Priorities

Cost Center	Activity/Project	Year to Initiate	Review Interval
MS4 Permit Compliance	Perform annual review of each MS4 program element	2018	Ongoing
	Formalize communication with the Conservation District regarding responsibilities for enforcing erosion control measures during land disturbance activities.	2018	5 years
	Review and update list of stormwater controls in Upper Merion (both public and private) and establish inspection protocol and schedule.	2018	Ongoing
	Update the defined planning area of the Pollutant Reduction Plan (PRP), taking into account regulated outfalls, stream impairments, PennDOT responsibilities, and the extent of PADEP's legal authority.	2018	5 years
	Update the public outreach and stormwater education program to: • Define target audiences and specific educational messages. • Routinely communicate with partners and invest in partnerships with the public and organizations.	2019	Annually
	Review the Township's list of MS4-regulated outfalls and transition to mobile data collection for illicit discharge detection.	2019	5 years
	Develop standard operating procedures, written maintenance timelines, and site inspection schedules for stormwater management at municipal facilities.	2019	5 years
Operations and Maintenance	Develop an Infrastructure Maintenance Plan	2019	5 years
	Add detail to the storm sewer map	2019	Ongoing
	Perform storm sewer infrastructure conditions assessment	2020	Ongoing
Land Use Regulations	Establish a Municipal Stormwater Maintenance Fund to hold funds in escrow for the Township to inspect privately-owned stormwater controls approved as part of the land development process.	2019	Ongoing
	Apply thresholds of impervious area and/or earth disturbance to the site improvement process that trigger the appropriate degree of design detail in applications submitted to the Township for approval.	2019	5 years
	Update the landscaping standards that specify plantings for parking lots and stormwater features.	2020	5 years
	Review right of way standards to expand their ability to serve as a location for stormwater management infrastructure.	2020	5 years
Planning and Administration	Prepare a Green Stormwater Infrastructure (GSI) Plan (and accompanying Stormwater Design Manual) that communicates the Township's preference for managing stormwater, including: • Prioritized installation of GSI elements at specific Township facilities; • Operations and maintenance standards for the Township-owned GSI system; • Vision for integrating GSI into Township, County, and PennDOT right of way; • Preferred methods for designing, locating, installing, inspecting, and maintaining stormwater management infrastructure linked to land development regulations; • Incentives offered to private property owners to encourage investment in GSI (grants, loans, flexibility within land development regulations, etc); • Identified specific locations on private properties ideally suited for regional GSI elements; • The Township's partnership strategy to work on private properties, including access, cost sharing, and maintenance agreements.	2019	5 years
	Prioritize watersheds in the Township for water quality and flood mitigation projects.	2019	5 years
	Inspect existing stormwater controls for their ability to be retrofitted to enhance their capacity to remove additional amounts of sediment through retrofits.	2020	5 years
	Establish a water quality monitoring program to develop understanding of the current status of impaired waters, the actions that may be necessary to improve water quality, and the Township's options for negotiating the terms of MS4 permit compliance with regulators.	2021	Ongoing
Capital Projects	Establish, review, and annually update a Stormwater Capital Improvement Plan. Add projects to a Stormwater Capital Improvement Plan, review priorities, and implement projects to meet the Township's goals for runoff control. Projects should include priority projects from the GSI Plan and projects included in the PRP.	2019	Annually

Upper Merion Township
Stormwater Management Plan
Pollutant Reduction Plan Review
September 6, 2017

In July 2017, Upper Merion Township posted its draft Pollutant Reduction Plan (PRP) for public review and comment. The PRP commits the Township to a plan to reduce the discharge of sediment from the Township's Municipal Separate Storm Sewer System (MS4) to local streams impaired by urban runoff by 10% over the five-year term of the Township's MS4 permit. Calculations of the sediment reduction required to meet the 10% goal, as set forth in the draft version of the plan, is 394 tons of sediment discharge per year. To accomplish this, the Township has identified 28 sediment reduction practices (street sweeping, basin retrofit, stream restoration) that, if implemented, would reduce sediment loading by approximately 398 tons per year. The PRP will be submitted to the Pennsylvania Department of Environmental Protection (PADEP) in September 2017, along with their Notice of Intent to renew their MS4 permit.

We conducted a cursory review of the PRP and offer the following comments for general consideration. Upper Merion may consider submitting a revised PRP that addresses any or all of the comments below following the initial submittal that accompanies the September Notice of Intent.

Planning Area Delineation

The PRP Planning Area in Figure 1 as calculated, is 9,399 acres (or 14.7 sq miles). We recommend the Township re-delineate the Planning Area, taking into account the following features that may be eliminated (or parsed) from the PRP.

- **Crow Creek**. The Crow Creek is listed on PADEP's *MS4 Requirements Table* as impaired by Water/Flow Variability. However, PADEP's map of impairments shows that the stream as it flows from County Line Road and Hobbs Road to Allendale Road is not impaired. Therefore, it appears that the Township does not contribute to the sediment load within this stream. The sediment load from this area of the Township should not be included in the PRP resulting in a reduction of the Planning Area by 900 acres. http://www.depgis.state.pa.us/integratedreport/index.html
- **Valley Forge National Park**. Figure 1 of the PRP may not show the full extent of the Park as it lies in Upper Merion. It appears that the acreage between North Outer Line Drive and the residential land use on Thomas Jefferson Road was not included in the Park boundary and was included into the calculation of the Township's baseline sediment load. This may reduce the Planning Area by 100 acres; therefore, a review of the Park delineation should be completed prior to finalization of the PRP.
- **PennDOT Right of Ways**. It appears that all PennDOT right of ways are included in the sediment load calculation. PennDOT operates under their own MS4 permit and are responsible for their sediment responsibility for these areas. Therefore, these rights of way should be parsed (removed) from the analysis in the PRP.
- **Private and PennDOT Drainage Systems**. There are areas of the Township that do not drain into the Township's MS4. These areas may flow through a privately-owned system and discharge to a water body through a privately-owned outfall; or they may flow into the PennDOT MS4 and discharge through a PennDOT outfall. These areas that do not flow through the Township's MS4 can be removed from the sediment calculations. The decrease in the number of acres of the Planning Area is unknown. It is recommended that the delineation be updated.

Calculation Analysis

The PRP presents a TSS load from the planning area as 3,914 tons per year. This was adjusted downward after calculating sediment reduction functions of existing stormwater controls (Table 6 of PRP). We recommend evaluating additional methods of calculating this load that may adjust the Township's pollutant reduction responsibility.

- **Review of Load Calculation Methods.**
  - The Township used land cover data from 2013 University of Vermont Spatial Analysis Laboratory to estimate impervious area as the basis for calculating sediment load. We reviewed the results of this calculation against the results using Natural Land Cover Data from the US Geological Survey (2014) and found that the Vermont Spatial Analysis Laboratory data resulted in a lower sediment reduction responsibility (4%).
  - However, in our limited review, using the MapShed tool for individual drainage areas, we calculated significantly lower sediment loading. Using the Trout Creek as an example, the method of calculating sediment load used in the PRP resulted in 1,005 tons of sediment discharge per year. In contrast, the discharge calculated using the MapShed tool dropped this sediment load to 621 tons per year. The Township should consider using MapShed or other similar methods which may offer a reduced baseline, to replace the method currently utilized in the draft PRP.
- **Impervious Area Mapping.** Instead of using raster data sources that generalize impervious area coverage to calculate sediment loads, the Township should consider mapping actual impervious area from higher resolution aerial imagery (to provide a more refined perspective of impervious area coverage). Such mapping will provide the Township with a tool to aid in watershed modeling, maintenance tracking, and infrastructure / asset management.

Existing and Future BMPs

Table 6 of the PRP presents 79 stormwater management BMPs that exist in the Township and quantifies how each reduces sediment loading. Table 7 presents stormwater management BMPs proposed for construction that will further reduce sediment loading. Table 8 presents proposed stream restoration projects that will reduce instream erosion as a source of sediment to local streams.

- **Credit for Existing BMPs.** During a field view of Township facilities, several features were identified whose stormwater management function was unclear (BMPs B3, B28, B29, and B30). The design and operation of these features should be reviewed and their sediment reduction potential, if any, should be quantified. Several other stormwater management features were observed in the field that were not included in the list of existing BMPs and should be included (infiltration basin and level spreaders at Heuser Park, multiple retention basins at Mancill Mill Road). The list of BMPs should be regularly reviewed and the locations should be visited to confirm function and condition of each feature.
- **PennDOT BMPs**. A review of Table 6 presents that at least six BMPs are associated with the Pennsylvania Turnpike who operate under their own MS4 permit. It is unknown how many PennDOT-owned BMPs are included on Table 6 that generate credit against the Township's sediment load. If the Township re-delineates the PRP Planning Area as recommended above to exclude areas not flowing through their MS4, these controls should be removed from Table 6 and the credit calculation.

- **Proposed Project Locations.** Tables 7 and 8 propose 16 basin retrofits and 1.2 miles of stream stabilization. The PRP should state the Township's existing right of access to each of these locations as one factor to determine the feasibility and the priority level of each project.
- **Proposed Project Budgets.** The PRP should include a conceptual budget for each proposed BMP and stream restoration project to inform decisions regarding the feasibility and the priority level of each project.
- **Crow Creek Watershed.** Approximately a dozen of the proposed BMPs and proposed stream restoration projects lie in the section of the Crow Creek watershed that is not currently listed as "impaired". Sediment reduction achieved by these projects may not be applicable to the Township's sediment reduction responsibility. The PRP should focus on achieving sediment reduction from drainage areas that discharge to impaired streams.

Appendix G – Public Open House / Engagement Events

Appendix G – Public Open House / Engagement Events

Public Open House – Stormwater Management Program / Study

FOR THE

UPPER MERION SANITARY AND STORMWATER AUTHORITY

EVENT DATE: July 23, 2018 at 4:00 p.m.

Response Form

Attendee Name	Mailing Address	Phone Number	Email Address

Your feedback from this event is critical to the efforts of the Township regarding stormwater management and the level of services provided by the Authority. As you circulate through the open house, there are various questions at some of the individual stations, designed to prompt feedback and solicit your opinions and thoughts. Those same questions are provided below, where your written response can be provided to help guide and shape the extent and types of stormwater services provided by the Authority;

Station No. 2 Question:
What do you think are the greatest sources of runoff and pollution flowing to streams in Upper Merion?

Station No. 5 Question:
Where have you seen information on stormwater? Township newsletter, Township cable station, Township website, Public meeting, Park signage

Station No. 6 Questions:
Do you feel you know enough about how the Township manages stormwater?

Which of these services are most important to you?

How could the Township improve its stormwater program services?

Public Open House – Stormwater Management Program / Study

FOR THE

UPPER MERION SANITARY AND
STORMWATER AUTHORITY

EVENT DATE: July 23, 2018 at 4:00 p.m.

Response Form

Attendee Name	Mailing Address	Phone Number	Email Address

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What do you think are the greatest sources of runoff and pollution flowing to streams in Upper Merion?

Station No. 5 Question:
Where have you seen information on stormwater? Township newsletter, Township cable station, Township website, Public meeting, Park signage

Station No. 6 Questions:
Do you feel you know enough about how the Township manages stormwater?

Which of these services are most important to you?

How could the Township improve its stormwater program services?

#124: New roadway bridge proposed for 23 crossing of Trout Creek; on regional TIP for future funding

Public Open House – Stormwater Management Program / Study

FOR THE

UPPER MERION SANITARY AND STORMWATER AUTHORITY

EVENT DATE: July 23, 2018 at 4:00 p.m.

Response Form

Attendee Name	Mailing Address	Phone Number	Email Address
Betty Hendrick foster Eddie Hendrick	424 Blueburff Rd K.O.P. PA 19406	484-410-9239	donz150@comcast.net Billyboytrucking1@yahoo.com

Your feedback from this event is critical to the efforts of the Township regarding stormwater management and the level of services provided by the Authority. As you circulate through the open house, there are various questions at some of the individual stations, designed to prompt feedback and solicit your opinions and thoughts. Those same questions are provided below, where your written response can be provided to help guide and shape the extent and types of stormwater services provided by the Authority;

Station No. 2 Question:

What do you think are the greatest sources of runoff and pollution flowing to streams in Upper Merion?

I live at 424 Blue bluff Rd. There is a drain between me and my neighbors driveways. If there is flash flooding the water all runs down to our end of the cul-d-sac and comes up our driveways and has flooded/lost 2 cars due to this problem. It comes over half way up drive way

Station No. 5 Question:

Where have you seen information on stormwater? Township newsletter, Township cable station, Township website, Public meeting, Park signage

No where really in the Valley forge Home areas

Station No. 6 Questions:

Do you feel you know enough about how the Township manages stormwater?

No

Which of these services are most important to you?

Doing something about the drainage and ensuring that the way flows away fast enough so you don't have to worry about your cars washing to the middle of street and getting full of water and you loose your car!

How could the Township improve its stormwater program services?

Keep working on it and observing/managing these water hole drains faster and better and make permanent changes! Also change pipes or make them bigger.

Also, on Powderhorn up from musket [redacted] there is a large drain there that is always clogged and when it rains heavy or flash floods there is always a large pool of water there practically cover the entire street that you can [illegible] May need to clean more often!

Public Open House – Stormwater Management Program / Study

FOR THE

UPPER MERION SANITARY AND
STORMWATER AUTHORITY

EVENT DATE: July 23, 2018 at 4:00 p.m.

Response Form

Attendee Name	Mailing Address	Phone Number	Email Address

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Peco ROW @ Kingwood Rd (Ed Mustard) ~ May 2018
culvert from ROW thru culvert to Blue Bluff Rd
to T-Pk ROW to Walker field.

Major flooding at west end of Blue Bluff inadequate
Reinforcement @ Kingwood - concrete

Station No. 2 Question:
What do you think are the greatest sources of runoff and pollution flowing to streams in Upper Merion?

Station No. 5 Question:
Where have you seen information on stormwater? Township newsletter, Township cable station, Township website, Public meeting, Park signage

Station No. 6 Questions:
Do you feel you know enough about how the Township manages stormwater?

Which of these services are most important to you?

How could the Township improve its stormwater program services?

Public Open House – Stormwater Management Program / Study

FOR THE

UPPER MERION SANITARY AND
STORMWATER AUTHORITY

EVENT DATE: July 23, 2018 at 4:00 p.m.

Response Form

Attendee Name	Mailing Address	Phone Number	Email Address
Stefanie J Hill	301 Bismark Way King of Prussia PA 19406	484-612-8469	stefanie_j_hill@comcast.net

Your feedback from this event is critical to the efforts of the Township regarding stormwater management and the level of services provided by the Authority. As you circulate through the open house, there are various questions at some of the individual stations, designed to prompt feedback and solicit your opinions and thoughts. Those same questions are provided below, where your written response can be provided to help guide and shape the extent and types of stormwater services provided by the Authority;

Station No. 2 Question:

What do you think are the greatest sources of runoff and pollution flowing to streams in Upper Merion?

Construction Sites; Industrial areas,

Station No. 5 Question:

Where have you seen information on stormwater? Township newsletter, Township cable station, Township website, Public meeting, Park signage

Township Newsletter, Township website

Station No. 6 Questions:

Do you feel you know enough about how the Township manages stormwater?

I definately need to educate myself more

Which of these services are most important to you?

Pipe inspection & repair

Public outreach and education

Inlet cleaning

How could the Township improve its stormwater program services?

Public Open House – Stormwater Management Program / Study

FOR THE

UPPER MERION SANITARY AND STORMWATER AUTHORITY

EVENT DATE: July 23, 2018 at 4:00 p.m.

Response Form

Attendee Name	Mailing Address	Phone Number	Email Address

Your feedback from this event is critical to the efforts of the Township regarding stormwater management and the level of services provided by the Authority. As you circulate through the open house, there are various questions at some of the individual stations, designed to prompt feedback and solicit your opinions and thoughts. Those same questions are provided below, where your written response can be provided to help guide and shape the extent and types of stormwater services provided by the Authority;

RICHARD ROOT
255 GYPSY LANE
610-688-7657
RSROOT421@AOL.COM

Station No. 2 Question:
What do you think are the greatest sources of runoff and pollution flowing to streams in Upper Merion?

Station No. 5 Question:
Where have you seen information on stormwater? Township newsletter, Township cable station, Township website, Public meeting, Park signage

Station No. 6 Questions:
Do you feel you know enough about how the Township manages stormwater?

Which of these services are most important to you?

How could the Township improve its stormwater program services?
BUILD A CATCH BASIN JUST EAST OF PINE HILL ROAD ALONG THE NORTH SIDE OF GYPSY LANE. THIS WOULD PREVENT/CONTROL/CONTAIN THE RUN OFF FROM ALL THE DEVELOPMENTS THAT EVENTUALLY FINDS ITS WAY INTO GYPSY CREEK. I LIVE@ 255 GYPSY LANE THE FLOODING IS THE GREATEST FROM APPROXIMATELY 390 GYPSY TO LONGVIEW.

To be more Specific,

I SUGGEST YOU RETHINK PROJECT #156. THE CATCH BASIN SHOULD be PLACED EAST OF PINE HILL ALONG THE NORTH SIDE OF GYPSY LANE. THAT WOULD ALSO BENEFIT ALL THE HOMEOWNERS FROM PINE HILL TO AND INCLUDING THE PROPOSED LOCATION OF PROJECT #156. THE AREA I'M SUGGESTING FOR THE BASIN IS A wooded, UNdeveloped LAND.

Public Open House – Stormwater Management Program / Study

FOR THE

UPPER MERION SANITARY AND STORMWATER AUTHORITY

EVENT DATE: July 23, 2018 at 4:00 p.m.

Attendance Form

No.	Attendee Name	Mailing Address	Phone Number	Email Address
1.	Mark McKee	1091 Jones Rd Gulph Mills PA	610-834-0187	MAMMFG@AOL.com
2.	Matt Popek	20728 Valley Forge Cir King of Prussia, PA 19406	610-202-6607	Mattpopek@gmail.com
3.	Jim Ruddy	181 RIVERVIEW RD KOP	610-265 1405	JIM@RUDDY.ORG
4.	ED MUSTARD	390 KINGWOOD RD	610 — 265-2993	VFHOMECA
5.	Edward Veneziale	591 Paul Revere Rd KOP	610-962-9824	eveneziale@verizon.net

No.	Attendee Name	Mailing Address	Phone Number	Email Address
6.	Betty Foster	424 Blueberry Rd	484-418-9239	don2150@comcast.net
7.	Stefanie J Hill	301 Bismark Way	484-612-8969	stefanie_j_hill@comcast.net
8.	RICHARD ROOT	255 GYPSY LANE	610-688-7657	RSROOT421@AOL.COM
9.	M Jonathan Gorzillo	412 Global Rd. Apt.	484 784 8661	MJDGDC@aol.com
10.	Ann Marchino	946 Longview Rd.	484-535-0575	ann.marchino@gmail.com
11.				
12.				
13.				
14.				
15.				
16.				

Public Open House – Stormwater Management Program / Study

FOR THE

UPPER MERION SANITARY AND STORMWATER AUTHORITY

EVENT DATE: September 24, 2018 at 6:00 p.m.

Response Form

Attendee Name	Mailing Address	Phone Number	Email Address
Grace Battista	211 King of Prussia Rd Wayne	610 299 8852	Battista.grace@gmail.com

Your feedback from this event is critical to the efforts of the Township regarding stormwater management and the level of services provided by the Authority. As you circulate through the open house, there are various questions at some of the individual stations, designed to prompt feedback and solicit your opinions and thoughts. Those same questions are provided below, where your written response can be provided to help guide and shape the extent and types of stormwater services provided by the Authority;

Station No. 2 Question:
What do you think are the greatest sources of runoff and pollution flowing to streams in Upper Merion?

Rainwater/lack of natural permeation/filtration

Station No. 5 Question:
Where have you seen information on stormwater? Township newsletter, Township cable station, Township website, Public meeting, Park signage

FaceBook - Upper Merion

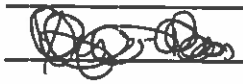
Station No. 6 Questions:
Do you feel you know enough about how the Township manages stormwater?

N/A - Just starting

Which of these services are most important to you?

Storm water management

How could the Township improve its stormwater program services?



Public Open House – Stormwater Management Program / Study

FOR THE

UPPER MERION SANITARY AND STORMWATER AUTHORITY

EVENT DATE: September 24, 2018 at 6:00 p.m.

Response Form

Attendee Name	Mailing Address	Phone Number	Email Address
Mark Keller	331 Crossfield Rd	6109979898	mkeller39@Comcast.net

Your feedback from this event is critical to the efforts of the Township regarding stormwater management and the level of services provided by the Authority. As you circulate through the open house, there are various questions at some of the individual stations, designed to prompt feedback and solicit your opinions and thoughts. Those same questions are provided below, where your written response can be provided to help guide and shape the extent and types of stormwater services provided by the Authority;

1) Storm Sewer In Rd seems Backed up on Crossfield & Heather Lane. Near Heather Lane → In Middle of

2) Drain Build up on Prince Fredric Rd near crossfield Street — where stream

Station No. 2 Question:
What do you think are the greatest sources of runoff and pollution flowing to streams in Upper Merion?

Station No. 5 Question:
Where have you seen information on stormwater? Township newsletter, Township cable station, Township website, Public meeting, Park signage

Station No. 6 Questions:
Do you feel you know enough about how the Township manages stormwater?

Which of these services are most important to you?

How could the Township improve its stormwater program services?

Public Open House – Stormwater Management Program / Study

FOR THE

UPPER MERION SANITARY AND STORMWATER AUTHORITY

EVENT DATE: September 24, 2018 at 6:00 p.m.

Response Form

Attendee Name	Mailing Address	Phone Number	Email Address
Chris Biele	730 ROY RD	908 872 9430	NovaBiele@gmail.com

Your feedback from this event is critical to the efforts of the Township regarding stormwater management and the level of services provided by the Authority. As you circulate through the open house, there are various questions at some of the individual stations, designed to prompt feedback and solicit your opinions and thoughts. Those same questions are provided below, where your written response can be provided to help guide and shape the extent and types of stormwater services provided by the Authority;

Sanitary Sewage Backup w/ time per year into multiple houses on Roy Rd Cul de sac.

Backup - 2 weeks ago @ neighbors

Station No. 2 Question:
What do you think are the greatest sources of runoff and pollution flowing to streams in Upper Merion?

Station No. 5 Question:
Where have you seen information on stormwater? Township newsletter, Township cable station, Township website, Public meeting, Park signage

Station No. 6 Questions:
Do you feel you know enough about how the Township manages stormwater?

Which of these services are most important to you?

How could the Township improve its stormwater program services?

Public Open House – Stormwater Management Program / Study

FOR THE

UPPER MERION SANITARY AND STORMWATER AUTHORITY

EVENT DATE: September 24, 2018 at 6:00 p.m.

Response Form

Attendee Name	Mailing Address	Phone Number	Email Address
Vasyl Fedkiv	130 HAMLET DR	2672405747	fvansuzz@yahoo.com

Your feedback from this event is critical to the efforts of the Township regarding stormwater management and the level of services provided by the Authority. As you circulate through the open house, there are various questions at some of the individual stations, designed to prompt feedback and solicit your opinions and thoughts. Those same questions are provided below, where your written response can be provided to help guide and shape the extent and types of stormwater services provided by the Authority;

Station No. 2 Question:

What do you think are the greatest sources of runoff and pollution flowing to streams in Upper Merion?

Kop Mall, new construction

Station No. 5 Question:

Where have you seen information on stormwater? Township newsletter, Township cable station, Township website, Public meeting, Park signage

In my back yard then at township open house

Station No. 6 Questions:

Do you feel you know enough about how the Township manages stormwater?

NO

Which of these services are most important to you?

How could the Township improve its stormwater program services?

Need to have township meeting in nearest future

Public Open House – Stormwater Management Program / Study

FOR THE

UPPER MERION SANITARY AND STORMWATER AUTHORITY

EVENT DATE: September 24, 2018 at 6:00 p.m.

Response Form

Attendee Name	Mailing Address	Phone Number	Email Address
Anthony Rothenberger	367 crossfield Rd (rental)	610-742-4603	anthony193@yahoo.com

Your feedback from this event is critical to the efforts of the Township regarding stormwater management and the level of services provided by the Authority. As you circulate through the open house, there are various questions at some of the individual stations, designed to prompt feedback and solicit your opinions and thoughts. Those same questions are provided below, where your written response can be provided to help guide and shape the extent and types of stormwater services provided by the Authority;

Station No. 2 Question:
What do you think are the greatest sources of runoff and pollution flowing to streams in Upper Merion?

Station No. 5 Question:
Where have you seen information on stormwater? Township newsletter, Township cable station, Township website, Public meeting, Park signage

Station No. 6 Questions:
Do you feel you know enough about how the Township manages stormwater?

Which of these services are most important to you?

How could the Township improve its stormwater program services?

Public Open House – Stormwater Management Program / Study

FOR THE

UPPER MERION SANITARY AND STORMWATER AUTHORITY

EVENT DATE: September 24, 2018 at 6:00 p.m.

Response Form

Attendee Name	Mailing Address	Phone Number	Email Address
Matthew Caine	138 Hamlet Dr	215 870-1097	mcaine82@gmail.com

Your feedback from this event is critical to the efforts of the Township regarding stormwater management and the level of services provided by the Authority. As you circulate through the open house, there are various questions at some of the individual stations, designed to prompt feedback and solicit your opinions and thoughts. Those same questions are provided below, where your written response can be provided to help guide and shape the extent and types of stormwater services provided by the Authority;

Station No. 2 Question:
What do you think are the greatest sources of runoff and pollution flowing to streams in Upper Merion?

Over development and poor maintenance

Station No. 5 Question:
Where have you seen information on stormwater? Township newsletter, Township cable station, Township website, Public meeting, Park signage

Township newsletter (email) and from neighbors

Station No. 6 Questions:
Do you feel you know enough about how the Township manages stormwater?

No. I learned a lot of ideas have been presented but I do not know what the next steps are.

Which of these services are most important to you?

Inspection and repair. Preventive Maintenance

How could the Township improve its stormwater program services?

I'm not an engineer. I hope the township asks one of these!

Feedback on the meeting: First, I was not hit terribly hard by the Aug. 13th storm. I had 32" of water in my shed resulting in about $400 damage. I was lucky - my house was spared. I got many answers at this meeting. There were a lot of angry residents here. They are not getting answers. I don't think the meeting organizers realized how intense this would get. A poster session and (what appeared to be only 2 people) did not have the feel of "we hear your concerns". My unanswered questions remain: how will the township prioritize improvements and fund them?

Attended 6:00-6:30

thanks
NC

Public Open House – Stormwater Management Program / Study

FOR THE

UPPER MERION SANITARY AND STORMWATER AUTHORITY

EVENT DATE: September 24, 2018 at 6:00 p.m.

Response Form

Attendee Name	Mailing Address	Phone Number	Email Address
John + Mary Schlerniteuer	709 General Scott Road King of Prussia 19406	610-265-5143	Schlerni2@msn.com

Your feedback from this event is critical to the efforts of the Township regarding stormwater management and the level of services provided by the Authority. As you circulate through the open house, there are various questions at some of the individual stations, designed to prompt feedback and solicit your opinions and thoughts. Those same questions are provided below, where your written response can be provided to help guide and shape the extent and types of stormwater services provided by the Authority;

Station No. 2 Question:
What do you think are the greatest sources of runoff and pollution flowing to streams in Upper Merion?
Storm water From poor grading

Station No. 5 Question:
Where have you seen information on stormwater? Township newsletter, Township cable station, Township website, Public meeting, Park signage
Township Newsletter, website + now Public meeting

Station No. 6 Questions:
Do you feel you know enough about how the Township manages stormwater?
No. I need To hear more. We have a Terrible drainage problem on our property + many of our adjoining neighbors. We'd like To remediate but do not want To make problem worse for neighbors. We need Township Plan & recommendation To remediate
Which of these services are most important to you?
Improve drainage on properTY + adjoining properTies leading To STream - many blockages we need help Please
How could the Township improve its stormwater program services?
Please help us begin plan To improve drainage for us + all of our neighbors on General Scott + Champlain. Our properties are like lakes several Times per year. Of course This was very high rainfall Year but iT's been a problem 4 several years + is getting worse. Please help us help the neighborhood + the Township Thanks so much!
Your reply + plan 4 improvemenT is so appreciated.

John + Mary Schlernitzauer
610-265-5143

Public Open House – Stormwater Management Program / Study

FOR THE

UPPER MERION SANITARY AND STORMWATER AUTHORITY

EVENT DATE: September 24, 2018 at 6:00 p.m.

Response Form

Attendee Name	Mailing Address	Phone Number	Email Address
Michelle Short	128 Hamlet Drive King of Prussia 19406	484 363 1902	m4short@verizon.net

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Station No. 2 Question:

What do you think are the greatest sources of runoff and pollution flowing to streams in Upper Merion?

The new building / mall
infrastructure damage -

Station No. 5 Question:

Where have you seen information on stormwater? Township newsletter, Township cable station, Township website, Public meeting, Park signage

Public Meeting / library presentation
by contracting / Township directly

Station No. 6 Questions:

Do you feel you know enough about how the Township manages stormwater?

Presumably - hopefully there is
funding to 'actually DO these things

Which of these services are most important to you?

Pipe inspection / outfall inspection

How could the Township improve its stormwater program services?

By letting residents know when
specific problems will be addressed.

Public Open House – Stormwater Management Program / Study

FOR THE

UPPER MERION SANITARY AND
STORMWATER AUTHORITY

EVENT DATE: September 24, 2018 at 6:00 p.m.

Response Form

Attendee Name	Mailing Address	Phone Number	Email Address
Drew Saunders	1118 Lafayette Rd	610-574-0888	Drew48@aol.com

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Station No. 2 Question:
What do you think are the greatest sources of runoff and pollution flowing to streams in Upper Merion?

Station No. 5 Question:
Where have you seen information on stormwater? Township newsletter, Township cable station, Township website, Public meeting, Park signage

Station No. 6 Questions:
Do you feel you know enough about how the Township manages stormwater?

Which of these services are most important to you?

How could the Township improve its stormwater program services?

I'm happy for this event as I've been a U.M. resident for 35 years and flooding on Lafayette Road has been a constant problem especially at the lowest point which is my property! HELP!

Public Open House – Stormwater Management Program / Study

FOR THE

UPPER MERION SANITARY AND STORMWATER AUTHORITY

EVENT DATE: September 24, 2018 at 6:00 p.m.

Response Form

Attendee Name	Mailing Address	Phone Number	Email Address
Richard C. Mariette	307 Tory Turn	267-872-1276	rmariette@comcast.net

Your feedback from this event is critical to the efforts of the Township regarding stormwater management and the level of services provided by the Authority. As you circulate through the open house, there are various questions at some of the individual stations, designed to prompt feedback and solicit your opinions and thoughts. Those same questions are provided below, where your written response can be provided to help guide and shape the extent and types of stormwater services provided by the Authority;

Station No. 2 Question:
What do you think are the greatest sources of runoff and pollution flowing to streams in Upper Merion?

Station No. 5 Question:
Where have you seen information on stormwater? Township newsletter, Township cable station, Township website, Public meeting, Park signage

Station No. 6 Questions:
Do you feel you know enough about how the Township manages stormwater?

Which of these services are most important to you?

How could the Township improve its stormwater program services?
BASED ON THE TOUR OF MY HOME DAMAGE THAT I SHOWED TO MR. LOEPA, POST 8/13 STORM, I RECEIVE A DISPROPORTIONATE AMOUNT OF RUN-OFF AND I WOULD LIKE TO REQUEST INTERVENTION BY U.M. TOWNSHIP.

THANK YOU.

RC Mantle

Public Open House – Stormwater Management Program / Study

FOR THE

UPPER MERION SANITARY AND STORMWATER AUTHORITY

EVENT DATE: September 24, 2018 at 6:00 p.m.

Response Form

Attendee Name	Mailing Address	Phone Number	Email Address
BOB BIANCO	1016 TRINITY LANE GULPH MILLS PA 19428	610-764-2777	Biancobob@msn.com

Your feedback from this event is critical to the efforts of the Township regarding stormwater management and the level of services provided by the Authority. As you circulate through the open house, there are various questions at some of the individual stations, designed to prompt feedback and solicit your opinions and thoughts. Those same questions are provided below, where your written response can be provided to help guide and shape the extent and types of stormwater services provided by the Authority;

Station No. 2 Question:

What do you think are the greatest sources of runoff and pollution flowing to streams in Upper Merion?

FROM OUR OBSERVATIONS ON TRINITY LANE THE SCHUYKILL EXPRESSWAY AND THE AREA WITHIN THE GULPH MILLS ENTRANCE RAMP SEEM TO BE A BIG PROBLEM. IT SEEMS PENDOT IS USING THIS AREA AS A DUMP FOR MILLINGS CREATING PROBABLY 2 ACRES of IMPERVIOUS AREA.

Station No. 5 Question:

Where have you seen information on stormwater? Township newsletter, Township cable station, Township website, Public meeting, Park signage

MOSTLY FROM PUBLIC MTGS.

Station No. 6 Questions:

Do you feel you know enough about how the Township manages stormwater?

NO

Which of these services are most important to you?

How could the Township improve its stormwater program services?

UNDERSTANDING THE EXPENSE INVOLVED I DON'T THINK I WOULD REALY KNOW HOW TO GIVE INPUT OTHER THAN IDEA'S I HAVE CONCERNING MY AREA.

Public Open House – Stormwater Management Program / Study

FOR THE

UPPER MERION SANITARY AND STORMWATER AUTHORITY

EVENT DATE: September 24, 2018 at 6:00 p.m.

Response Form

Attendee Name	Mailing Address	Phone Number	Email Address
Rhonda Hager	373 Thomas Dr.	610-265-7896	rihager@comcast.net

Your feedback from this event is critical to the efforts of the Township regarding stormwater management and the level of services provided by the Authority. As you circulate through the open house, there are various questions at some of the individual stations, designed to prompt feedback and solicit your opinions and thoughts. Those same questions are provided below, where your written response can be provided to help guide and shape the extent and types of stormwater services provided by the Authority;

Station No. 2 Question:
What do you think are the greatest sources of runoff and pollution flowing to streams in Upper Merion?

Station No. 5 Question:
Where have you seen information on stormwater? Township newsletter, Township cable station, Township website, Public meeting, Park signage

Station No. 6 Questions:
Do you feel you know enough about how the Township manages stormwater?

NO!

Which of these services are most important to you?

How could the Township improve its stormwater program services?

Thomas + Crossfield - often has flooding from overflow of Trout Creek. Monday, 8/13 was terrible.

Public Open House – Stormwater Management Program / Study

FOR THE

UPPER MERION SANITARY AND STORMWATER AUTHORITY

EVENT DATE: September 24, 2018 at 6:00 p.m.

Response Form

Attendee Name	Mailing Address	Phone Number	Email Address
Anthony & Sylvia Pizza	349 Brownlie Rd.	610-992-0293	Avpizza@aol.com

Your feedback from this event is critical to the efforts of the Township regarding stormwater management and the level of services provided by the Authority. As you circulate through the open house, there are various questions at some of the individual stations, designed to prompt feedback and solicit your opinions and thoughts. Those same questions are provided below, where your written response can be provided to help guide and shape the extent and types of stormwater services provided by the Authority;

Put me BACK ON your List

Station No. 2 Question:
What do you think are the greatest sources of runoff and pollution flowing to streams in Upper Merion?

Not enough drainage containment & water running freely in the street

Station No. 5 Question:
Where have you seen information on stormwater? Township newsletter, Township cable station, Township website, Public meeting, Park signage

We have been dealing with the Township since the 1990s with our water problem and nothing has been done. Driveway is starting to sink where water is flowing across from adjacent property. Ground erosion.

Station No. 6 Questions:
Do you feel you know enough about how the Township manages stormwater?

Yes — nothing has been done in over 20 years since our complaint.

Which of these services are most important to you?

Water runoff and property erosion.

How could the Township improve its stormwater program services?

Deal with the water I need help Someone is going to get hurt Safety problem now

Tony Pizza
349 Brownlie Rd
K of P. Russia

610-992-0293
484-645-0403

Public Open House – Stormwater Management Program / Study

FOR THE

UPPER MERION SANITARY AND STORMWATER AUTHORITY

EVENT DATE: September 24, 2018 at 6:00 p.m.

Response Form

Attendee Name	Mailing Address	Phone Number	Email Address
David Glauner	164 Rebel Rd.	610-476-9484	Dfglaunere msn.com

Your feedback from this event is critical to the efforts of the Township regarding stormwater management and the level of services provided by the Authority. As you circulate through the open house, there are various questions at some of the individual stations, designed to prompt feedback and solicit your opinions and thoughts. Those same questions are provided below, where your written response can be provided to help guide and shape the extent and types of stormwater services provided by the Authority;

Station No. 2 Question:
What do you think are the greatest sources of runoff and pollution flowing to streams in Upper Merion?

Station No. 5 Question:
Where have you seen information on stormwater? Township newsletter, Township cable station, Township website, Public meeting, Park signage
Township Website

Station No. 6 Questions:
Do you feel you know enough about how the Township manages stormwater?
I could Always learn more. My issue is in Brandywine Village. @ the bottom of Rebel Rd.

Which of these services are most important to you?
Water Run off study - From all the changes up above Hillview Rd & Brandywine New houses being built & Retention walls being put in by homeowners. I have a creek that runs through my back yard to my side yard. Coming From UP ABOVE. Continued on Back →

How could the Township improve its stormwater program services?
~~Flag it~~ Encourage Residents to Report any issues Especially the small ones, they develop the into big issues. Investigate when it rains and walk the streets and Follow the Flow of water.

My neighbor directly behind me. (1480 Hillview RD) has made a Resovoir which holds the water, which is an issue, but the bigger issue is where it is coming from. Which is from Rebel Circle, Hillview Rd. & Brandywine. There is a flow of water coming into his backyard, which yrs ago he has diverted it by making a Retention Basin of some sort. When it fills up, it over flows and affects my properby. The beginning of the flow is the ultimate solution. I have video and pictures. I work in the water industry/construction field for over 12yrs.

Public Open House – Stormwater Management Program / Study

FOR THE

UPPER MERION SANITARY AND STORMWATER AUTHORITY

EVENT DATE: September 24, 2018 at 6:00 p.m.

Response Form

Attendee Name	Mailing Address	Phone Number	Email Address
Nicole Leget-Morton	738 Pot Rd	610 937 3329	Nmorton716@yahoo

Your feedback from this event is critical to the efforts of the Township regarding stormwater management and the level of services provided by the Authority. As you circulate through the open house, there are various questions at some of the individual stations, designed to prompt feedback and solicit your opinions and thoughts. Those same questions are provided below, where your written response can be provided to help guide and shape the extent and types of stormwater services provided by the Authority;

Station No. 2 Question:
What do you think are the greatest sources of runoff and pollution flowing to streams in Upper Merion?

Planning of 20 + New construction

Poor management by occupants

Station No. 5 Question:
Where have you seen information on stormwater? Township newsletter, Township cable station, Township website, Public meeting, Park signage

News articles - website

Station No. 6 Questions:
Do you feel you know enough about how the Township manages stormwater?

no

Which of these services are most important to you?

better education - information on how to manage

How could the Township improve its stormwater program services?

→ Lessen construction of trees work on current lots first

Public Open House – Stormwater Management Program / Study

FOR THE

UPPER MERION SANITARY AND STORMWATER AUTHORITY

EVENT DATE: September 24, 2018 at 6:00 p.m.

Response Form

Attendee Name	Mailing Address	Phone Number	Email Address
KRISHNAN NATARAJAN	345 Glenn Rose Circle King of Prussia	2159191604	KRISTNANN@GMAIL.COM

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WATER collects below our deck whenever it rains even moderately. The retaining wall behind which borders the parking lot, has some gaps through which water pours out onto the grounds below our deck. This causes wetness/dampness in our basement. I have replaced the carpet twice in 8 years.

Station No. 2 Question:

What do you think are the greatest sources of runoff and pollution flowing to streams in Upper Merion?

Inadequate Infrastructure to handle increased demands

Station No. 5 Question:

Where have you seen information on stormwater? Township newsletter, Township cable station, Township website, Public meeting, Park signage

~~About~~ ~~Here~~, Public meeting here

Station No. 6 Questions:

Do you feel you know enough about how the Township manages stormwater?

Much more now. But need to know more. Too technical

Which of these services are most important to you?

Prevention of flooding of main roadways

How could the Township improve its stormwater program/services?

Spend the necessary funds by planning for future expenses.

Public Open House – Stormwater Management Program / Study

FOR THE

UPPER MERION SANITARY AND STORMWATER AUTHORITY

EVENT DATE: September 24, 2018 at 6:00 p.m.

Response Form — stormdrain issues behind our house coming

Attendee Name	Mailing Address	Phone Number	Email Address
Joe Appicciafuoco	612 Nantucket Cir K of P	610-265-6995	bapp914@gmail.com

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down from Brownlie Rd. Storm drain overflows.

Station No. 2 Question:
What do you think are the greatest sources of runoff and pollution flowing to streams in Upper Merion?

Station No. 5 Question:
Where have you seen information on stormwater? Township newsletter, Township cable station, Township website, Public meeting, Park signage

Station No. 6 Questions:
Do you feel you know enough about how the Township manages stormwater?

Which of these services are most important to you?

How could the Township improve its stormwater program services?

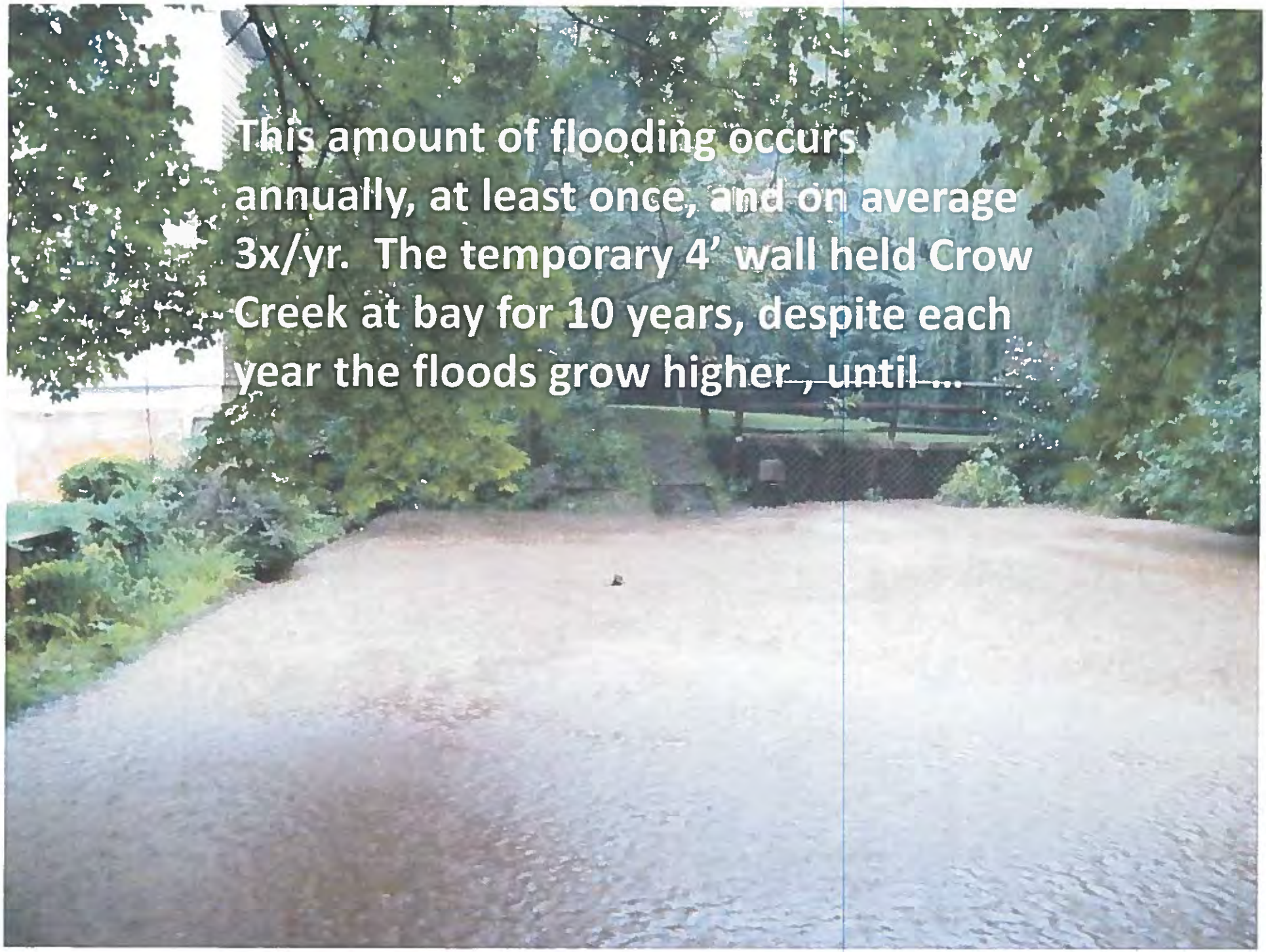
1-Clear clog on Radnor Street Road
2-De snag streams
3-manage each site plan and subdivision to implement strategic plan
4-Fill in erosion on Radnor Street Road –
5-crow Creek, especially upstream, is a priority – Tredyffrin
6-1,000 year storm
7-No major infrastructure on private property

Private dam removal
road rehab

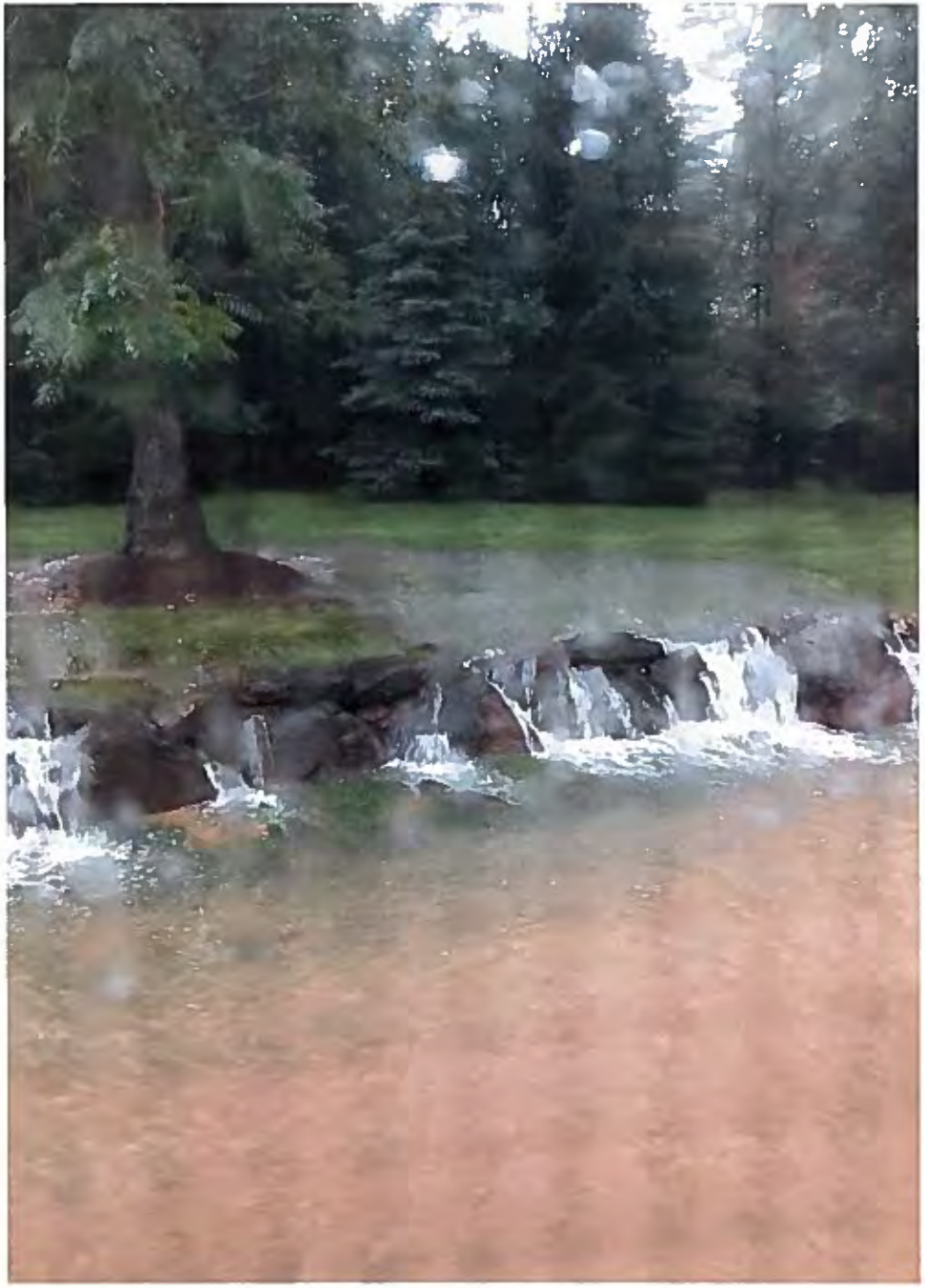
Robert Frederick
515 Spring Brook


PAUL ARNOTT
GIO 3019676
PDJARNOTT@GW
410 James St
2002 - 2007
Sealed Garages
Crow Creek


410 James St
2007 - Present
Garages still sealed, open for work, then sealed again for flood protection. Cars never parked inside
4' High Temporary Flood Wall around lower driveway, permitted construction 2007.


This amount of flooding occurs annually, at least once, and on average 3x/yr. The temporary 4' wall held Crow Creek at bay for 10 years, despite each year the floods grow higher, until ...


It was no longer good enough. Over 5' of water entered through garage into basement, destroying everything.
August 13, 2017



Public Open House – Stormwater Management Program / Study

FOR THE

UPPER MERION SANITARY AND STORMWATER AUTHORITY

EVENT DATE: September 24, 2018 at 6:00 p.m.

Response Form

Attendee Name	Mailing Address	Phone Number	Email Address
Greg Shorter	351 Trillium Lane	215-669 8328	greg@shorter.net

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Station No. 2 Question:
What do you think are the greatest sources of runoff and pollution flowing to streams in Upper Merion?

Station No. 5 Question:
Where have you seen information on stormwater? Township newsletter, Township cable station, Township website, Public meeting, Park signage

Station No. 6 Questions:
Do you feel you know enough about how the Township manages stormwater?

Which of these services are most important to you?

How could the Township improve its stormwater program services?
WATER COMES ACROSS CROTIN RD - & BEHIND HOUSES
A SHORT SODE CURB 4 YRS AGO WAS PUT IN ON THE DOWNSIDE OF CROTIN
BETWEEN TRILLIUM & CATHWOOD - DOES NOTHING IN A HEAVY RAIN

Public Open House – Stormwater Management Program / Study

FOR THE

UPPER MERION SANITARY AND STORMWATER AUTHORITY

EVENT DATE: September 24, 2018 at 6:00 p.m.

Response Form

Attendee Name	Mailing Address	Phone Number	Email Address
Paul McNulty	BNY Mellon 240 Greenwich St - 7E New York NY 10286	212-815-4939	Paul.McNulty@BNYmellon.com

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Station No. 2 Question:

What do you think are the greatest sources of runoff and pollution flowing to streams in Upper Merion?

① New / overdevelopment related to parking lots, roofs, etc.

② lack of coordination between new development & existing stormwater infrastructure

Station No. 5 Question:

Where have you seen information on stormwater? Township newsletter, Township cable station, Township website, Public meeting, Park signage

web sit & experiance related to storm events

Station No. 6 Questions:

Do you feel you know enough about how the Township manages stormwater?

ND Need more info on stormwater plans and improvements

Which of these services are most important to you?

Improvements, maintenadce, cost, taxes

How could the Township improve its stormwater program services?

Invest in upgrades to infra structure. Incorporate storm wate plans / improvements to new developments.

BNY mellon has a facility at 760 Moores Road King of Prussia flooding has become more frequent and more intense over the past few years.

Appendix H – Supplemental Analysis

Appendix H – Supplemental Analysis

Submitted to:

Upper Merion Township, Montgomery County



Supplemental Analysis
for
TOWNSHIP-WIDE
STORMWATER MANAGEMENT PLAN

May 2019

Submitted by:

Gannett Fleming

*Excellence Delivered **As Promised***

ISO 9001:2015 CERTIFIED

Appendices

Watershed A

Modeling Results

1. Minor expansion of flooding extents (aerial) mostly in area north of B Street (for 10yr vs. 25yr) and fringe of area that is now below Fed-Ex facility. Channel from Horizon Drive towards Flint Hill Road largely unchanged between two modeled events.
2. Likely the Fed-Ex stormwater management basins (which are not in the model) may alter (lessen) the extent of flooding through over control of discharge.
3. Large (existing) stormwater management basin at intersection of Flint Hill Road and Viking Road likely to provide attenuation of flooding before it encroaches on Flint Hill Road. Basin not built into HEC-RAS modeling (aside from terrain of depression).
4. Flooding slightly expanded in 25yr event in Swedeland Park. Benefits of project to lessen B Street flooding or lessen park land flooding not perceived to be high "return on investment" due to low impacts (area flooding is passive and/or wooded).

New / Revised Projects from 25-year analysis;

- ✓ (141) Upsize of Swedeland Park Culvert from single 48" culvert to dual 48" culverts. Would lessen increased flooding within upper portions of park.


Watershed A
N
Known Flooding Areas
Modeled Flooding Areas
Existing 10-yr Flood Zone
Existing 25-yr Flood Zone
Glennie Circle
Hertzog Blvd
Flint Hill Rd
Schuylkill River Rd
Williamsburg Way
Brentwood Ct
Summit St
Horizon Dr
Renaissance Blvd
B St
A St
bing
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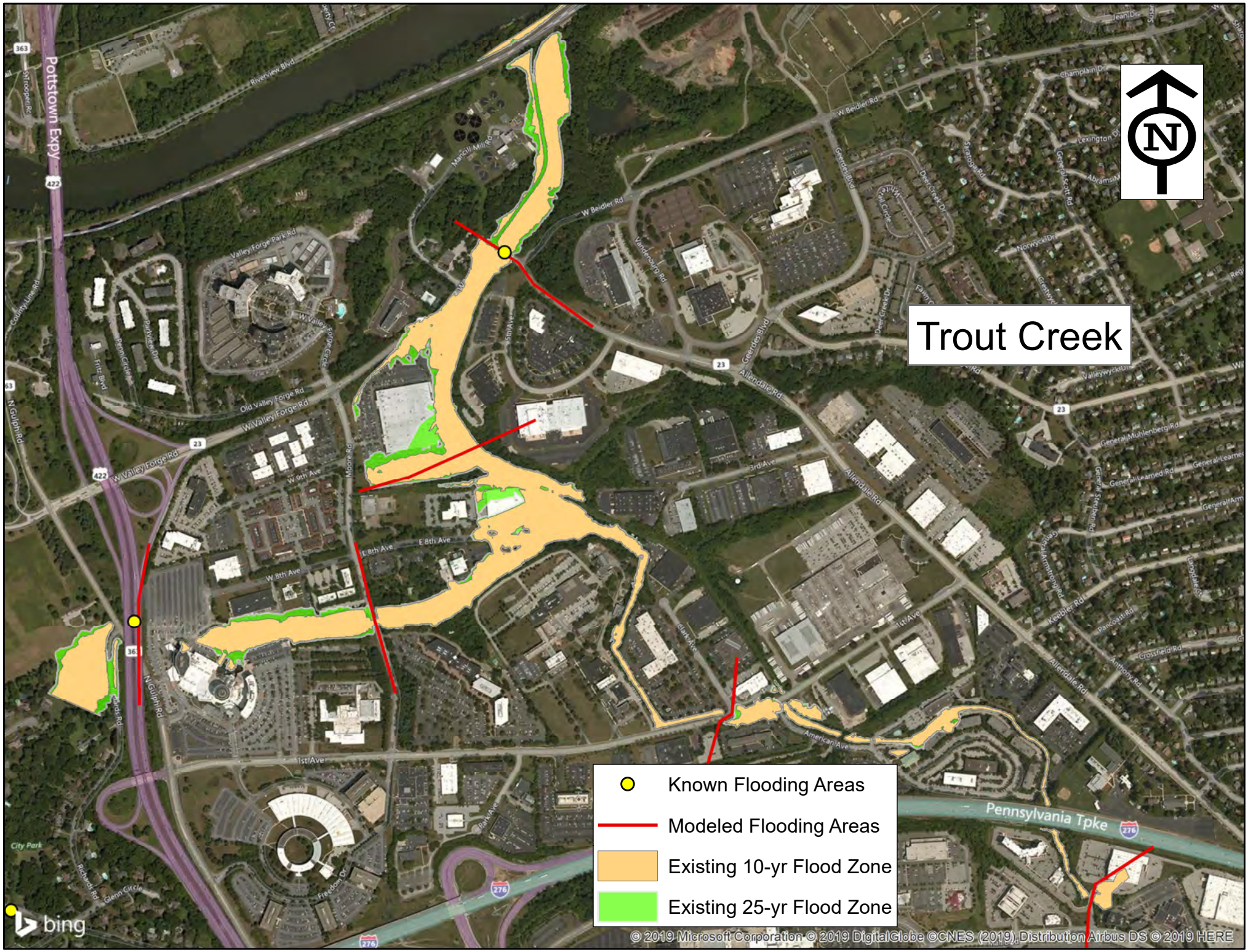
Trout Creek

Modeling Results

1. Minor expansion of flooding encroachment onto BNY building complex (for 10yr vs. 25yr).
2. Minor expansion of flooding limits south of W. 8th Ave and in area of casino.
3. Increasing culvert size under W Valley Forge Road may not alleviate flooding situations upstream. Flooding is caused by small channel capacity and severe backwater from Schuylkill River.

New / Revised Projects from 25-year analysis;

- ✓ (208) Increasing the size of the 1st Ave. culvert (to 14'x8') and adding another culvert under the American Ave. (10'x6') can reduce increased flooding between the two roads.
- ✓ (New) Increasing bridge span for Moore Rd crossing (by 20 feet) would further decrease upstream flood depth by approximately 1.7 feet but the number roads and structures impacted by flood (in 25-year event) would not change significantly (thereby offsetting the value of project).


Trout Creek
N
Known Flooding Areas
Modeled Flooding Areas
Existing 10-yr Flood Zone
Existing 25-yr Flood Zone
Pottstown Expy
W Beidler Rd
Allendale Rd
W Valley Forge Rd
Old Valley Forge Rd
Valley Forge Park Rd
Riverview Blvd
Geerdes Blvd
Vandenburg Rd
Moore Rd
N Gulph Rd
E 8th Ave
W 8th Ave
3rd Ave
1st Ave
American Ave
Pennsylvania Tpke
City Park
bing
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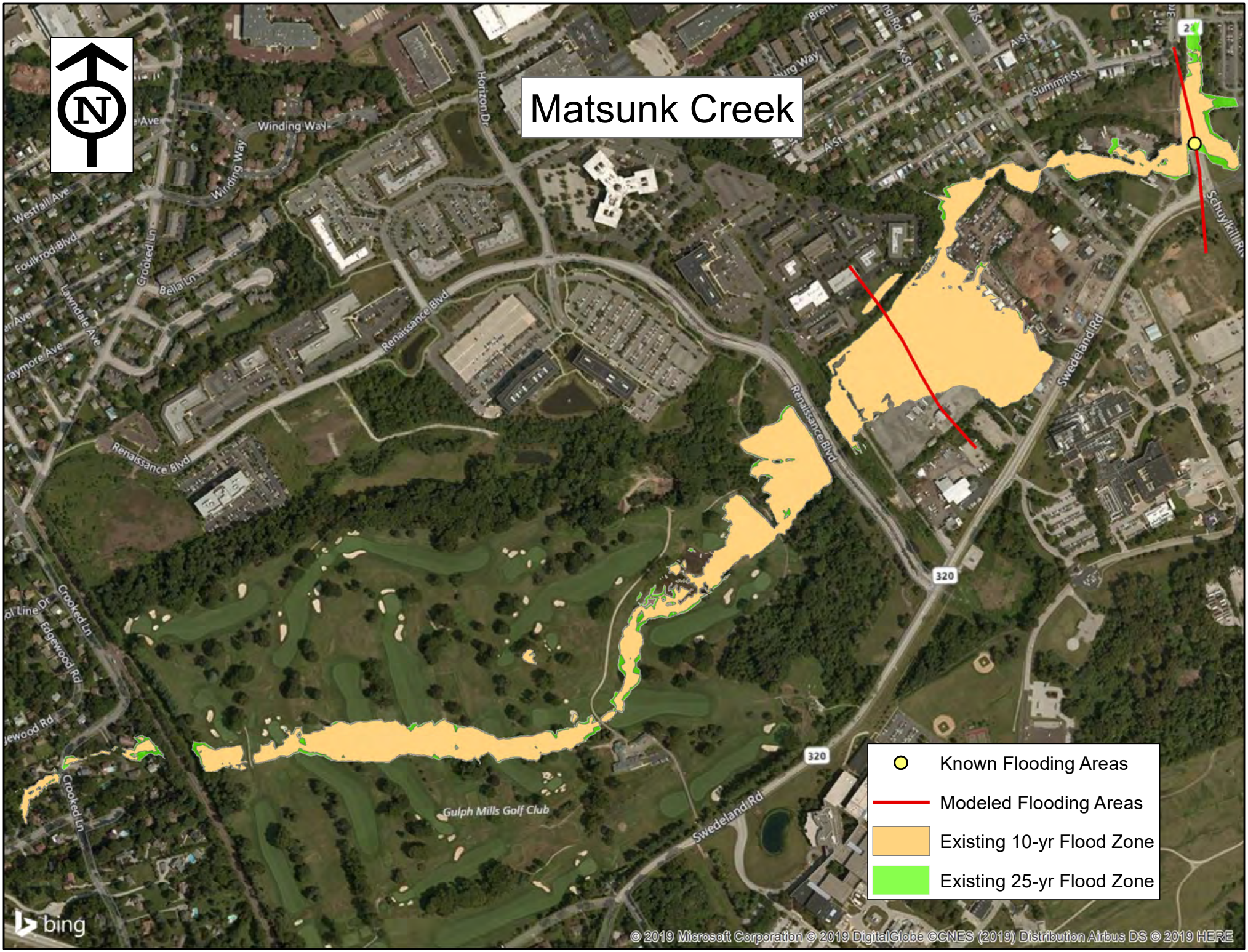
Matsunk Creek

Modeling Results

1. Very minor expansion of flooding limits (for 10yr vs. 25yr). Slight variations in the area near the golf course and at Route 23 (Schuylkill Road) where road and adjacent areas appear to be under increased risk for flooding in larger storm event.

New / Revised Projects from 25-year analysis;

- ✓ With limited changes to flooding limits, no new projects from those previously proposed for 10 year.


Matsunk Creek
N
Known Flooding Areas
Modeled Flooding Areas
Existing 10-yr Flood Zone
Existing 25-yr Flood Zone
Gulph Mills Golf Club
Renaissance Blvd
Swedeland Rd
Crooked Ln
Winding Way
Horizon Dr
Summit St
Schuylkill R
Westfall Ave
Foulkrod Blvd
Bella Ln
Lawndale Ave
Edgewood Rd
320
bing
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Gulph Mill Creek

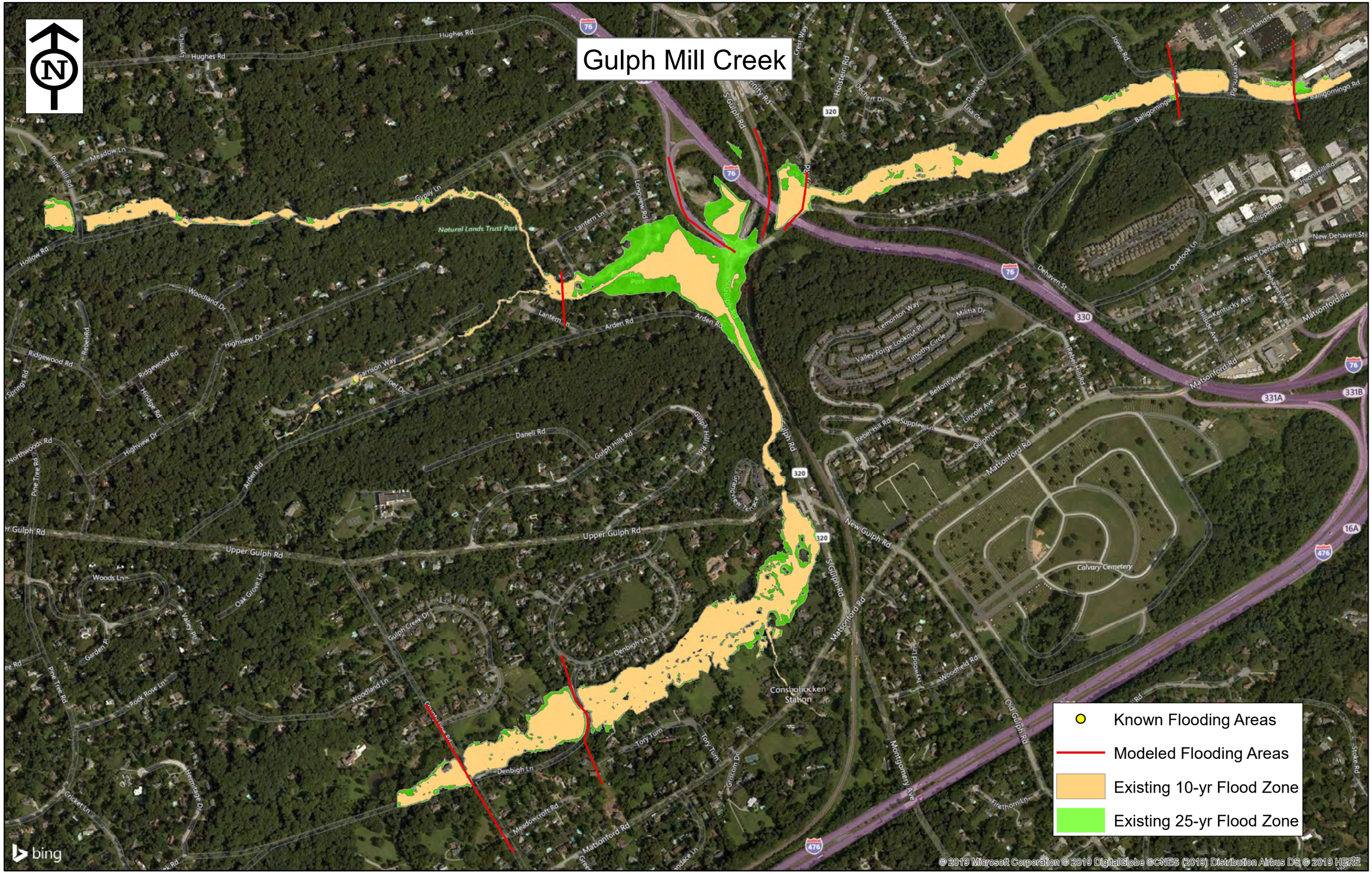
Modeling Results

1. Most significant expansion of aerial flooding limits (for 10yr vs. 25yr) in the area bounded by Longview Road, South Gulph Road and north of Arden Road. Occurs in and near a confluence of waterways.
2. Flooding limits in area between South Gulph Road and County Line Road (last section in model reach) generally the same in both 10yr and 25yr events, with most variation observed nearer to South Gulph Road.
3. Flooding on SR 320 is caused by low ground. Increasing embankment height may reduce flooding on the road.
4. Flooding behind Upper Gulph Road is because small channel capacity. It does not appear to be caused by limited culvert capacity.

New / Revised Projects from 25-year analysis;

- ✓ (161) Replacing arch with larger box culvert (15'x30') under the railroad and the South Gulph Rd will significantly reduce increased upstream flooding. Downstream flood risks will largely remain unchanged. Railroad improvements not generally accepted as viable option due to ownership issues. Previous analysis (10yr) focused on only adding inlets and pipes to better convey runoff.

Gulph Mill Creek



Frog Run

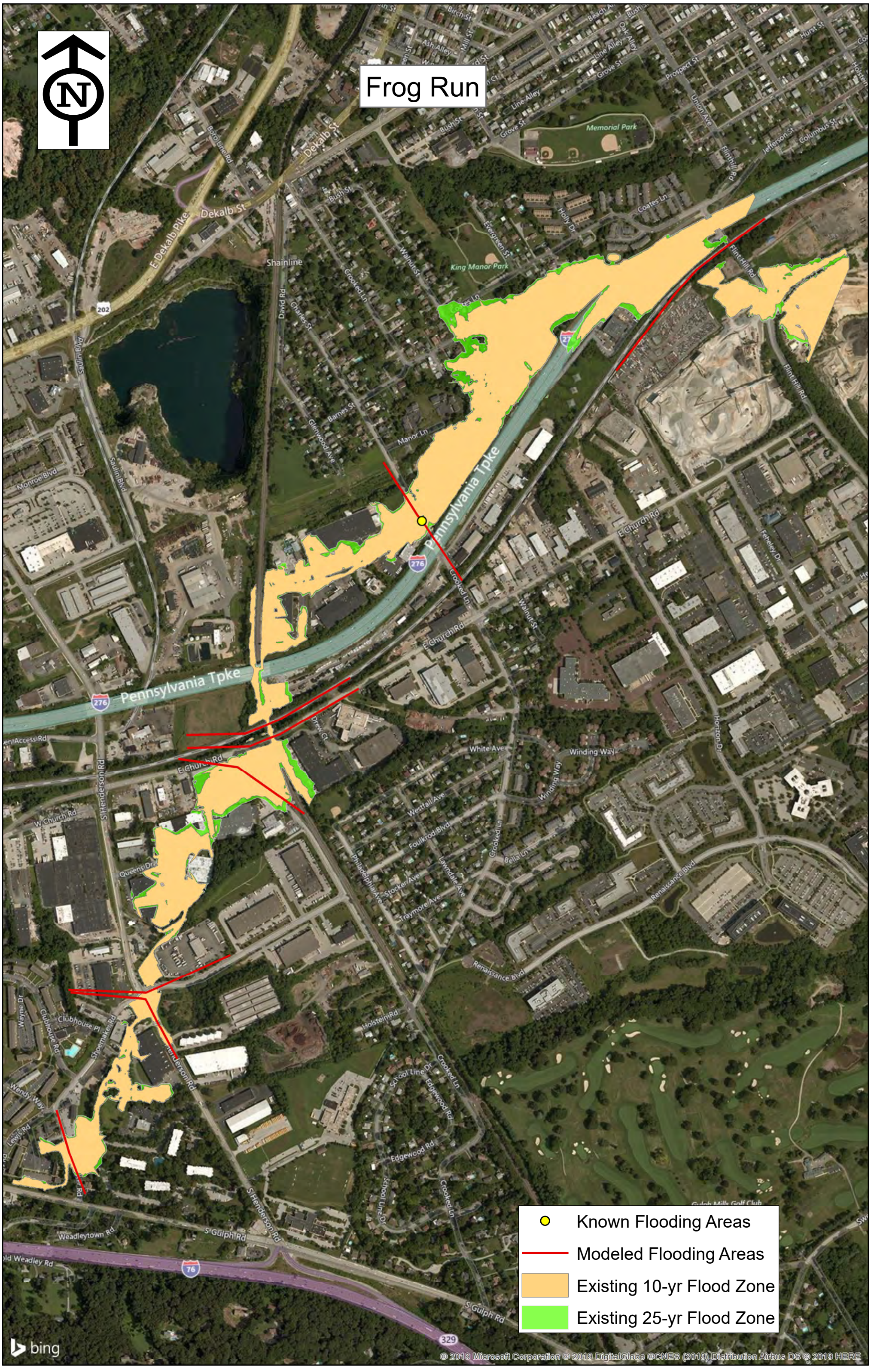
Modeling Results

1. Terrain files used in modeling do not represent the Turnpike road elevations and would likely "remove" any portion of the anticipated flooding limits.
2. Most significant expansion of aerial flooding limits (for 10yr vs. 25yr) in the area southeast of Coates Lane southwest of King Manor Park.
3. Doubling the size of the culvert south of Manor Lane may not significantly change the existing flooding condition.
4. Doubling the size of the culvert at Queens Drive may not significantly change the existing flooding condition in either flooding event.

New / Revised Projects from 25-year analysis;

- ✓ (172) Increasing culvert size under the railroad from an 10' by 10' arch to a 12' by 16' box may reduce upstream flooding up to Crooked Ln. Flooding is caused by small channel capacity and severe backwater effect from Schuylkill River. Railroad improvements not generally accepted as viable option due to ownership issue(s). Flooding on Yerkes Road appears to be caused by a backwater effect, likely caused by the downstream railroad culvert, small channel capacity, and low-lying ground. It is offered that even if the downstream culvert under the railroad is increased (to eliminate backwater) elevating the road may not be an effective means of mitigating flooding.
- ✓ (172) Increasing the culvert size under East Church Rd and under the railroad (to a 20'x20' box) would reduce upstream flood depth and inundation boundary. However, the number of impacted buildings will not decrease, and railroad improvements not generally accepted as viable option due to ownership issue(s).

Frog Run


Known Flooding Areas
Modeled Flooding Areas
Existing 10-yr Flood Zone
Existing 25-yr Flood Zone
Memorial Park
King Manor Park
Shainline
Dekalb St
E Dekalb Pike
Bush St
Grove St
Line Alley
Oak Alley
Ash Alley
Birch St
Mill St
Prospect St
Union Ave
Hurst St
Jefferson St
Columbus St
Elmhill Rd
Holly Dr
Coates Ln
Evergreen St
Walnut St
Crooked Ln
Charles St
David Rd
Barnes St
Glenwood Ave
Manor Ln
Flint Hill Rd
Saulin Blvd
Monroe Blvd
202
Pennsylvania Tpke
276
E Church Rd
Drew Ct
White Ave
Winding Way
Westfall Ave
Foulkrod Blvd
Philadelphia Ave
Stocker Ave
Lawndale Ave
Traymore Ave
Bella Ln
Renaissance Blvd
Horizon Dr
Fetherley Dr
S Henderson Rd
W Church Rd
Queens Dr
Clubhouse Pl
Clubhouse Rd
Shoemaker Rd
Wayne Dr
Wendy Way
Lewis Rd
Holstein Rd
School Line Dr
Edgewood Rd
Weadleytown Rd
S Gulph Rd
76
329
bing
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Crow Creek

Modeling Results

1. Most significant expansion of aerial flooding limits (for 10yr vs. 25yr) in the area of the KOP mall and immediately downstream (south of Route 276). Flooding in this area is more appropriately controlled by the mall (rather than Township led capital improvements drainage project).
2. Slight increases (along perimeter of flooding limits were noted near Crossfield Road, north of Keebler Road, West Valley Forge Road and along creek (parallel to Hidden Valley Road).
3. Flooding at Abrams Road due to backwater effect from Schuylkill River. Recent flooding damaged that was repaired appears to have been focused on addressing upstream inlet damaged and channel stabilization but did not increase or modify culvert sizing.
4. Flooding on West Valley Forge Road not likely mitigated by increased culvert size, as flooding over roadway appears to be caused by low lying ground.
5. Area of flooding in cemetery increases for the 25yr event along south to northeastern boundary, and southwest boundary. While improvements continue to be an option, there is a concern that even if the railroad owner allowed a culvert to be expanded (to 8x6 ft box), the increased opening would likely allow larger volume of water to adversely impact downstream areas.

New / Revised Projects from 25-year analysis;

- ✓ (2) Increasing culvert size under Keebler Road (where the 25yr event shows some increased limits north and west of culvert location) could help to lessen flood depth (approx. 0.5 feet) but upstream area likely to remain flooded in either event due to topography of low ground and lack of adequate channel capacity.
- ✓ (New) Increasing culvert size (to 10x45 box) under West Beidler Road could have adverse collateral impacts by allowing the passage of upstream floodwaters, which appears by the model, to increase the degree of encroachment of floodwaters on downstream properties (e.g., rear yard of residences on Hamlet Drive and the Abrams Road Pump Station).
- ✓ (New) With refined 25yr analysis, it was observed that the primary issue in watershed seems to be inadequate channel capacity between Tannery Drive and Croton Road. Larger culverts under Croton effectiveness may be limited by restriction of channel downstream. Increasing culvert sizes (as noted in 2018 study) must be tied together with improvements and stabilization of connecting channel as well.

Crow Creek

Known Flooding Areas

Modeled Flooding Areas

Existing 10-yr Flood Zone

Existing 25-yr Flood Zone

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Abrams Creek

Modeling Results

1. There was some observed expansion of flooding limits (for 10yr vs. 25yr) in the area of the railroad tracks (both upstream and downstream of the existing culvert).

New / Revised Projects from 25-year analysis;

- ✓ Flooding in this area is minor in nature for both modeled events and no additional improvements were required / considered.


N
Abrams Creek
E Beidler Rd
Roy Rd
Brownlie Rd
Brownlie Rd
Redwood Rd
Brownlie Rd
Avon Rd
Lowell Te
Colmar Dr
Known Flooding Areas
Existing 10-yr Flood Zone
Existing 25-yr Flood Zone
bing
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Appendix A
Upper Merion Township
List of Recommendations

Project Type	LabelID	MapSheet	Number of Sources	1995 Study	2017 Model	Public Survey	EMA Staff	Problem	Recommendations	Notes	Estimated Cost (10-year Storm)	Estimated Cost (25-year Storm)
C	105	6	4	Yes	Yes	Yes	Yes	Insufficient Culvert Capacity on Croton Road near Elementary School	Install a 2'x20' box culvert, adjust road alignment (vertical) and adjust stream banks accordingly.	Must be tied to improvements on Tannery Drive.	$ 850,000.00	
C	95	5	1		Yes			Flooding of Tannery Drive	Improve inlet and outlet conditions, stabilize channel banks, maintenance of culvert barrel(s).	This area was observed by results of study and staff.	$ 200,000.00	**$ 1,930,000.00**
	105/95							**Insufficient Culvert Capacity on Croton Road near Elementary School & flooding of Tannery Drive**	**Croton Road culvert must be increased as noted above in conjunction with Tannery Drive work AND adding a connecting channel**	**Includes cost of (105) and (95) 10-year storm recommendations. Effectiveness of larger culverts under Croton may be limited by restriction of channel downstream.**	-	
D	160	7	2	Yes			Yes	Erosion and property flooding between 947 & 961 Trinity road	Stabilize channel; culvert maintenance; larger culvert under SEPTA tracks	Authorization by SEPTA to adjust drainage structures reduces viability of project	$ 20,000.00	$ 20,000.00
E	147	7	4	Yes	Yes	Yes	Yes	Trinity Road - Bridge overtopping, sedimentation, and standing water	Berm to prevent overflow to low point on Ballimingo Road; Replace stone arch with 2 - 11'x8' RCB and evaluate possible need for storage BMP.	Twp. resists replacing Stone arch for historical landmark reasons, need alternate plan	$ 700,000.00	$ 700,000.00
A	36	3	3	Yes		Yes	Yes	Abrams Road Bridge overtopping	Increase Roadway Elevation; grade swale to drain north side of road; improve channel alignment.		$ 100,000.00	$ 100,000.00
A	232	7	1				Yes	Flooding of River Road	Clean out storm water facilities in area. If nothing found, increasing size of culvert should be investigated		$ 360,000.00	$ 360,000.00
E	203	2	2		Yes		Yes	Low ground on Richards Road near N Gulph Road	Install Culvert of adequate size. Elevation of Richards Road just above 10-year floodplain according to model. Can construct levee on west side (2 feet high, approximately 600 feet long)of Richards Road to prevent future flooding of Richards road.	Close proximity to Tref. Twp. reduces priority of this project.	$ 860,000.00	$ 860,000.00
A	161	7	2	Yes			Yes	Street flooding - South Gulph Road	Add inlets and pipes under road to stream		$ 130,000.00	$ 130,000.00
	161	**7**						**Street flooding - South Gulph Road (25-year storm)**	**Replace arch with larger box culvert (15'x30') under the railroad and South Gulph Road**	**Railroad improvements not generally accepted as viable option due to ownership issue(s).**	-	**$ 5,200,000.00**
E	229	4	1				Yes	Flooding of River Road near and at underpass of I-276	Construct channel on west side of road. No current stormwater facility in area.		$ 20,000.00	$ 20,000.00
B	135	7	2	Yes			Yes	Street flooding on B Street and Rt. 23	Add 27" pipe under B Street		$ 140,000.00	$ 140,000.00
B	211	5	1				Yes	Flooding on N Gulph Road near I-76 underpass	Clean out storm water facilities in area. If nothing found, increasing size of culvert should be investigated		$ 10,000.00	$ 10,000.00
A	44	3	3	Yes	Yes		Yes	Low Ground at Walker Park	Install levee along east creek bank 2,200 feet from 134 to 125 feet elevation (approximately 5 feet above existing elevation).	Improvements here could push flooding to other less desirable areas	$ 110,000.00	$ 110,000.00
B	127	7	3	Yes	Yes		Yes	Road flooding on River Road between Swedeland Road and 3rd Street	Due to creek dropping elevation prior to River Road, the high velocity of the creek raises the water level over the road level, culvert work alone would not solve issue, would need a detention basin to settle the water prior to culverts.		$ 160,000.00	$ 160,000.00
B	210	5	2			Yes	Yes	Flooding on Guthrie Road	Further investigation Required		N/A	
	74	3	2	Yes			Yes	Flooding on East Valley Forge Road	Inlet Maintenance / Modifications		$ 3,000.00	$ 3,000.00
C	172	6	2	Yes	Yes		Yes	Yerkes and Church Roads - Overtopping due to backwater from railroad and Church Road culverts	Replace culverts under Church Rd and RR Tracks with 5.5' x 26' RCB; replace Yerkes Rd culvert with 4.5' x 27' RCV, increase Yerkes Rd elevation 2 feet; Project is likely more conveyance in nature since the end of line is the existing Quarry (which could receive/control the volume). There is little room in the upper watershed to place any large scale detention facilities.		$ 2,130,000.00	$ 2,130,000.00
	172	**6**						**Yerkes and Church Roads - Overtopping due to backwater from railroad and Church Road culverts (25-year storm)**	**Increase culvert size under railroad from 10'x10' arch to a 12'x16' box. Increase culvert size under East Church Rd and under the railroad to a 20'x20' box.**	**Railroad improvements not generally accepted as viable option due to ownership issue(s).**	-	**$ 1,600,000.00**
C	179	4	3	Yes	Yes		Yes	Crooked Lane Overtopping	Replace with 6'x13' box culvert		$ 1,010,000.00	$ 1,010,000.00
D	188	6	2	Yes			Yes	Hughes Park - Street Flooding	Add inlets and piping at Traymore and Schenley, and Traymore and Philadelphia; inlet maintenance		$ 60,000.00	$ 60,000.00

A	208	2	2		Yes		Yes	Insufficient Culvert Capacity under 1st Street and American Avenue	Increase culverts size on 1st Avenue and American Avenue to 20' x 8'		$ 1,800,000.00	$ 1,800,000.00
A	221	3	3		Yes	Yes	Yes	Low ground in Fire Company parking lot.	Install levee along north stream bank to protect King of Prussia Fire Company building and parking lot (approx. 450 feet at elevation of 143)	Priority is given due to EMS need to access facility. Pushing runoff with levee could impact other sites adversely.	$ 22,000.00	$ 22,000.00
	2	3	2	Yes			Yes	Property and street flooding on Keebler Road	Replace with 54" pipe under Keebler Road, 48" pipe under Springhouse Road		$ 220,000.00	$ 220,000.00
	2	**3**						**Property and street flooding on Keebler Road (25-year storm)**	**Increase culvert size under Keebler Road**	**Upstream area likely to remain flooded in either event dur to topography of low ground and lack of adequate channel capacity**	**-**	**$ 2,730,000.00**
									Increase culvert size to 10' x 45' under West Beidler Road		**-**	**$ 2,800,000.00**
B	17	3	2	Yes			Yes	Property and Regimental Road flooding near Caley Road	Conduct Inlet maintenance; Grade swale and add inlets between Regiment and West Valley Forge/Covered Bridge Road; Property grading to convey flows to existing inlets along Regimental Road between every home.	The school is in the process of rebuilding and new SWM regulations may reduce this flooding.	$ 110,000.00	$ 110,000.00
C	89	6	3	Yes	Yes		Yes	Insufficient Culvert Capacity causing flooding on South Gulph Road and Church Road.	Increase culvert on Croton Road to 18'x6' box culvert, increase culvert on Gulph Road to 25' x 6' box culvert, adjust stream banks accordingly.	By field review, opening up culvert could push large volume of water into neighborhood. Study should focus on possible detainment in memorial site.	$ 770,000.00	$ 770,000.00
E	152	8	2	Yes	Yes		Yes	South County Line Road - Culvert overtopping	Replace 2 - 5' x 15' RCB		$ 1,310,000.00	$ 1,310,000.00
A	235	7	3		Yes	Yes	Yes	Bridge overtopping	Elevate the Jones Road bridge 2 feet	Project expected to be costly.	$ 600,000.00	$ 600,000.00
A	86	6	2	Yes	Yes			Intersection flooding at Colonial and Powderhorn	Replace 18" & 21" pipes with 24" & 30" pipes		$ 20,000.00	$ 20,000.00
D	124	2	2	Yes	Yes			Insufficient Culvert Capacity, low road elevation on W Valley Forge Road from Mancill Mill Road to Trout Creek bridge.	Elevate W Valley Forge Road from the Bridge to approximately 1,000 feet southwest of the bridge. This includes raising the bridge 2 feet and conducting some stream work before the bridge.		$ 870,000.00	$ 870,000.00
B	130	7	2	Yes	Yes			Culvert undersized	Add second 48" pipe to Existing Culvert, add 26 ac/ft. detention basin in lower end of golf course. Note our model does not include a 48" under parking lot, but a swale between properties.		$ 490,000.00	$ 490,000.00
D	141	7	2	Yes	Yes			Intersection 3rd Street and Rt. 23 - street flooding, deep water at culvert near park	Regrade swale further to west side of road; add inlet and a 72" pipe prior to Route 23 and add second 48" pipe under Route 23	Anticipated low priority with lack of residential area nearby.	$ 60,000.00	$ 60,000.00
B	144	7	2	Yes	Yes			Flooding on B Street, erosion and debris build-up upstream of B Street	Add second 48" pipe if all downstream pipes are dual 48" or single 72"		$ 340,000.00	$ 340,000.00
	156	7	2	Yes	Yes			Stream Erosion, deposition and flooding of properties from Garrison to Longview	Construct Detention Basin south of Gypsy Ln		$ 280,000.00	$ 280,000.00
B	170	6	2	Yes	Yes			South Henderson Road/Shoemaker Road - Culvert overtopping/Street Flooding	Replace Ex. Culvert with 4.5'x15.5' Box Culvert	No field investigation, Google Earth data shows modifications to the region potentially resulting in improvements of the SWM conditions.	$ 1,180,000.00	$ 1,180,000.00
										TOTAL:	**$ 14,935,000.00**	**$ 28,145,000.00**

A Project type is valid as a stand alone project, whose benefit must be evaluated by the Authority.

B Project type where adjacent large scale development project may have significantly altered the topography of the land and included various BMP practices that could have altered perceived (prior) flooding. Given the scale of the watershed modeling effort, additional (more refined) modeling analysis would be required to fully evaluate the effectiveness of the improvements and the potential mitigation of any flooding.

C Project type where improvements for this item are inherently "connected" to another project area and must be completed in conjunction with one another in order to avoid creating augmented flooding by only partially addressing.

D Project type is not a high priority given relatively low return on investment (i.e., investment on this project will reduce flooding, but with limited benefits to the residents.)

E Project type where perceived improvements is a low priority given proximity to adjacent municipality (where either runoff originates or where flooding impacts are observed).