



Post Construction Stormwater Management Report

Project: Proposed Wawa Food Market
Route 30 (Lancaster Ave.) & Aberdeen Ave.
Radnor Township
Delaware County, Pennsylvania

Client: Wayne Property Acquisition, Inc.
1747 Spring House Road
Chester Springs, PA 19425

Project Number: PC181016

Dated: July 13, 2018
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General Project Description/Stormwater Management

GENERAL PROJECT DESCRIPTION

Wayne Property Acquisition Inc. proposes to develop the properties located at the southeast corner of East Lancaster Avenue and Aberdeen Avenue (Folio #36-03-01682-00 & Folio #36-03-01683-00) in Radnor Township, Delaware County into a 4,736 SF retail Wawa store (5,124 SF including retail store canopies) with retail sale of gas consisting of six (6) MPDs (multi-product dispensers), along with associated access, parking, lighting, landscaping, utility connections, and stormwater management controls necessary to support the site. This development proposes to replace the two (2) existing retail gas stores with retail gas (Sunoco and BP; currently a motor vehicle repair shop (Sunoco) and car wash (BP)), which consist of two (2) buildings totaling 4,230 SF with eleven (11) existing MPDs. As part of the application, the project proposes to consolidate the two (2) properties. The consolidated property will remain under the ownership of the Applicant and/or its successors.

The proposed Wawa convenience store constructed on site will consist of one (1) 1-story 4,736 square foot building and six multiple product fueling dispensers along with on-site parking to accommodate a total of 53 parking spaces. The new building will be served by both public sanitary sewer service and public water service. Vehicular access to the property will be provided by two (2) access driveways, one (1) on Lancaster Avenue and one (1) on Aberdeen Avenue, which is a reduction from the six (6) existing access points (four (4) on Lancaster Avenue and two (2) on Aberdeen Avenue). In addition to the buildings, fueling stations, and on-site parking areas, the project includes the installation of utilities, landscaping, and stormwater management controls necessary to support the development.

General PCSM Planning and Design §102.8(b)

1. The following measures were taken to preserve the integrity of stream channels and to maintain and protect the physical, biological, and chemical qualities of the receiving stream:
 - Direct runoff from impervious surfaces including roadways to BMPs.
 - Use native species, which require less fertilization and chemical application than non-native species.
 - Maintain generally the same drainage patterns as in the existing condition
 - Perform soil amendments, which restore soil porosity through tilling and composting to improve the soil's capacity for infiltration and pollutant removal.
2. The following measures were taken to prevent an increase in the rate of storm water runoff:
 - Utilize underground managed release basin to help reduce runoff rates.
 - Minimize impervious areas where practical.
 - Maintain generally the same drainage patterns as in the existing condition
3. The following measures were taken to minimize any increase in storm water runoff volume:
 - Utilize underground managed release basin to help reduce runoff volume.
 - Provide landscape restoration to help reduce runoff volume.
 - Minimize impervious areas where practical.
 - Maintain generally the same drainage patterns as in the existing condition
 - Provide amended soils throughout the site to help reduce runoff volume.
4. The following measures were taken to minimize impervious areas:
 - Increase in pervious area within limit of disturbance by approximately 7%
 - Only provide sidewalk where required by code.
 - Maximize the number of landscaped island within the site.
5. The following measures are taken to maximize protection of existing drainage features and vegetation:
 - Access the site thru designated construction entrance.
 - Protect woodlands/existing trees with tree protection fencing.
 - Utilizing the existing conveyance system within Aberdeen Avenue
 - Maintain existing flow path to POI#2

6. The following measures were taken to minimize land clearing and grading:
 - Protect woodlands/existing trees with tree protection fencing.
 - Adjust road slope and site grading so there are no drastic proposed cuts or fills to existing grades.
 - Maintain existing grades within the site where plausible.
7. The following measures are taken to minimize soil compaction:
 - Access the site thru designated construction entrance.
 - As specified in the construction sequence, use treaded machinery where practical during earthmoving operations.
 - Grade site to minimize extent of cuts/fills.
8. the following measures were taken to utilize other structural or nonstructural BMPs that prevent or minimize changes in storm water runoff:
 - Direct runoff to an above ground storm water basin to control runoff rates.
 - Utilize underground managed release basin to help reduce runoff volume.
 - Provide landscape restoration to help reduce runoff volume.
 - Minimize impervious areas where practical.

**Types, Depth, Slope, Locations, and Limitations of the Soils and Geologic Formations
§102.8(f)(2)**

Soil Descriptions:

| Soil | Description | Soil Group |
|------|--|------------|
| Md | Made land, gabbro and diabase materials, 0 to 8 percent slopes | C |

- No geologic mapping features were identified.

Geotechnical Testing:

The Preliminary Geotechnical Investigation as prepared by Whitestone Associates, Inc. on July 25, 2017, has been included in Appendix A of this report.

As detailed in the two-page Preliminary Stormwater Management Area Evaluation letter, the Geotechnical Engineer has recommended that the site generally appears not to be conducive for infiltration design. This is the reasoning for utilizing a Managed Release Basin instead of an infiltration basin. The two-page report is included in Appendix A of this report.

An additional Geotechnical Investigation was conducted by JK Environmental on February 27, 2018 which is also included in Appendix A of this report.

**Past, Present and Proposed Land Uses and Proposed Alteration to Project Site
§102.8(f)(3)**

During the past 5 years, both existing lots have been utilized for the current use of Convenience store and fueling stations.

During the past 50 years, both existing lots have been utilized for the current use of Convenience store and fueling stations.

Geologic Formations or Soil Conditions
§102.8(f)(12)

There are no known geologic formations or soil conditions that could cause contaminant pollution during earth disturbance activities.

Potential Thermal Impacts
§102.8(f)(13)

A potential for thermal impacts exists in instances where surface runoff is directly conveyed to a receiving stream without adequate attenuation or cooling. To avoid thermal impacts, the following has been employed: underground managed release basin, amended soils, and landscape restoration. All of these measures will help to control runoff volume and rate and thereby provide additional cooling time, thereby minimizing thermal impacts to the receiving stream.

Riparian Forest Buffer Management Plan
§102.8(f)(14)

Regarding existing or proposed riparian forest buffers, note the following:

- There are no existing/proposed riparian forest buffers located within or outside the limits of disturbance for this project.
- The following impairments are listed for this portion of the Ithan Creek
 - Water/Flow Variability
 - Siltation
 - Habitat Modification
 - Pathogens

Stormwater Management

Watershed

The overall property is within the tributary area of Ithan Creek, which is tributary to Darby Creek. Darby Creek ultimately flows to the Delaware River. Ithan Creek has a Chapter 93 classification of CWF (Cold Water Fishes) & MF (Migratory Fish). The project site is located within district A of the Stormwater Management District Watershed Map.

Design Methodology

The Design Method was used in Worksheet 4 of the BMP Manual to determine the change in 2-year storm volumes which is required to be controlled on site per the Radnor Township Stormwater Management Ordinance requirements set forth in Chapter 245 and the CG-1 guidelines of the PADEP BMP Manual. The SCS Runoff Curve Number Method was used to calculate peak runoff rates and generate hydrographs for the pre and post development conditions for the Points of Interests. The computer watershed software 2018 HydroCAD Software Solutions, LLC was utilized for this analysis. The hydrographs generated for these calculations were based on the rainfall intensities from the NOAA Atlas 14, Volume 2, Version 3, Wayne, PA gauge. Actual land cover conditions, were assumed for the pre-development peak rate calculations for areas of disturbance, as detailed in the following report. In order to be compliant with §245-27.J of the Radnor Township Stormwater Management Ordinance, the stage storage volume for the underground managed release basin only includes the volume within the chambers. The stone bedding surrounding the basin was not included in the volume calculations. Management of stormwater runoff through the storage of the 2-year storm in one Managed Release Basin and corresponding outlet structure provide the necessary volume and peak rate controls along with sufficient water quality to meet Radnor Township & PADEP regulations. It is by the recommendation of the Geotechnical Engineer that the site generally appears not to be conducive for infiltration design, therefore this project is proposing to utilize a Managed Release Concept basin. In review of the

monitoring wells provided in the above-mentioned report by JK Environmental, the highest corrected groundwater elevation in the area of the proposed Managed Release Basin was determined to be 359.31', as shown in Monitoring Well table for MW-3. The invert of the proposed Managed Release basin was designed at 360.00' in order to provide 0.69' between the high-water table elevation and the invert of the basin. The landscaped areas within the limit of disturbance outside of the proposed R.O.W. will utilize amended soils for water quality mitigation.

Peak Rate Control Standards

In accordance with the Radnor Township Chapter 245-25 Stormwater Management Ordinance, the pre-development pervious condition of the site has been assumed to be actual land cover conditions, except 20% existing impervious surface being considered meadow when computing runoff coefficients for the peak rate analysis. Based on these assumptions, the development will still result in an overall decrease in runoff rates and volume. When reviewing the dewatering calculations based on the HydroCAD analysis, please note that the basin does not completely dewater in the required 192 hours. Currently the water elevation in the basin at 192 hours is 360.04' (360.00' basin bottom) and the flow is at 0.001 cfs. Due to the size of the basin foot print and unfavorable infiltration results, the basin is not completely dewatered at 192 hours. The analysis conducted for this area compares the pre-development discharge rates to the post-development discharge rates in accordance the Radnor Township Chapter 245-25 Stormwater Management Ordinance. As the site is located within the Darby Creek watershed it must follow the peak rate runoff control standards set forth in Table 408.1 of the Ordinance. The reduction requirements are as follows:

| <u>Post Development Condition</u> | | <u>Pre Development Condition</u> |
|-----------------------------------|------------|----------------------------------|
| 2-year | Reduced to | 1-year |
| 5-year | Reduced to | 5-year |
| 10-year | Reduced to | 10-year |
| 25-year | Reduced to | 25-year |
| 100-year | Reduced to | 100-year |

Pre-Development Conditions

The pre-development condition of the site consists of two (2) points of interest, which are delineated on the Pre-Development Drainage Area Plan. Stormwater runoff flows to either the existing conveyance system in Aberdeen Avenue or to the east of the existing curb line near the southeast corner of the site. The majority of the site runoff flows overland to the Aberdeen Avenue conveyance system with the exception of the small amount of runoff produced by the green area behind the curb line.

Post Development Conditions

The post-development condition of the site maintains the existing Points of Interest. The areas tributary to each POI have been delineated on the Pre and Post-Development Drainage Area Plans and hydrographs have been generated for the 1, 2, 5, 10, 25, and 100-year storms. The proposed Managed Release Concept basin has been utilized to manage a portion of the runoff within the proposed limit of disturbance. The calculations indicate that the design proposes to decrease the peak flow rates to the points of interest in accordance with the Radnor Township Chapter 245-25 Stormwater Management Ordinance peak rate design requirements listed above. State water quality requirements are addressed by the Managed Release Basin along with the utilization of amended soils in the disturbed lawn areas.

Alternatives Analysis of PCSM BMPs

In a review of the volume reducing BMPs to consider if any other method was feasible the following considerations and constraints were evaluated:

Structural BMPs

1. Infiltration Testing completed in the Limit of Disturbance came back unfavorable due to high ground water.
 - a. For these reasons no Infiltration BMPs are feasible (BMPs 6.4.1 – 6.4.10)

2. Due to the delta 2-yr volume of approx. 2,000 cuft., it is not feasible to provide the entire amount of storage within a vegetated roof. The extensive cost to provide the roof structure and the ability to make a vegetated roof accessible through the proposed buildings also render this BMP infeasible (BMP 6.5.1)
3. Also due to the delta 2-yr volume of approx. 2,000 cuft., it is not feasible to provide the entire amount of storage within a capture and re-use system since the area needed to dewater within 7 days exceed the amount of non-basin landscape area available on site (BMP 6.5.2)

All Volume BMPs (6.4.1 – 6.4-10 and 6.5.1-2) have been analysis and deemed not feasible for this project, therefore requiring the design to utilize Managed Release Concept for management of the delta 2yr storm.

Non-Structural BMPs

4. BMP 5.4.1. Protect Sensitive/Special Value Features, is not feasible to account for up to 25% of the required volume because areas must be protected and undisturbed which is not possible in the Limit of Disturbance due to the improvements proposed.
5. BMP 5.4.2, Protect/Conserve/Enhance Riparian Areas, is not feasible to account for up to 25% of the required volume because there are no riparian areas located within the limit of disturbance.
6. BMP 5.4.3, Protect/Utilize Natural Flow Pathways in Overall Stormwater Planning and Design, is not feasible to account for up to 25% of the required volume because the natural flow pathway (Aberdeen Avenue conveyance system) is located outside the limit of disturbance.
7. BMP 5.6.1, Minimized Total Disturbed Area, is not feasible to account for up to 25% of the required volume because Chapter 8 states that areas must be protected and undisturbed which is not possible in the Limit of Disturbance due to the improvements proposed.
8. BMP 5.6.2, Minimize Soil Compaction in Disturbed Areas, is not feasible to account for up to 25% of the required volume because areas where minimum soil compaction occurs is already being account for with the proposed amended soils volume credit.
9. Non-Structural BMP 5.6.3 Revegetate and Reforest disturbed areas are not feasible to account for up to 25% of the required volume as a majority of the site sees a reduce in existing tree cover versus proposed tree cover and cannot utilize the revegetate/reforest volume credit.
10. BMP 5.7.1, 5.7.2 are not feasible to account for up to 25% of the required volume because they do not have any quantifiable volume reduction credit detailed in Chapter 8 of the PADEP BMP Manual. Parking and Street areas have been reduced as much as possible to still make the proposed use plausible.

All Non-Structural BMPs, except 5.6.3, 5.8.1, and 5.8.2 (5.4.1 – 5.7.2) have been analysis and deemed not feasible to account for up to 25% of the required volume for this project. therefore, requiring the design to utilize Managed Release Concept for management of the delta 2-yr storm.

Storm Drainage

The storm drainage system has been designed to intercept runoff at topographic low points and areas of significant runoff quantities and convey stormwater to the proposed Managed Release Concept basin. Conveyance design precipitation amounts are based on the rainfall intensities specified within the Radnor Township Chapter 245-25 Stormwater Management Ordinance for the 25-year storm event. Bentley StormCAD V8i has been utilized for the design of the storm conveyance system. The proposed stormwater management program described within this report has been designed to comply with the Radnor Township Chapter 245-25 Stormwater Management Ordinance

The storm drainage system consists of inlets placed within paved areas to capture runoff in order to minimize flows to both points of interest. Runoff is then conveyed to the Managed Release Concept basin which then outlets to the existing conveyance system in Aberdeen Avenue. Amended soils have also been provided in the disturbed landscape areas to provide water quality mitigation.

Radnor Township Water Quality Volume

Per §245-23(D)(1) of the Radnor Township Stormwater Management code 1,692.1 cubic feet of water quality volume is required (WQv). This volume was obtained from the equation in §245-23(D)(1) of $WQv = [(P)(Rv)(A)]/12$ where P=1” of rainfall, A= 0.51 acres of flow to the Water Quality BMP (Managed Release Basin), and Rv= 0.05+0.009(96) or 0.914 based upon 96% of the drainage area to the Water Quality BMP being impervious.

Post Construction Stormwater Management BMP's

Stormwater Management Facilities - The proposed Managed Release Concept basin is maintained to meet the volume and peak rate reduction requirements of the Radnor Township Chapter 245-25 Stormwater Management Ordinance, as well as the State water quality requirements.

Managed Release Concept (MRC) is a post-construction stormwater management (PCSM) strategy that involves the collection, storage, and filtration of captured runoff through a best management practice (BMP) that is preferably vegetated and includes a release of a portion of the captured runoff through an underdrain within the BMP, or from a pool protected from solar radiation. If the MRC BMP is not vegetated, then pretreatment is required to meet water quality requirements. The MRC is intended to be used for project areas or subareas where infiltration is not feasible to meet regulatory requirements under § 102.8(g)(2).

6.6.4-Water Quality Filters & Hydrodynamic Devices - These structural BMPs vary in size and function, but utilize some form of settling and filtration to remove particulate pollutants from stormwater runoff. Commercially available water quality filters, catch basin inserts, and hydrodynamic devices are generally configured to remove particulate contaminants, including coarse sediment, oil and grease, and debris. Water Quality Inlets are commonly used as pretreatment BMPs and can provide “hotspot” control by reducing sediment loads to infiltration devices. Hydrodynamic Devices are not truly inserts, but separate flow through devices designed to serve in concert with inlets and storm sewer. Ideally, the flow through the device should remove litter, oil, sediment, heavy metals, dissolved, solids, and nutrients. Clays and fine silts do not easily settle out unless they are coagulated with some kind of chemical addition or polymer.

6.7.2-Landscape Restoration - Landscape Restoration is an effective method of reducing runoff volume and rate, as well as significant nonpoint source load reduction/prevention. This BMP includes the restoration of forest and/or meadow and the conversion of turf to meadow. In a truly sustainable site design process, this practice should be considered only after the areas of development that require landscaping and/or vegetation are minimized. Landscape Restoration is characterized by the careful selection and use of vegetation that does not require significant chemical maintenance by fertilizers, herbicides, and pesticides. The use of native species is recommended as they have the greatest tolerance and resistance to pests and require less fertilization and chemical application than nonnative species.

6.7.3-Soil Amendment & Restoration - Soil Amendment and Restoration is the process of improving disturbed soils and low organic soils by restoring soil porosity and/or adding a soil amendment, for the purpose of reestablishing the soil's long-term capacity for infiltration and pollution removal. This BMP addresses minor and major compaction from various sources. Compaction typically leads to limited root growth and is dependent on bulk density. Limiting root growth will reduce the uptake of water and nutrients by vegetation. Soil organisms are also affected by compaction; biological activity is greatly reduced, decreasing their ability to intake and release nutrients.

INSPECTIONS AND MAINTENANCE

Until the site is stabilized and during the construction activities, all BMPs must be maintained properly by contractor. All permanent maintenance procedures shall be performed by the property owner. Maintenance must include inspections of all BMPs after each runoff event and on a weekly basis. All preventative and remedial maintenance work, including clean-out, repair, replacement, regrading, reseeding, remulching and renetting must be performed immediately and in accordance with these procedures, plans, and details. Any areas disturbed during maintenance must be stabilized immediately in accordance with the general conservation notes and specifications. All site inspections must be documented in an inspection log kept for this purpose indicating the compliance actions and the date, time and name of the person conducting the inspection. The inspection log must be kept on site at all times and made available to the district upon request.

Stormwater Management Facilities – Stormwater management basins shall be inspected for litter and sediment accumulation on an annual basis or as directed by the township engineer. Needed maintenance should be initiated immediately after the inspection. The litter and sediment must be removed to restore design capacities. The litter and sediment shall be disposed of in an approved manner and in accordance with applicable state regulations. Any areas

disturbed during maintenance must be stabilized immediately in accordance with the general conservation notes and specifications.

Storm Drainage Systems – The stormwater management facilities including the inlets, stormwater piping, and other BMPs listed herein and shown on the plans for this site shall be maintained in proper working order in accordance with these plans and per the recommendation of the structure(s) manufacturer(s). Maintenance of these stormwater management facilities, as noted below, shall be the responsibility of the property owner(s) upon whose property the facilities are located.

All onsite inlets and stormwater piping shall be cleared of debris every three (3) months or when accumulation hinders operation of the facility. Systems shall be flushed every five (5) years.

All sediment/debris/oil removed from the stormwater management system shall be disposed per local, state, and federal standards.

Should onsite erosion occur from the landscaped areas, source of erosion shall be immediately stabilized and the inlets and stormwater piping shall be checked for accumulation and cleared if accumulation of sediment exists.

5.6.2-Minimizing Soil Compaction in Disturbed Areas - Sites that have minimized soil compaction areas designated properly during the development process should require considerably less maintenance than sites that have not. Some maintenance activities such as frequent lawn mowing can cause considerable soil compaction after construction and should be avoided whenever possible. Planting low-maintenance native vegetation is the best way to avoid damage due to maintenance.

Managed Release Concept (MRC) The licensed professional engineer should provide an appropriate long-term operation and maintenance schedule for the MRC BMP. Guidance should be based on the Stormwater BMP Manual to the greatest degree possible. The long-term operation and maintenance schedule should be project-specific. At a minimum, the long-term operation and maintenance schedule must meet 25 Pa. Code § 102.8(f)(10) and include the following:

1. Upgradient catch basins and inlets should be inspected and cleaned annually, or more often if historical maintenance records suggest a more frequent cleaning.
2. The vegetation (for the MRC BMP and contributing drainage area) should be maintained in good condition, and any bare spots revegetated.
3. Care should be taken to avoid excessive compaction by mowers. Mow only as appropriate for vegetative species.
4. Inspect at least two times per year after runoff events greater than 0.8 inch and make sure that runoff drains down within the design parameters (the licensed professional engineer should clearly identify what these parameters are).
5. At least two times per year, or more if historical maintenance indicate it is necessary, inspect for accumulation of sediment, damage to outlet control structures, erosion, signs of water contamination/spills, and instability. Leaf litter needs to be removed annually.
6. As needed, remove accumulated sediment as required to maintain infiltration through the MRCs soil media and to maintain water quality functionality. Restore original cross section. Properly dispose of sediment.
7. If porous pavement is included in the design, vacuum at least twice per year. Vacuum should have sufficient suction power and be designed for use with porous pavements.
8. All MRC BMP components should be maintained as indicated in the Stormwater BMP Manual.

As noted above, if the MRC BMP will manage peak flows in excess of the 2-year/24-hour storm event, an increased inspection and maintenance frequency will typically be necessary.

6.6.4-Water Quality Filters & Hydrodynamic Devices - Maintenance is crucial to the effectiveness of this BMP and should be conducted in accordance with manufacturer recommendations. More frequent cleaning is desired and some sites benefit from keeping a log of removed sediment amount to determine a cleaning schedule. Disposal of removed material will depend on the nature of the drainage area and the intent and function of the water quality insert.

6.7.2-Landscape Restoration - Meadows and Forests are considered low maintenance. They usually require more frequent maintenance in the first few years immediately following installation. Forest restoration areas planted with a proper cover crop can be expected to require annual mowing in order to control invasives. Carefully selected herbicides, mowing, and cutting may be necessary especially in the initial two (2) to three (3) years of growth until the tree canopy begins to form. Meadow management may require a seasonal mowing or burning. Care must be taken to make sure that any management is coordinated with essential reseeding and other important aspects of meadow reestablishment. Weeds must be carefully controlled in the first year and mowed to a height of four (4) to six (6) inches up through the second year. Burn off the meadow when mid-spring arrives in the third season or mow it closely to the ground if this is not possible. Soil exposure to the sun is necessary; therefore, mowed material should be removed to encourage proper “warm season” plant growth.

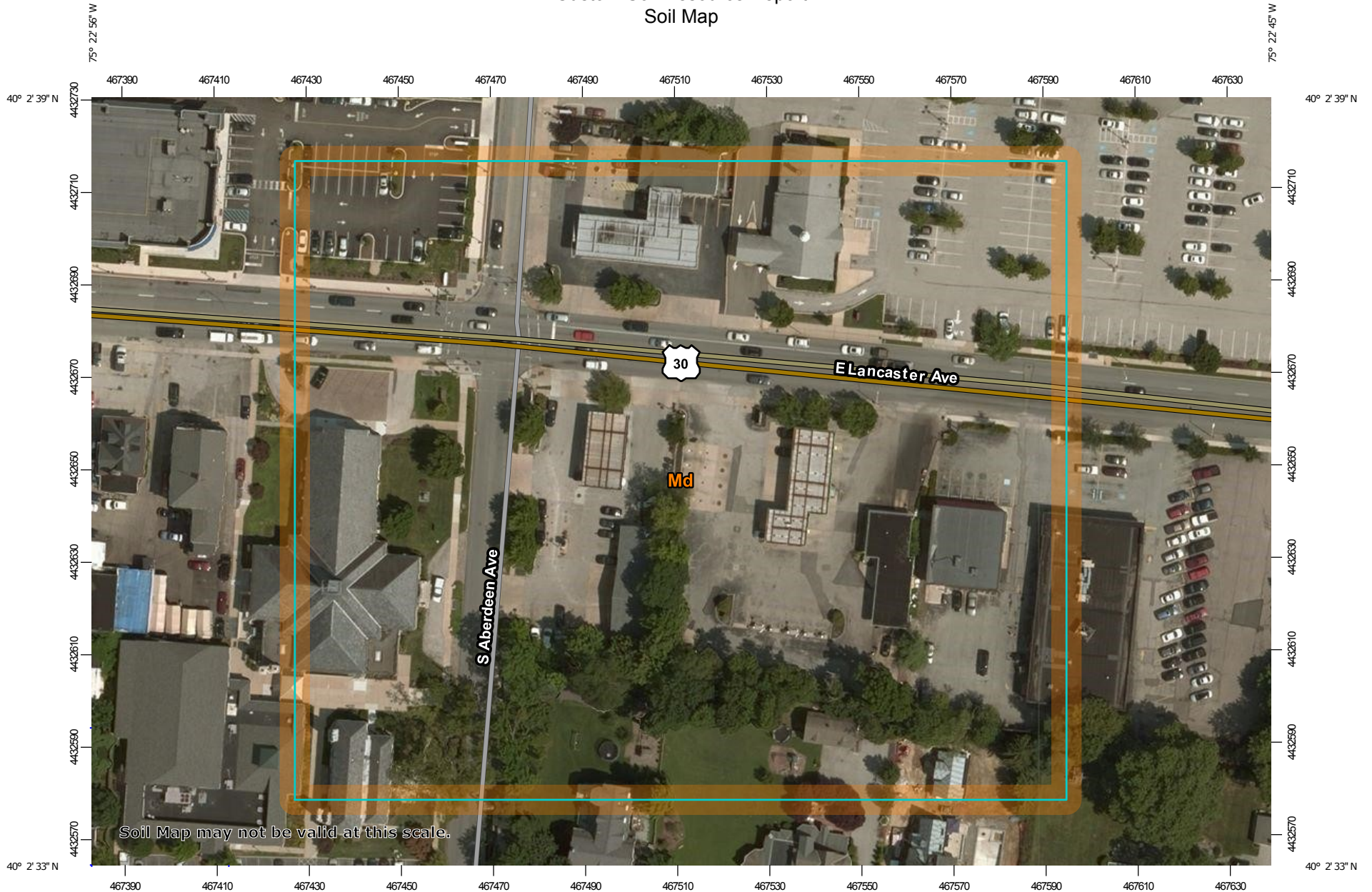
6.7.3-Soil Amendment & Restoration – The soil restoration process may be repeated over time, due to compaction by use of settling. For example, playfields and park areas will be compacted by foot traffic.



Name: VALLEY FORGE
 Date: 07/09/18
 Scale: 1 inch = 1,000 ft.

Location: 040° 02' 36.75" N 075° 22' 52.11" W

Custom Soil Resource Report Soil Map



Map Scale: 1:1,170 if printed on A landscape (11" x 8.5") sheet.


0 15 30 60 90 Meters

0 50 100 200 300 Feet

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 18N WGS84

MAP LEGEND

Area of Interest (AOI)

 Area of Interest (AOI)




















Soils







 Soil Map Unit Polygons

 Soil Map Unit Lines


 Soil Map Unit Points

Special Point Features






-  Blowout
-  Borrow Pit
-  Clay Spot
-  Closed Depression
-  Gravel Pit
-  Gravelly Spot
-  Landfill
-  Lava Flow
-  Marsh or swamp
-  Mine or Quarry
-  Miscellaneous Water
-  Perennial Water
-  Rock Outcrop
-  Saline Spot
-  Sandy Spot
-  Severely Eroded Spot
-  Sinkhole
-  Slide or Slip
-  Sodic Spot

-  Spoil Area
-  Stony Spot
-  Very Stony Spot
-  Wet Spot
-  Other
-  Special Line Features


Water Features

 Streams and Canals

Transportation

-  Rails
-  Interstate Highways
-  US Routes
-  Major Roads
-  Local Roads

Background

 Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
 Web Soil Survey URL:
 Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Delaware County, Pennsylvania
 Survey Area Data: Version 14, Nov 27, 2017

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jul 25, 2014—Aug 11, 2014

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

| Map Unit Symbol | Map Unit Name | Acres in AOI | Percent of AOI |
|------------------------------------|---|--------------|----------------|
| Md | Made land, gabbro and diabase materials | 5.7 | 100.0% |
| Totals for Area of Interest | | 5.7 | 100.0% |

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Custom Soil Resource Report

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Delaware County, Pennsylvania

Md—Made land, gabbro and diabase materials

Map Unit Setting

National map unit symbol: 121fx
Elevation: 300 to 2,000 feet
Mean annual precipitation: 36 to 55 inches
Mean annual air temperature: 41 to 62 degrees F
Frost-free period: 110 to 235 days
Farmland classification: Not prime farmland

Map Unit Composition

Udorthents, unstable fill, and similar soils: 95 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Udorthents, Unstable Fill

Setting

Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Acid loamy human transported material derived from interbedded sedimentary rock

Typical profile

C - 0 to 65 inches: extremely channery silt loam

Properties and qualities

Slope: 0 to 8 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 4.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: C
Hydric soil rating: No

Minor Components

Glenelg

Percent of map unit: 5 percent
Hydric soil rating: No

**PCSM WORKSHEET
PLAN PREPARER RECORD OF TRAINING AND EXPERIENCE IN
POST CONSTRUCTION STORMWATER MANAGEMENT METHODS AND TECHINQUES**

NAME OF PLAN PREPARER: Eric A. Britz, P.E.

FORMAL EDUCATION:

Name of College or Technical Institute: Temple University

Curriculum or Program: Environmental Engineering Technology

Dates of Attendance: **From:** Fall 1993 **To:** May 1996

Degree Received: Bachelor of Science

OTHER TRAINING:

Name of Training: _____ **Presented By:** _____

Date: _____

EMPLOYMENT HISTORY:

Current Employer: Bohler Engineering PA, LLC

Telephone: (215) 996-9100

Former Employer: Weeks Marine, Inc.

Telephone: (856) 963-0963

RECENT PCSM PLANS PREPARED:

| | | | |
|--------------------------|-------------------------|------------------------|--------------------------|
| Name of Project: | <u>Maris Grove</u> | <u>Vertical Screen</u> | <u>PNC Bank</u> |
| County: | <u>Delaware</u> | <u>Bucks</u> | <u>Montgomery</u> |
| Municipality: | <u>Concord Township</u> | <u>Warminster Twp.</u> | <u>Whitpain Township</u> |
| Permit Number: | _____ | <u>PAR10D618-R</u> | _____ |
| Approving Agency: | <u>DCCD</u> | <u>BCCD</u> | <u>MCCD</u> |

Supporting Calculations

Worksheet 1 . General Site Information

Instructions: Fill out Worksheet 1 for each watershed.

Date: 02/25/2019

Project Name: Wawa Radnor

Municipality: Radnor Township

County: Delaware

Total Area (Acres): 1.5

Major River Basin Delaware River

<http://www.pawaterplan.dep.state.pa.us/StateWaterPlan/docroot/default.aspx>

Watershed: Darby Creek

Sub-Basin: Darby Creek

Nearest Surface Water(s) to Receive Runoff: Ithan Creek

Chapter 93 - Designated Water Use: CWF (Cold Water Fishes) & MF (Migratory Fish)

<http://www.pacode.com/secure/data/025/chapter93/chap93toc.html>

Impaired according to Category 4 or 5 of the Integrated Water Quality Monitoring Assessment Report?

Yes No

http://www.portal.state.pa.us/portal/server.pt/community/water_quality_standards/10556/integrated_water_quality_repor

List Causes of Impairment: Water/Flow Variability, Siltation, Habitat Modification, Pathogens

Is there an established TMDL that applies?: Yes No

Total Maximum Daily Loads(TMDLs): _____

http://www.dep.state.pa.us/watermanagement_apps/tmdl/

http://www.epa.gov/reg3wapd/tmdl/pa_tmdl/index.htm

Is project subject to, or part of:

Municipal Separate Storm Sewer System (MS4) Requirements? Yes No

http://www.portal.state.pa.us/portal/server.pt/community/stormwater_management/10628/npdes_ms4%C2%A0information/669119

Existing or planned drinking water supply? Yes No

If yes, distance from proposed discharge (miles): _____

Approved Act 167 Plan? Yes No

<http://www.portal.state.pa.us/portal/server.pt?open=514&objID=554325&mode=2>

Existing River Conservation Program? Yes No

<http://www.dcnr.state.pa.us/brc/rivers/riversconservation/registry/>

Worksheet 2 . Sensitive Resources

Project Name: Wawa Radnor

Instructions:

1. Provide Sensitive Resources Map according to non-structural BMP 5.4.1 in Chapter 5. This map should identify wetlands, woodlands, natural drainage ways, steep slopes and other sensitive natural areas.
2. Summarize the existing extent of each sensitive resource in the Existing Sensitive Resources Table (below, using acres). If none present, insert 0.
3. Summarize Total Protected Area as defined under BMPs in Chapter 5.
4. Do not count any area twice. For example, an area that is both a floodplain and a wetland may only be considered once.

| Existing Natural Sensitive Resource | Mapped? Yes, No, N/A | Total Area (Ac) | Protected Area (Ac) |
|-------------------------------------|-------------------------|--------------------|---------------------|
| Waterbodies | | | |
| Floodplains | | | |
| Riparian Areas | | | |
| Wetlands | | | |
| Woodlands | | | |
| Natural Drainage Ways | | | |
| Steep Slopes, 15%-25% | | | |
| Steep Slopes, over 25% | | | |
| Other: | | | |
| Other: | | | |
| Other: | | | |
| Total Existing: | | 0.00 | 0.00 |

Worksheet 3 . Non-Structural BMP Credits

Project Name: Wawa Radnor

Protected Area

- 1.1 Area of Protected Sensitive/Special Value Features (see WS 2) 0.00 Ac
- 1.2 Area of Riparian Forest Buffer Protection Ac
- 3.1 Area of Minimum Disturbance/Reduced Grading Ac
- Total Protected Area (Ac)** **0.00 Ac**

| | | | | |
|-----------|--------------|----------------|---|----------------------------|
| Site Area | <i>minus</i> | Protected Area | = | Stormwater Management Area |
| 1.50 | - | 0.00 | = | 1.50 |

This is the area that requires stormwater management

Non-Structural Volume Credits

- 3.1 Minimum Soil Compaction (See Chapter 8, Pg. 22 - SW BMP Manual)
 - Lawn s.f. x 1/4" x 1/12 = 0.00 cuft
 - Meadow s.f. x 1/3" x 1/12 = 0.00 cuft
 - 3.3 Protect Existing Trees (See Chapter 8, Pg. 23 - SW BMP Manual)

For trees within 100 feet of impervious area:

 - Tree Canopy s.f. x 1/2" x 1/12 = 0.00 cuft
 - 5.1 Disconnect Roof Leaders to Vegetated Areas (See Chapter 8, Pg. 25 - SW BMP Manual)

For runoff directed to areas protected under 5.8.1 and 5.8.2

 - Roof Area s.f. x 1/3" x 1/12 = 0.00 cuft

For all other disconnected roof areas

 - Roof Area s.f. x 1/4" x 1/12 = 0.00 cuft
 - 5.2 Disconnect Non-Roof Impervious to Vegetated Areas (See Chapter 8, Pg. 26 - SW BMP Manual)

For runoff directed to areas protected under 5.8.1 and 5.8.2

 - Impervious s.f. x 1/3" x 1/12 = 0.00 cuft

For all other disconnected areas

 - Impervious s.f. x 1/4" x 1/12 = 0.00 cuft
- Total Non-Structural Volume Credit*** **0.00 cuft**

** For Use on Worksheet 5*

Worksheet 4 . Change in Runoff Volume for 2-Year Storm Event

Project Name: Wawa Radnor
 Drainage Area: Overall
 2-Year Rainfall: 3.27 in.
 Total Site Area: 1.50 Acres
 Protected Site Area: 0.00 Acres
 Managed Area: 1.50 Acres

Existing Conditions *

| Cover Type/Condition | Soil Type | Area (Ac) | CN | S | la (0.2 x S) | Q Runoff ¹ (in) | Runoff Volume ² (cuft) |
|------------------------------------|-----------|-------------|----|-------|--------------|----------------------------|-----------------------------------|
| Meadow | C | 0.14 | 71 | 4.085 | 0.817 | 0.920 | 481.15 |
| Woods, Good Condition | C | 0.13 | 70 | 4.286 | 0.857 | 0.869 | 403.83 |
| Impervious | C | 0.98 | 98 | 0.204 | 0.041 | 3.037 | 10,837.73 |
| Impervious (20% considered meadow) | C | 0.25 | 71 | 4.085 | 0.817 | 0.920 | 821.96 |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| Total | | 1.50 | | | | | 12,544.67 |

* Per Chapter 3, the following must be implemented:

1. Existing non-forested pervious areas must be considered meadow (good condition) or its equivalent.
2. Twenty-percent (20%) of existing impervious area, when present, shall be considered meadow (good condition).

Developed Conditions

| Cover Type/Condition | Soil Type | Area (Ac) | CN | S | la (0.2 x S) | Q Runoff ¹ (in) | Runoff Volume ² (cuft) |
|------------------------------------|-----------|-------------|----|-------|--------------|----------------------------|-----------------------------------|
| Open Space (Lawns), Good Condition | C | 0.30 | 74 | 3.514 | 0.703 | 1.084 | 1,180.37 |
| Impervious | C | 1.20 | 98 | 0.204 | 0.041 | 3.037 | 13,230.19 |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| Total | | 1.50 | | | | | 14,410.56 |

2-year Volume Increase = 1,865.89 cuft

2-year Volume Increase = Developed Conditions Runoff Volume - Existing Conditions Runoff Volume

1. Runoff (in) = $Q = (P - 0.2S)^2 / (P + 0.8S)$ where:
 $P = 2\text{-year Rainfall (in)}$
 $S = (1000/CN) - 10$

2. Runoff Volume (cf) = $Q \times \text{Area} \times 1/12$
 $Q = \text{Runoff (in)}$
 $\text{Area} = \text{Land use area (s.f.)}$

Note: Runoff Volume must be calculated for EACH land use type/condition and HSGI. The use of a weighted CN value for volume calculations is not acceptable.

Worksheet 4 . Change in Runoff Volume for 2-Year Storm Event

Project Name: **Wawa Radnor**
 Drainage Area: **POI#1**
 2-Year Rainfall: **3.27** in.
 Total Site Area: **1.50** Acres
 Protected Site Area: **0.00** Acres
 Managed Area: **1.50** Acres

Existing Conditions *

| Cover Type/Condition | Soil Type | Area (Ac) | CN | S | la (0.2 x S) | Q Runoff ¹ (in) | Runoff Volume ² (cuft) |
|------------------------------------|-----------|-------------|----|-------|--------------|----------------------------|-----------------------------------|
| Meadow | C | 0.12 | 71 | 4.085 | 0.817 | 0.920 | 390.93 |
| Woods, Good Condition | C | 0.13 | 70 | 4.286 | 0.857 | 0.869 | 403.83 |
| Impervious | C | 0.98 | 98 | 0.204 | 0.041 | 3.037 | 10,837.73 |
| Impervious (20% considered meadow) | C | 0.25 | 71 | 4.085 | 0.817 | 0.920 | 821.96 |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| Total | | 1.47 | | | | | 12,454.46 |

- * Per Chapter 3, the following must be implemented:
1. Existing non-forested pervious areas must be considered meadow (good condition) or its equivalent.
 2. Twenty-percent (20%) of existing impervious area, when present, shall be considered meadow (good condition).

Developed Conditions

| Cover Type/Condition | Soil Type | Area (Ac) | CN | S | la (0.2 x S) | Q Runoff ¹ (in) | Runoff Volume ² (cuft) |
|------------------------------------|-----------|-------------|----|-------|--------------|----------------------------|-----------------------------------|
| Open Space (Lawns), Good Condition | C | 0.29 | 74 | 3.514 | 0.703 | 1.084 | 1,141.03 |
| Impervious | C | 1.20 | 98 | 0.204 | 0.041 | 3.037 | 13,230.19 |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| Total | | 1.49 | | | | | 14,371.21 |

2-year Volume Increase = 1,916.76 cuft

2-year Volume Increase = Developed Conditions Runoff Volume - Existing Conditions Runoff Volume

1. Runoff (in) = $Q = (P - 0.2S)^2 / (P + 0.8S)$ where:
 $P = 2\text{-year Rainfall (in)}$
 $S = (1000/CN) - 10$

2. Runoff Volume (cf) = $Q \times \text{Area} \times 1/12$
 $Q = \text{Runoff (in)}$
 $\text{Area} = \text{Land use area (s.f.)}$

Note: Runoff Volume must be calculated for EACH land use type/condition and HSGI. The use of a weighted CN value for volume calculations is not acceptable.

Worksheet 4 . Change in Runoff Volume for 2-Year Storm Event

Project Name: Wawa Radnor
 Drainage Area: POI#2
 2-Year Rainfall: 3.27 in.
 Total Site Area: 1.50 Acres
 Protected Site Area: 0.00 Acres
 Managed Area: 1.50 Acres

Existing Conditions *

| Cover Type/Condition | Soil Type | Area (Ac) | CN | S | Ia (0.2 x S) | Q Runoff ¹ (in) | Runoff Volume ² (cuft) |
|----------------------|-----------|-------------|----|-------|--------------|----------------------------|-----------------------------------|
| Meadow | C | 0.03 | 71 | 4.085 | 0.817 | 0.920 | 93.56 |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| Total | | 0.03 | | | | | 93.56 |

* Per Chapter 3, the following must be implemented:

1. Existing non-forested pervious areas must be considered meadow (good condition) or its equivalent.
2. Twenty-percent (20%) of existing impervious area, when present, shall be considered meadow (good condition).

Developed Conditions

| Cover Type/Condition | Soil Type | Area (Ac) | CN | S | Ia (0.2 x S) | Q Runoff ¹ (in) | Runoff Volume ² (cuft) |
|------------------------------------|-----------|-------------|----|-------|--------------|----------------------------|-----------------------------------|
| Open Space (Lawns), Good Condition | C | 0.01 | 74 | 3.514 | 0.703 | 1.084 | 47.21 |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| Total | | 0.01 | | | | | 47.21 |

2-year Volume Increase = -46.34 cuft

2-year Volume Increase = Developed Conditions Runoff Volume - Existing Conditions Runoff Volume

1. Runoff (in) = $Q = (P - 0.2S)^2 / (P + 0.8S)$ where:
 $P = 2\text{-year Rainfall (in)}$
 $S = (1000/CN) - 10$

2. Runoff Volume (cf) = $Q \times \text{Area} \times 1/12$
 $Q = \text{Runoff (in)}$
 $\text{Area} = \text{Land use area (s.f.)}$

Note: Runoff Volume must be calculated for EACH land use type/condition and HSGI. The use of a weighted CN value for volume calculations is not acceptable.

Worksheet 4 . Change in Runoff Volume for 2-Year Storm Event

Project Name: Wawa Radnor
 Drainage Area: DA to Basin #1
 2-Year Rainfall: 3.27 in.
 Total Site Area: 1.50 Acres
 Protected Site Area: 0.00 Acres
 Managed Area: 1.50 Acres

Existing Conditions *

| Cover Type/Condition | Soil Type | Area (Ac) | CN | S | Ia (0.2 x S) | Q Runoff ¹ (in) | Runoff Volume ² (cuft) |
|----------------------|-----------|-----------|----|---|--------------|----------------------------|-----------------------------------|
| | | | | | | | |
| | | | | | | | |
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| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| Total | | | | | | | 0.00 |

- * Per Chapter 3, the following must be implemented:
- Existing non-forested pervious areas must be considered meadow (good condition) or its equivalent.
 - Twenty-percent (20%) of existing impervious area, when present, shall be considered meadow (good condition).

Developed Conditions

| Cover Type/Condition | Soil Type | Area (Ac) | CN | S | Ia (0.2 x S) | Q Runoff ¹ (in) | Runoff Volume ² (cuft) |
|------------------------------------|-----------|-----------|----|-------|--------------|----------------------------|-----------------------------------|
| Impervious | C | 0.49 | 98 | 0.204 | 0.041 | 3.037 | 5,446.43 |
| Open Space (Lawns), Good Condition | C | 0.02 | 74 | 3.514 | 0.703 | 1.084 | 78.69 |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| Total | | | | | | | 5,525.12 |

2-year Volume Increase = 5,525.12 cuft

2-year Volume Increase = Developed Conditions Runoff Volume - Existing Conditions Runoff Volume

- Runoff (in) = $Q = (P - 0.2S)^2 / (P + 0.8S)$ where:
 P = 2-year Rainfall (in)
 S = (1000/CN) - 10
- Runoff Volume (cf) = Q x Area x 1/12
 Q = Runoff (in)
 Area = Land use area (s.f.)

Note: Runoff Volume must be calculated for EACH land use type/condition and HSGI. The use of a weighted CN value for volume calculations is not acceptable.

Worksheet 5 . Structural BMP Volume Credits

Project Name: Wawa Radnor
 Sub-Basin: _____

Required Control Volume (ft³) - from Worksheet 4: 1865.89
 Non-structural Volume Credit (ft³) - from Worksheet 3:
 (Maximum is 25% of Required Volume) - 0
Structural Volume Requirement (ft³) 1,866
 (Required Control Volume minus Non-structural Credit)

| Proposed BMP | Area (ft ²) | Volume Reduction Permanently Removed (ft ³) |
|--|-------------------------|---|
| 6.4.1 Porous Pavement | | |
| 6.4.2 Infiltration Basin | | |
| 6.4.3 Infiltration Bed | | |
| 6.4.4 Infiltration Trench | | |
| 6.4.5 Rain Garden/Bioretention | | |
| 6.4.6 Dry Well/Seepage Pit | | |
| 6.4.7 Constructed Filter | | |
| 6.4.8 Vegetated Swale | | |
| 6.4.9 Vegetated Filter Strip | | |
| 6.4.10 Berm | | |
| Managed Release Concept | 22,216 | 2,694 |
| 6.5.1 Vegetated Roof | | |
| 6.5.2 Capture and Re-Use | | |
| 6.6.1 Constructed Wetlands | | |
| 6.6.2 Wet Pond/Retention Basin | | |
| 6.7.1 Riparian Buffer / Riparian Forest Buffer Restoration | | |
| 6.7.2 Landscape Restoration / Reforestation | | |
| 6.7.3 Soil Amendment | | |
| 6.8.1 Level Spreader | | |
| 6.8.2 Special Storage Areas | | |
| Other | | |
| | | |
| | | |
| | | |
| | | |
| | | |

Total Structural Volume (ft³): 2,694
 Structural Volume Requirement (ft³): 1,866
DIFFERENCE 828

Worksheet 10 . Water Quality Compliance For Nitrate

Project Name: Wawa Radnor

Does the site design incorporate the following BMPs to address nitrate pollution? A summary "yes" rating is achieved if at least 2 Primary BMPs for nitrate are provided across the site or 4 secondary BMPs for nitrate are provided across the site (or the equivalent). "Provided across the site" is taken to mean the specifications for that BMP set forward in Sections 5 and 6 are satisfied.

PRIMARY BMPs FOR NITRATE:

| | YES | NO |
|---|-------------------------------------|-------------------------------------|
| NS BMP 5.4.2 - Protect / Conserve / Enhance Riparian Buffers | <input type="checkbox"/> | <input checked="" type="checkbox"/> |
| NS BMP 5.5.4 - Cluster Uses at Each Site | <input type="checkbox"/> | <input checked="" type="checkbox"/> |
| NS BMP 5.6.1 - Minimize Total Disturbed Area | <input type="checkbox"/> | <input checked="" type="checkbox"/> |
| NS BMP 5.6.3 - Re-Vegetate / Re-Forest Disturbed Areas (Native Species) | <input type="checkbox"/> | <input checked="" type="checkbox"/> |
| NS BMP 5.9.1 - Street Sweeping / Vacuuming | <input type="checkbox"/> | <input checked="" type="checkbox"/> |
| Structural BMP 6.7.1 - Riparian Buffer Restoration | <input type="checkbox"/> | <input checked="" type="checkbox"/> |
| Structural BMP 6.7.2 - Landscape Restoration | <input checked="" type="checkbox"/> | <input type="checkbox"/> |

SECONDARY BMPs FOR NITRATE:

| | | |
|--|-------------------------------------|-------------------------------------|
| NS BMP 5.4.1 - Protect Sensitive / Special Value Features | <input type="checkbox"/> | <input checked="" type="checkbox"/> |
| NS BMP 5.4.3 - Protect / Utilize Natural Drainage Features | <input type="checkbox"/> | <input checked="" type="checkbox"/> |
| NS BMP 5.6.2 - Minimize Soil Compaction | <input checked="" type="checkbox"/> | <input type="checkbox"/> |
| Structural BMP 6.4.5 - Rain Garden / Bioretention | <input type="checkbox"/> | <input checked="" type="checkbox"/> |
| Structural BMP 6.4.8 - Vegetated Swale | <input type="checkbox"/> | <input checked="" type="checkbox"/> |
| Structural BMP 6.4.9 - Vegetated Filter Strip | <input type="checkbox"/> | <input checked="" type="checkbox"/> |
| Structural BMP 6.6.1 - Constructed Wetland | <input type="checkbox"/> | <input checked="" type="checkbox"/> |
| Structural BMP 6.7.1 - Riparian Buffer Restoration | <input type="checkbox"/> | <input checked="" type="checkbox"/> |
| Structural BMP 6.7.2 - Landscape Restoration | <input type="checkbox"/> | <input checked="" type="checkbox"/> |
| Structural BMP 6.7.3 - Soils Amendment / Restoration | <input checked="" type="checkbox"/> | <input type="checkbox"/> |

Summary of Peak Flow Rates

Project: [Wawa - Radnor Township](#)

POI-1 - Runoff Rates On-Site (cfs)

| Storm Frequency | <u>1 yr</u> | <u>2 yr</u> | <u>5 yr</u> | <u>10 yr</u> | <u>25 yr</u> | <u>50 yr</u> | <u>100 yr</u> |
|--|-------------|-------------|-------------|--------------|--------------|--------------|---------------|
| Pre-Development POI #1 | 4.96 | 6.18 | 8.04 | 9.55 | 11.74 | 13.58 | 15.54 |
| Post-Dev. Basin#1 Outflow | -- | 0.40 | 1.42 | 2.28 | 3.37 | 4.19 | 5.21 |
| Post-Dev. Bypass | -- | 3.88 | 5.11 | 6.12 | 7.59 | 8.82 | 10.13 |
| Overall Post-Development POI #1 Allowed | -- | 4.96 | 8.04 | 9.55 | 11.74 | 13.58 | 15.54 |
| Overall Post-Development Proposed (Combined POI #1) | -- | 4.27 | 6.53 | 8.40 | 10.97 | 13.02 | 15.34 |

POI-2 - Runoff Rates On-Site (cfs)

| Storm Frequency | <u>1 yr</u> | <u>2 yr</u> | <u>5 yr</u> | <u>10 yr</u> | <u>25 yr</u> | <u>50 yr</u> | <u>100 yr</u> |
|--|-------------|-------------|-------------|--------------|--------------|--------------|---------------|
| Pre-Development POI #2 | 0.03 | 0.05 | 0.07 | 0.10 | 0.14 | 0.17 | 0.21 |
| Post-Dev. POI #2 Bypass | -- | 0.02 | 0.04 | 0.05 | 0.07 | 0.08 | 0.10 |
| Overall Post-Development POI #2 Allowed | -- | 0.03 | 0.07 | 0.10 | 0.14 | 0.17 | 0.21 |
| Overall Post-Development Proposed POI#2 | -- | 0.02 | 0.04 | 0.05 | 0.07 | 0.08 | 0.10 |

* - Permitted post-development peak rates are based on the requirements of the Radnor Township Chapter 245-25 Stormwater Management Peak Rate Control and Management Districts in the Darby and Cobbs Creeks Watershed, as follows:

District A Peak Rate Requirements
 2-yr post-development = 1-yr pre-development
 5-yr post-development = 5-yr pre-development
 10-yr post-development = 10-yr pre-development
 25yr post-development = 25-yr pre-development
 50yr post-development = 50-yr pre-development
 100-yr post-development = 100-yr pre-development

Runoff Calculation CN Worksheets

Project: Wawa - Radnor

Description: Pre- POI 1

$$Q = [(P - 0.2S)^2 / (P + 0.8S)] * 1/12 * 43,560, \text{ where } S = (1000/CN) - 10 \text{ and:}$$

$$P = \boxed{3.27}$$

Catchment Areas

| Description | HSG C / CN | | | Impervious | Total Area (Ac) | Composite CN | Runoff Q (cuft) |
|----------------|---|-----------------------------|--------|------------|--------------------|-----------------|--------------------|
| | Open Space (Lawns), Good Condition | Woods, Good Condition | Meadow | Impervious | | | |
| Pre POI#1 | 74 | 70 | 71 | 98 | 1.47 | 93 | 14,345 |
| | | | | | | | |
| | | | | | | | |
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| | | | | | | | |
| Totals: | | 0.13 | 0.12 | 1.23 | 1.47 | | 14,345 |

Runoff Calculation CN Worksheets

Project: Wawa - Radnor

Description: Pre- POI 2

$$Q = [(P - 0.2S)^2 / (P + 0.8S)] * 1/12 * 43,560, \text{ where } S = (1000/CN) - 10 \text{ and:}$$

$$P = \boxed{3.27}$$

Catchment Areas

| Description | HSG C / CN | | | Impervious | Total Area (Ac) | Composite CN | Runoff Q (cuft) |
|----------------|---|-----------------------------|--------|------------|--------------------|-----------------|--------------------|
| | Open Space (Lawns), Good Condition | Woods, Good Condition | Meadow | Impervious | | | |
| Pre POI#2 | 74 | 70 | 0.03 | 98 | 0.03 | 71 | 94 |
| | | | | | | | |
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| | | | | | | | |
| Totals: | | | 0.03 | | 0.03 | | 94 |

Runoff Calculation CN Worksheets

Project: Wawa - Radnor

Description: Post POI 1

$Q = [(P - 0.2S)^2 / (P + 0.8S)] * 1/12 * 43,560$, where $S = (1000/CN) - 10$ and:

P = 3.27

Catchment Areas

| Description | HSG C / CN | | | Impervious | Total Area (Ac) | Composite CN | Runoff Q (cuft) |
|----------------------------|--|-----------------------------|--------------|------------------|-----------------|--------------|-----------------|
| | Open Space (Lawns), Good Condition 74 | Woods, Good Condition 70 | Meadow 71 | Impervious 98 | | | |
| Post-dev DA to Basin POI#1 | 0.02 | | | 0.49 | 0.51 | 97 | 5,525 |
| Post-dev Bypass POI#1 | 0.27 | | | 0.71 | 0.98 | 91 | 8,878 |
| | | | | | | | |
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| | | | | | | | |
| Totals: | 0.29 | | | 1.20 | 1.49 | | 14,404 |

Runoff Calculation CN Worksheets

Project: Wawa - Radnor

Description: Post POI 2

$Q = [(P - 0.2S)^2 / (P + 0.8S)] * 1/12 * 43,560$, where $S = (1000/CN) - 10$ and:
 P = 3.27

Catchment Areas

| Description | HSG C / CN | | | Impervious | Total Area (Ac) | Composite CN | Runoff Q (cuft) |
|-----------------------|---|-----------------------------|--------|------------|--------------------|-----------------|--------------------|
| | Open Space (Lawns), Good Condition | Woods, Good Condition | Meadow | Impervious | | | |
| Post-dev Bypass POI#2 | 0.01 | | | | 0.01 | 74 | 47 |
| | | | | | | | |
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| | | | | | | | |
| Totals: | 0.01 | | | | 0.01 | | 47 |

Time of Concentration (Tc) or (Tt) Calculations

Project: Wawa - Radnor

Description: Pre-development

Note: Space for as many as three segments per flow type can be used for each worksheet.

Sheet Flow (Applicable to Tc only)

1. Surface Description (table 3-1)
 2. Manning's roughness coeff., n (table 3-1)
 3. Flow length, L (total $L \leq 150$ ft)
 4. Two-yr 24-hr rainfall, P_2
 5. Land slope, s^*
 6. $T_t = 0.007(nL)^{0.8} / P_2^{0.5} s^{0.4}$
- *S is averaged

| Segment ID | | | | |
|----------------------|------------------|---|---|--|
| | Dense grasses | | | |
| | | | | |
| ft | | | | |
| in | | | | |
| ft/ft | | | | |
| Compute Tt hr | + | + | = | |

Shallow Concentrated Flow

7. Surface Description (paved or unpaved)
8. Flow length, L
9. Watercourse slope, s^*
10. Average velocity, V
11. $T_t = L / 3600V$

| Segment ID | | | | |
|------------|--------|--------|---|--------|
| | AB | BC | | |
| | Paved | Paved | | |
| ft | 205 | 223 | | |
| ft/ft | 0.0098 | 0.0304 | | |
| ft/sec | 2.02 | 3.57 | | |
| | 0.0281 | 0.0174 | + | = |
| | | | | 0.0455 |

Channel Flow

12. Cross sectional flow area, a
13. Wetted perimeter, p
14. Hydraulic radius, $r = a/wp$
15. Channel Slope, s
16. Manning's roughness coeff., n
17. $V = 1.49r^{2/3}s^{1/2} / n$
18. Flow length, L
19. $T_t = L / 3600V$
20. Watershed or subarea T_c or T_t (add T_t in steps 6,11, and 19)

| Segment ID | | | | |
|-----------------|---|---|---|--------|
| ft ² | | | | |
| ft | | | | |
| ft | | | | |
| ft/ft | | | | |
| ft | | | | |
| | + | + | = | 0.0455 |

Tc = 2.73 minutes ***Minimum is 5 minutes for Rational Method**

Prepared For:

| | |
|----------------|-----|
| Name | |
| Company Name | |
| Street Address | |
| City | |
| State | Zip |
| Phone | |
| Fax | |
| Email | |

Project Information:

| | |
|----------------|---------|
| Name | |
| Street Address | |
| City | |
| State | Zip |
| Date: | (mm/dd) |

Engineer:

| | |
|----------------|-----|
| Name | |
| Company Name | |
| Street Address | |
| City | |
| State | Zip |
| Phone | |
| Fax | |
| Email | |

Calculations Performed By:

| | |
|----------------|-----|
| Name | |
| Company Name | |
| Street Address | |
| City | |
| State | Zip |
| Phone | |
| Fax | |
| Email | |

Input Given Parameters

| | |
|----------------------------------|------------------|
| Unit of Measure | English |
| Select Model | Recharger 280HD |
| Stone Porosity | 40.0% |
| Number of Header Systems | 1 Header |
| Stone Depth Above Chamber | 6 inches |
| Stone Depth Below Chamber | 6 inches |
| Workable Bed Depth | 10.00 feet |
| Max. Bed Width | 30.00 feet |
| Storage Volume Required | 7000.00 cu. feet |

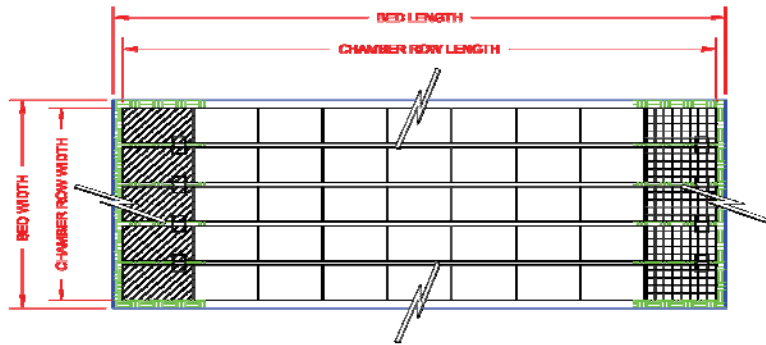


| Chamber Specifications | | |
|---|----------------|-----------------|
| Height | 26.5 | inches |
| Width | 47.00 | inches |
| Length | 8.00 | feet |
| Installed Length | 7.00 | feet |
| Bare Chamber Volume | 42.55 | cu. feet |
| Installed Chamber Volume | 64.46 | cu. feet |
| <i>Image for visual reference only. May not reflect selected model.</i> | | |
| Bed Depth | 4.13 | feet |
| Bed Width | 27.58 | feet |
| Storage Volume Provided | 7346.88 | cu. feet |

Materials List

| | | | |
|---|--------|-----------|--|
| Recharger 280HD Stormwater System by CULTEC, Inc. | | | |
| Approx. Unit Count - not for construction | 108 | pieces | |
| Actual Number of Chambers Required | 108 | pieces | |
| Starter Chambers | 6 | pieces | |
| Intermediate Chambers | 96 | pieces | |
| End Chambers | 6 | pieces | |
| HVLV FC-24 Feed Connector | 5 | pieces | |
| CULTEC No. 410™ Filter Fabric | 992.60 | sq. yards | |
| CULTEC No. 20L Polyethylene Liner | 27.58 | feet | |
| Stone | 251.18 | cu. yards | |

Bed Detail



| | | |
|-------------------------|---------|----------|
| Number of Rows Wide | 6 | pieces |
| Number of Chambers Long | 18 | pieces |
| Chamber Row Width | 25.58 | feet |
| Chamber Row Length | 127.00 | feet |
| Bed Width | 27.58 | feet |
| Bed Length | 129.00 | feet |
| Bed Area Required | 3558.25 | sq. feet |

Bed detail for reference only. Not project specific. Not to scale. Use CULTEC StormGenie to output project specific detail.

Project Name: Name

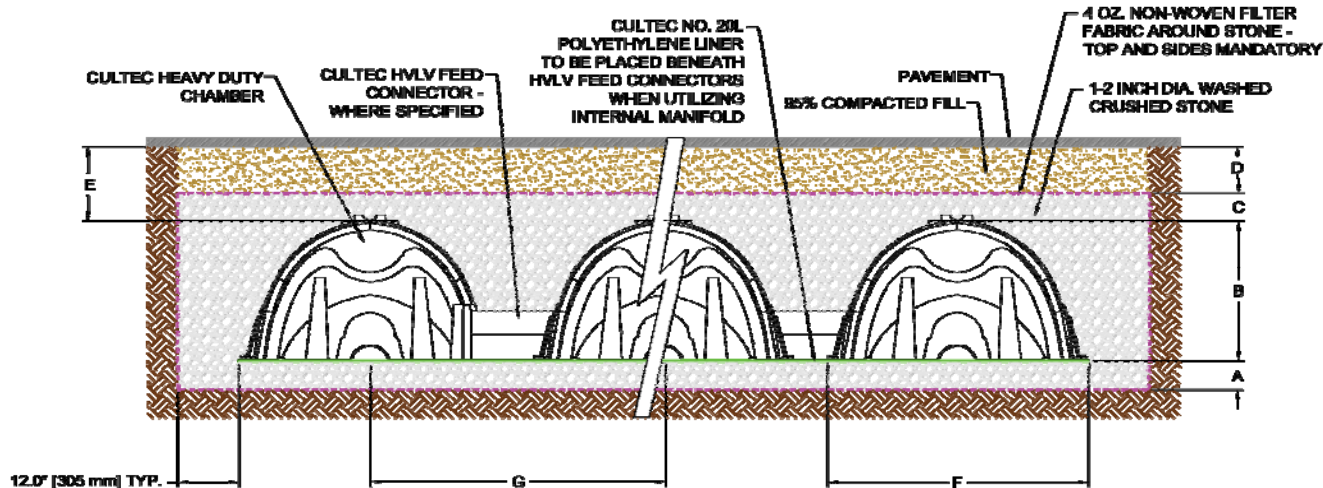
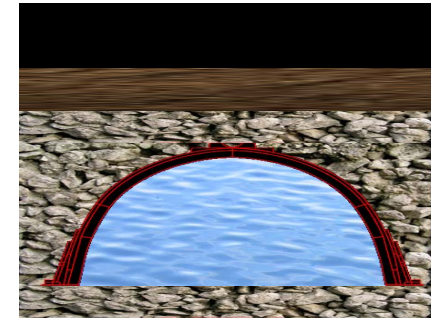
Date: (mm/dd)

Cross Section Detail



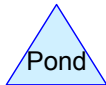
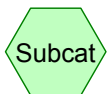
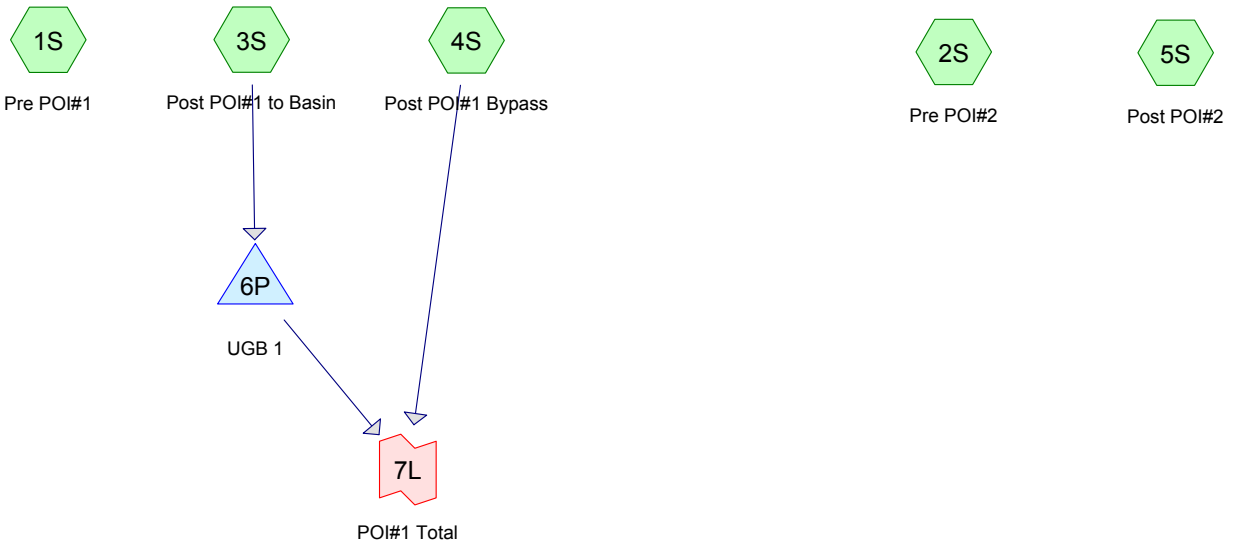
Conceptual graphic only. Not job specific.

| Recharger 280HD | | |
|--------------------|------|--------|
| Pavement | 12 | inches |
| 95% Compacted Fill | 8 | inches |
| Stone Above | 6 | inches |
| Chamber Height | 26.5 | inches |
| Stone Below | 6 | inches |
| Effective Depth | 38.5 | inches |
| Bed Depth | 58.5 | inches |



| | | | |
|---|--|------|--------|
| A | Depth of Stone Base | 6.0 | inches |
| B | Chamber Height | 26.5 | inches |
| C | Depth of Stone Above Units | 6.0 | inches |
| D | Depth of 95% Compacted Fill | 8.0 | inches |
| E | Max. Depth of Cover Allowed Above Crown of Chamber | 12.0 | feet |
| F | Chamber Width | 47.0 | inches |
| G | Center to Center Spacing | 4.33 | feet |

| Breakdown of Storage Provided by | | |
|----------------------------------|-----------------|-------------------|
| | Recharger 280HD | Stormwater System |
| Chambers | 4632.20 | cu. feet |
| Feed Connectors | 1.90 | cu. feet |
| Stone | 2712.78 | cu. feet |
| Total Storage Provided | 7346.88 | cu. feet |



Routing Diagram for PC181016 Rev-2_MRC_no stone
 Prepared by Bohler Engineering, Printed 2/28/2019
 HydroCAD® 10.00-22 s/n 03478 © 2018 HydroCAD Software Solutions LLC

Summary for Subcatchment 1S: Pre POI#1

Runoff = 6.184 cfs @ 11.97 hrs, Volume= 13,447 cf, Depth= 2.51"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-192.00 hrs, dt= 0.01 hrs
 Type II 24-hr 2 year Rainfall=3.27"

| Area (ac) | CN | Description |
|-----------|----|------------------------|
| * 0.128 | 70 | woods |
| * 0.117 | 71 | meadow |
| * 1.229 | 98 | impervious |
| 1.474 | 93 | Weighted Average |
| 0.245 | | 16.62% Pervious Area |
| 1.229 | | 83.38% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|----------|---------------|---------------|-------------------|----------------|--------------------------------|
| 6.0 | | | | | Direct Entry, Pre POI#1 |

Summary for Subcatchment 2S: Pre POI#2

Runoff = 0.045 cfs @ 11.98 hrs, Volume= 94 cf, Depth= 0.92"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-192.00 hrs, dt= 0.01 hrs
 Type II 24-hr 2 year Rainfall=3.27"

| Area (ac) | CN | Description |
|-----------|----|-----------------------|
| * 0.028 | 71 | meadow |
| 0.028 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|----------|---------------|---------------|-------------------|----------------|--------------------------------|
| 6.0 | | | | | Direct Entry, Pre POI#2 |

Summary for Subcatchment 3S: Post POI#1 to Basin

Runoff = 2.346 cfs @ 11.97 hrs, Volume= 5,460 cf, Depth= 2.93"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-192.00 hrs, dt= 0.01 hrs
 Type II 24-hr 2 year Rainfall=3.27"

| Area (ac) | CN | Description |
|-----------|----|------------------------|
| * 0.020 | 74 | Open Space |
| * 0.494 | 98 | Impervious |
| 0.514 | 97 | Weighted Average |
| 0.020 | | 3.89% Pervious Area |
| 0.494 | | 96.11% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|----------|---------------|---------------|-------------------|----------------|---------------------------------|
| 6.0 | | | | | Direct Entry, Post POI#1 |

Summary for Subcatchment 4S: Post POI#1 Bypass

Runoff = 3.875 cfs @ 11.97 hrs, Volume= 8,242 cf, Depth= 2.32"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-192.00 hrs, dt= 0.01 hrs
 Type II 24-hr 2 year Rainfall=3.27"

| Area (ac) | CN | Description |
|-----------|----|------------------------|
| * 0.267 | 74 | Open Space |
| * 0.710 | 98 | Impervious |
| 0.977 | 91 | Weighted Average |
| 0.267 | | 27.33% Pervious Area |
| 0.710 | | 72.67% Impervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|----------|---------------|---------------|-------------------|----------------|--|
| 6.0 | | | | | Direct Entry, Post POI#1 Bypass |

Summary for Subcatchment 5S: Post POI#2

Runoff = 0.023 cfs @ 11.98 hrs, Volume= 47 cf, Depth= 1.08"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-192.00 hrs, dt= 0.01 hrs
 Type II 24-hr 2 year Rainfall=3.27"

| Area (ac) | CN | Description |
|-----------|----|-----------------------|
| * 0.012 | 74 | Open Space |
| 0.012 | | 100.00% Pervious Area |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description |
|----------|---------------|---------------|-------------------|----------------|---------------------------------|
| 6.0 | | | | | Direct Entry, Post POI#2 |

Summary for Pond 6P: UGB 1

Inflow Area = 22,390 sf, 96.11% Impervious, Inflow Depth = 2.93" for 2 year event
 Inflow = 2.346 cfs @ 11.97 hrs, Volume= 5,460 cf
 Outflow = 0.395 cfs @ 12.15 hrs, Volume= 5,349 cf, Atten= 83%, Lag= 11.2 min
 Primary = 0.386 cfs @ 12.15 hrs, Volume= 2,310 cf
 Secondary = 0.009 cfs @ 12.15 hrs, Volume= 3,039 cf

Routing by Stor-Ind method, Time Span= 0.00-192.00 hrs, dt= 0.01 hrs
 Peak Elev= 361.24' @ 12.15 hrs Surf.Area= 2,237 sf Storage= 3,256 cf

Plug-Flow detention time= 2,230.9 min calculated for 5,349 cf (98% of inflow)
 Center-of-Mass det. time= 2,218.2 min (2,980.0 - 761.8)

| Volume | Invert | Avail.Storage | Storage Description |
|--------|---------|---------------|---|
| #1 | 360.00' | 4,590 cf | Cultec R-280HD x 108 Effective Size= 46.9"W x 26.0"H => 6.07 sf x 7.00'L = 42.5 cf Overall Size= 47.0"W x 26.5"H x 8.00'L with 1.00' Overlap |

| Device | Routing | Invert | Outlet Devices |
|--------|-----------|---------|--|
| #1 | Primary | 360.00' | 18.00" Round RCP_Round 18" L= 115.0' RCP, groove end projecting, Ke= 0.200 Inlet / Outlet Invert= 360.00' / 356.88' S= 0.0271 '/' Cc= 0.900 n= 0.013, Flow Area= 1.77 sf |
| #2 | Secondary | 360.00' | 0.55" Vert. Orifice/Grate C= 0.600 |
| #3 | Device 1 | 361.00' | 1.0' long Sharp-Crested Rectangular Weir 2 End Contraction(s) |
| #4 | Device 1 | 361.20' | 1.0' long Sharp-Crested Rectangular Weir 2 End Contraction(s) |

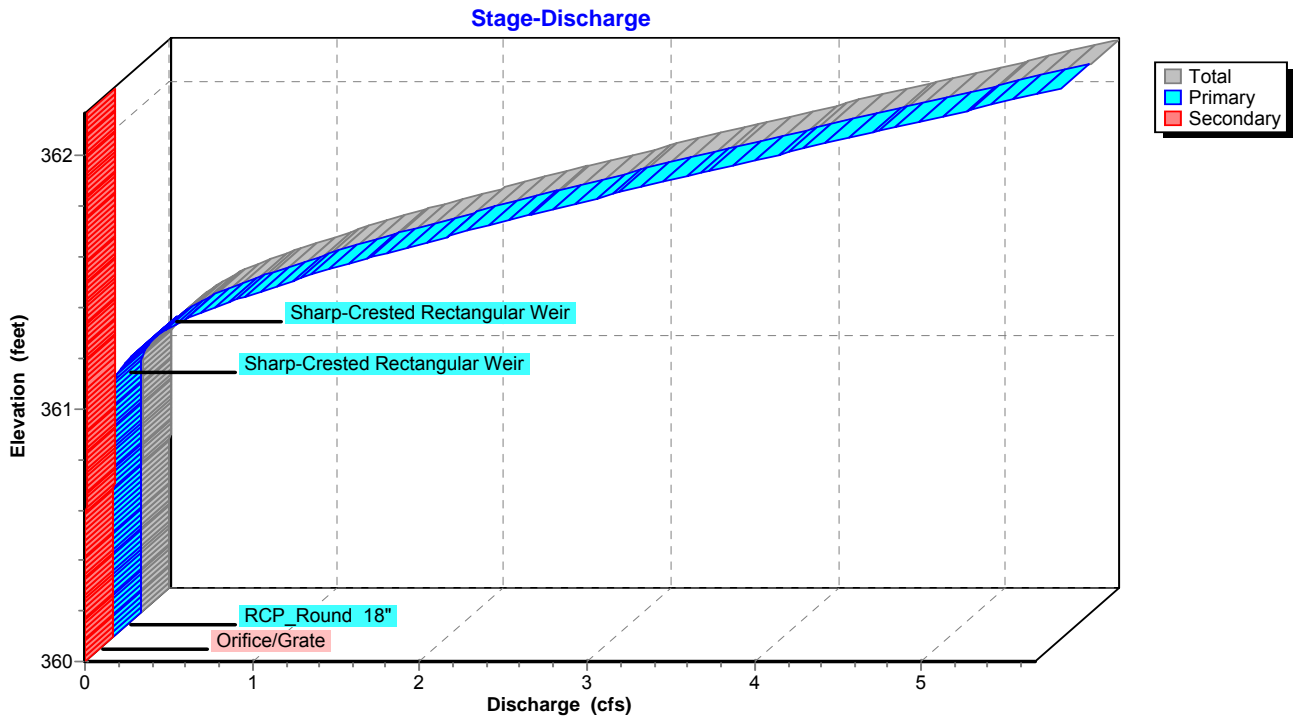
Primary OutFlow Max=0.385 cfs @ 12.15 hrs HW=361.24' (Free Discharge)

- ↑ 1=RCP_Round 18" (Passes 0.385 cfs of 7.387 cfs potential flow)
- ↑ 3=Sharp-Crested Rectangular Weir (Weir Controls 0.361 cfs @ 1.60 fps)
- ↑ 4=Sharp-Crested Rectangular Weir (Weir Controls 0.024 cfs @ 0.64 fps)

Secondary OutFlow Max=0.009 cfs @ 12.15 hrs HW=361.24' (Free Discharge)

- ↑ 2=Orifice/Grate (Orifice Controls 0.009 cfs @ 5.31 fps)

Pond 6P: UGB 1



Stage-Area-Storage for Pond 6P: UGB 1

| Elevation (feet) | Storage (cubic-feet) | Elevation (feet) | Storage (cubic-feet) | Elevation (feet) | Storage (cubic-feet) |
|---------------------|-------------------------|---------------------|-------------------------|---------------------|-------------------------|
| 360.00 | 0 | 361.06 | 2,840 | 362.12 | 4,585 |
| 360.02 | 59 | 361.08 | 2,888 | 362.14 | 4,588 |
| 360.04 | 118 | 361.10 | 2,936 | 362.16 | 4,590 |
| 360.06 | 176 | 361.12 | 2,984 | | |
| 360.08 | 234 | 361.14 | 3,031 | | |
| 360.10 | 292 | 361.16 | 3,078 | | |
| 360.12 | 349 | 361.18 | 3,124 | | |
| 360.14 | 406 | 361.20 | 3,170 | | |
| 360.16 | 463 | 361.22 | 3,215 | | |
| 360.18 | 520 | 361.24 | 3,260 | | |
| 360.20 | 576 | 361.26 | 3,305 | | |
| 360.22 | 632 | 361.28 | 3,349 | | |
| 360.24 | 688 | 361.30 | 3,393 | | |
| 360.26 | 744 | 361.32 | 3,436 | | |
| 360.28 | 800 | 361.34 | 3,479 | | |
| 360.30 | 856 | 361.36 | 3,521 | | |
| 360.32 | 912 | 361.38 | 3,563 | | |
| 360.34 | 968 | 361.40 | 3,605 | | |
| 360.36 | 1,023 | 361.42 | 3,646 | | |
| 360.38 | 1,079 | 361.44 | 3,687 | | |
| 360.40 | 1,134 | 361.46 | 3,727 | | |
| 360.42 | 1,190 | 361.48 | 3,767 | | |
| 360.44 | 1,245 | 361.50 | 3,806 | | |
| 360.46 | 1,300 | 361.52 | 3,845 | | |
| 360.48 | 1,355 | 361.54 | 3,883 | | |
| 360.50 | 1,409 | 361.56 | 3,921 | | |
| 360.52 | 1,464 | 361.58 | 3,958 | | |
| 360.54 | 1,517 | 361.60 | 3,994 | | |
| 360.56 | 1,571 | 361.62 | 4,030 | | |
| 360.58 | 1,624 | 361.64 | 4,065 | | |
| 360.60 | 1,678 | 361.66 | 4,100 | | |
| 360.62 | 1,731 | 361.68 | 4,134 | | |
| 360.64 | 1,783 | 361.70 | 4,167 | | |
| 360.66 | 1,836 | 361.72 | 4,199 | | |
| 360.68 | 1,888 | 361.74 | 4,230 | | |
| 360.70 | 1,941 | 361.76 | 4,261 | | |
| 360.72 | 1,993 | 361.78 | 4,291 | | |
| 360.74 | 2,044 | 361.80 | 4,319 | | |
| 360.76 | 2,096 | 361.82 | 4,347 | | |
| 360.78 | 2,147 | 361.84 | 4,374 | | |
| 360.80 | 2,197 | 361.86 | 4,399 | | |
| 360.82 | 2,248 | 361.88 | 4,423 | | |
| 360.84 | 2,298 | 361.90 | 4,446 | | |
| 360.86 | 2,348 | 361.92 | 4,468 | | |
| 360.88 | 2,398 | 361.94 | 4,488 | | |
| 360.90 | 2,448 | 361.96 | 4,506 | | |
| 360.92 | 2,498 | 361.98 | 4,522 | | |
| 360.94 | 2,547 | 362.00 | 4,537 | | |
| 360.96 | 2,596 | 362.02 | 4,549 | | |
| 360.98 | 2,645 | 362.04 | 4,560 | | |
| 361.00 | 2,694 | 362.06 | 4,569 | | |
| 361.02 | 2,743 | 362.08 | 4,576 | | |
| 361.04 | 2,792 | 362.10 | 4,581 | | |

Summary for Link 7L: POI#1 Total

Inflow Area = 64,948 sf, 80.75% Impervious, Inflow Depth = 1.95" for 2 year event

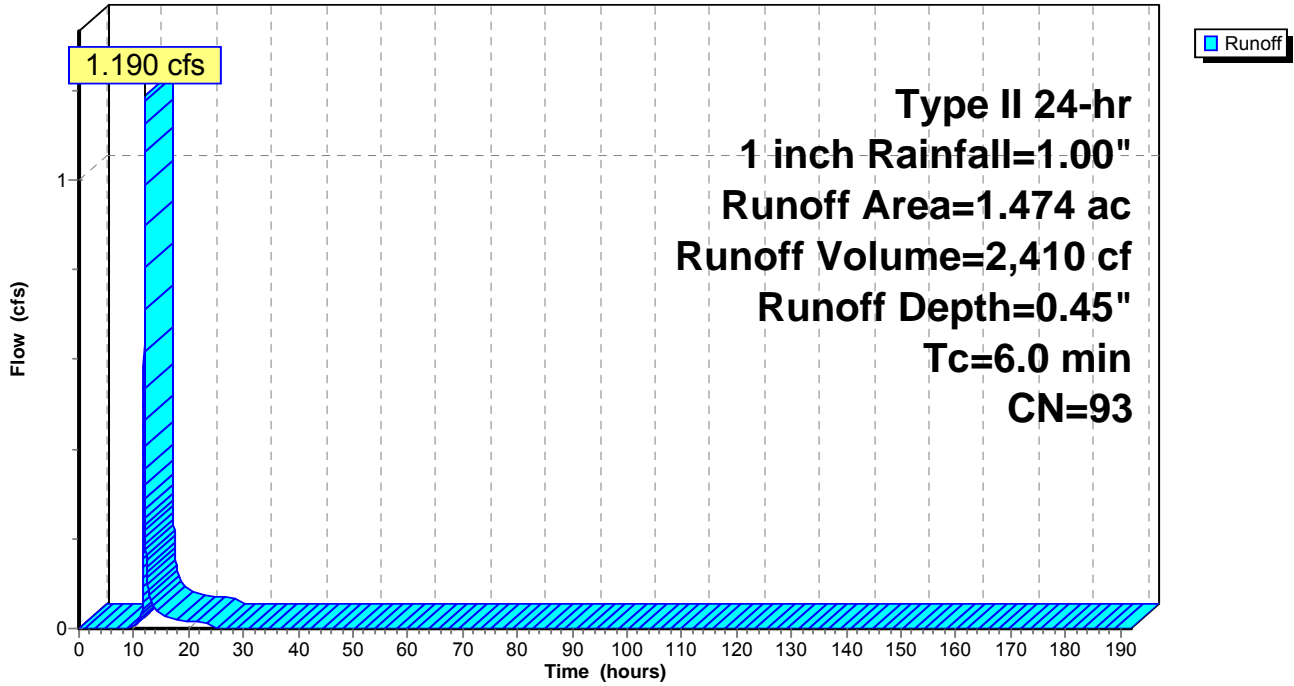
Inflow = 3.875 cfs @ 11.97 hrs, Volume= 10,552 cf

Primary = 3.875 cfs @ 11.97 hrs, Volume= 10,552 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-192.00 hrs, dt= 0.01 hrs

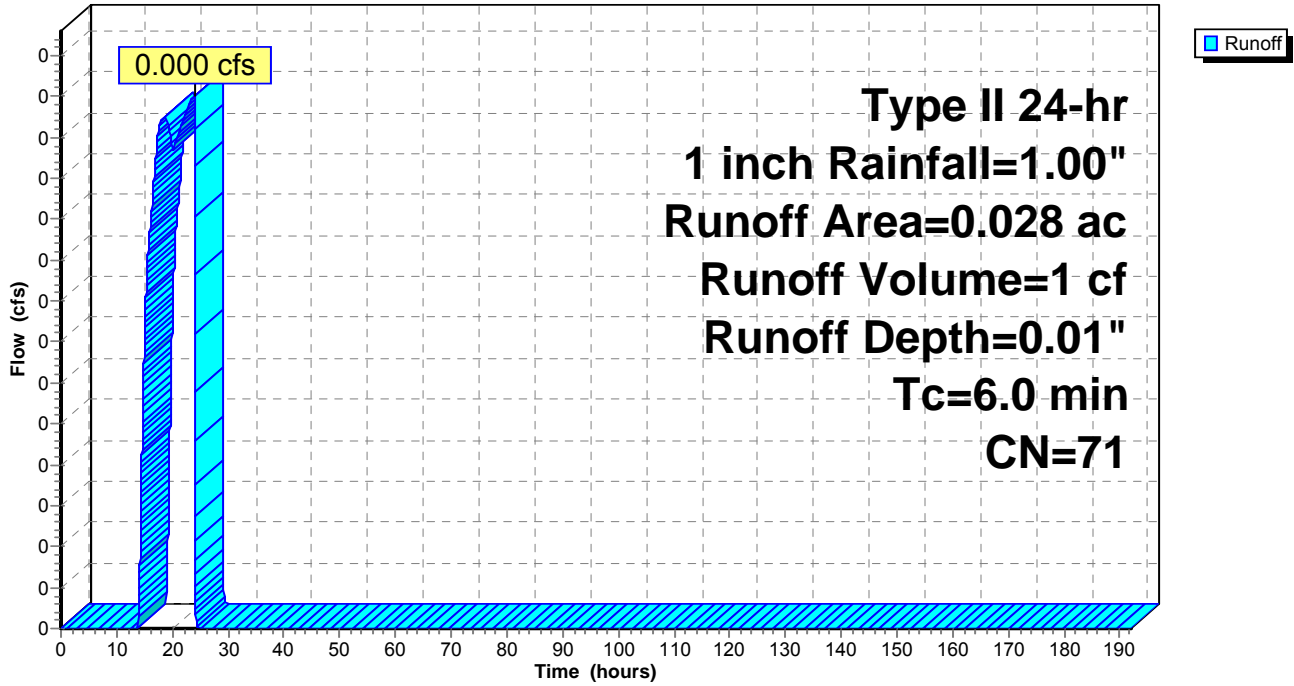
Subcatchment 1S: Pre POI#1

Hydrograph



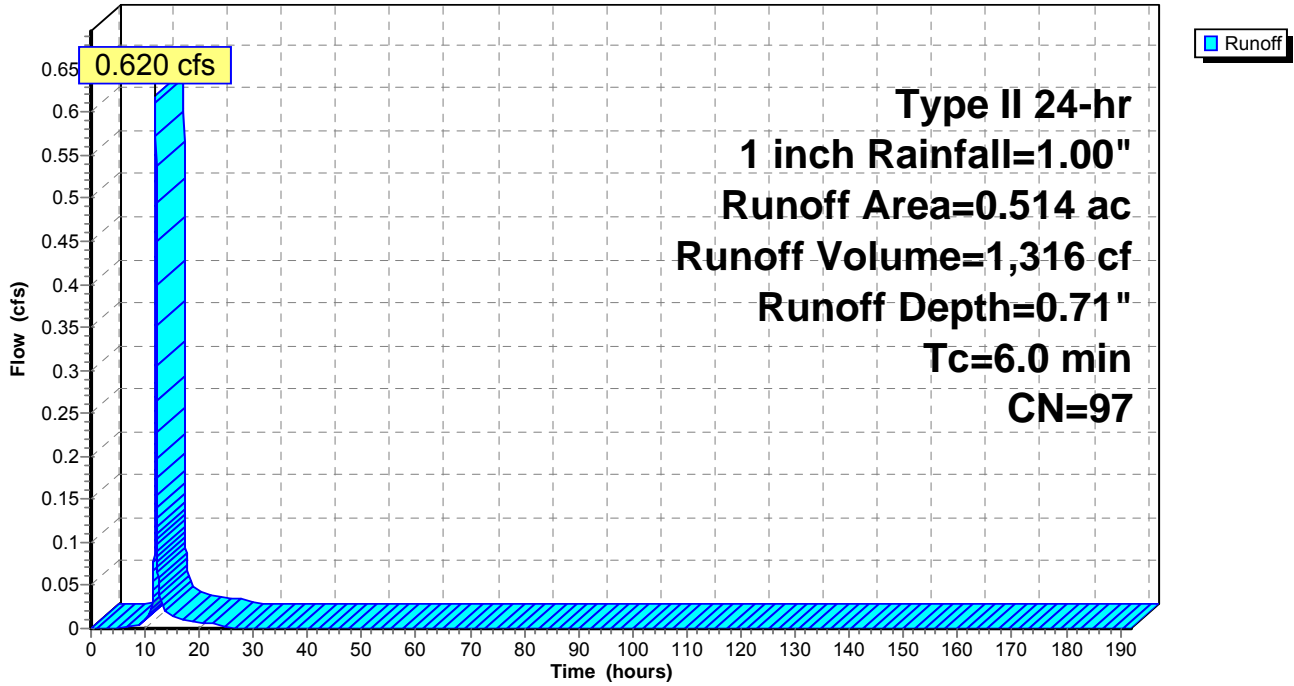
Subcatchment 2S: Pre POI#2

Hydrograph



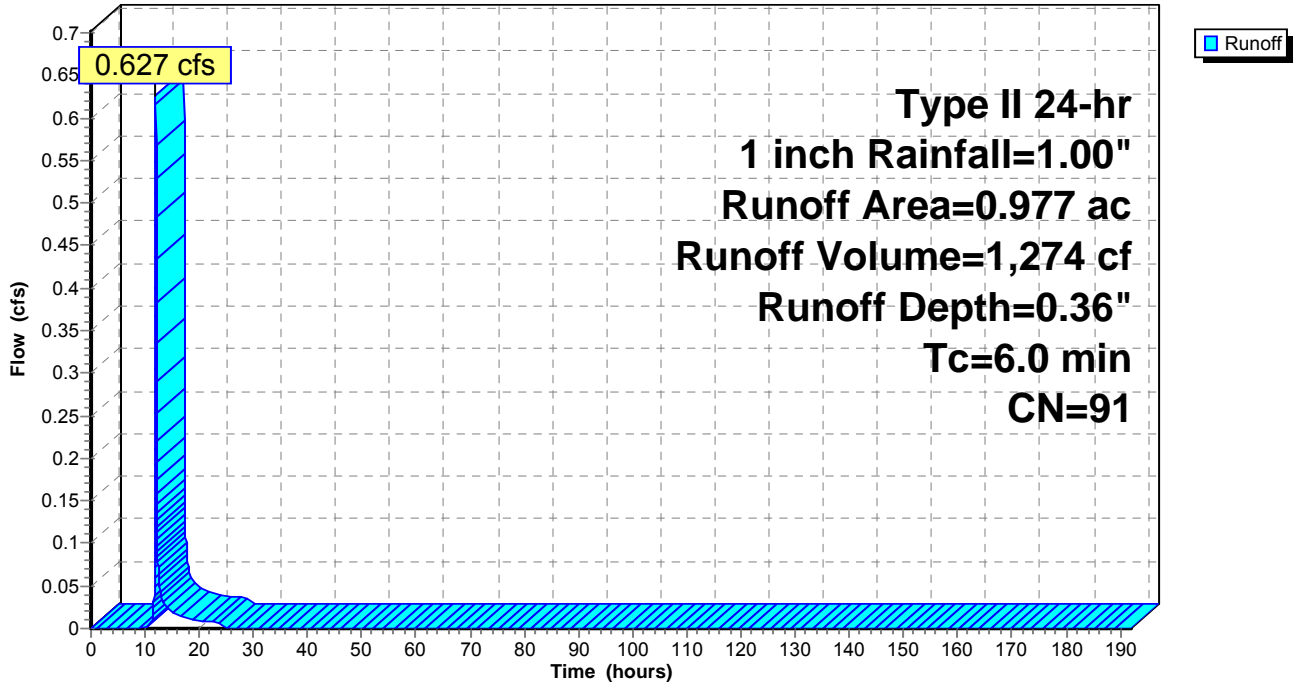
Subcatchment 3S: Post POI#1 to Basin

Hydrograph



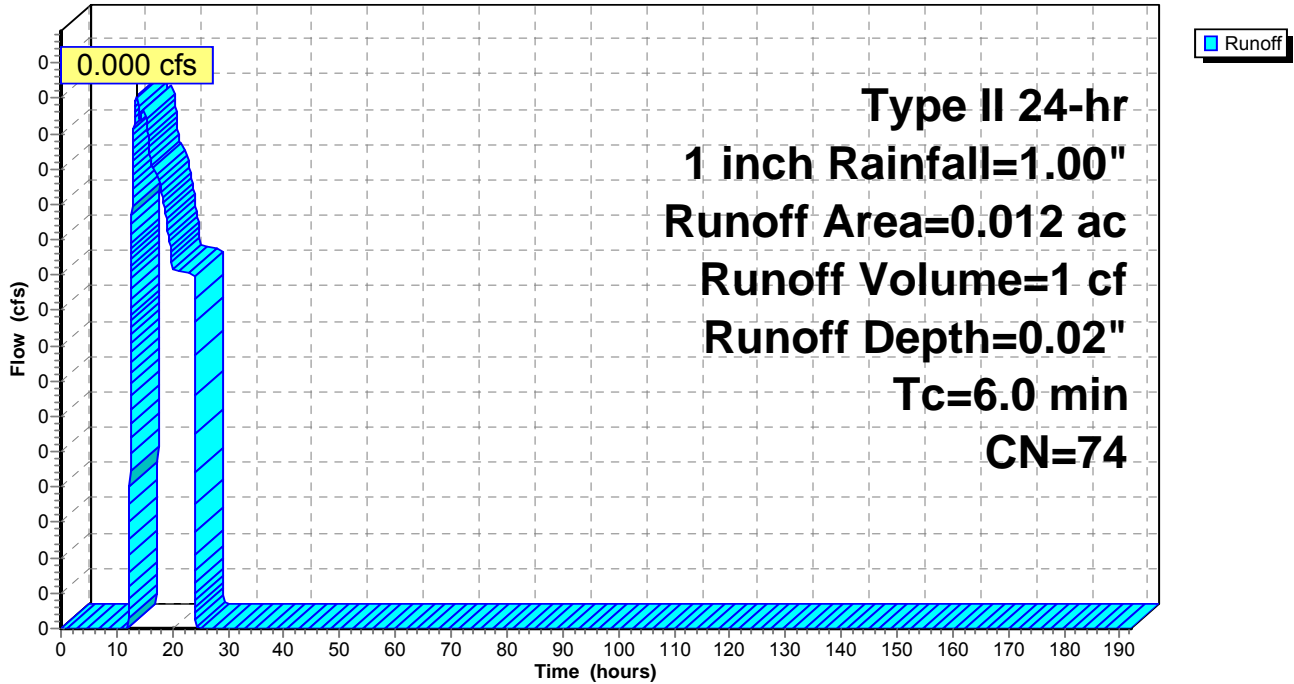
Subcatchment 4S: Post POI#1 Bypass

Hydrograph



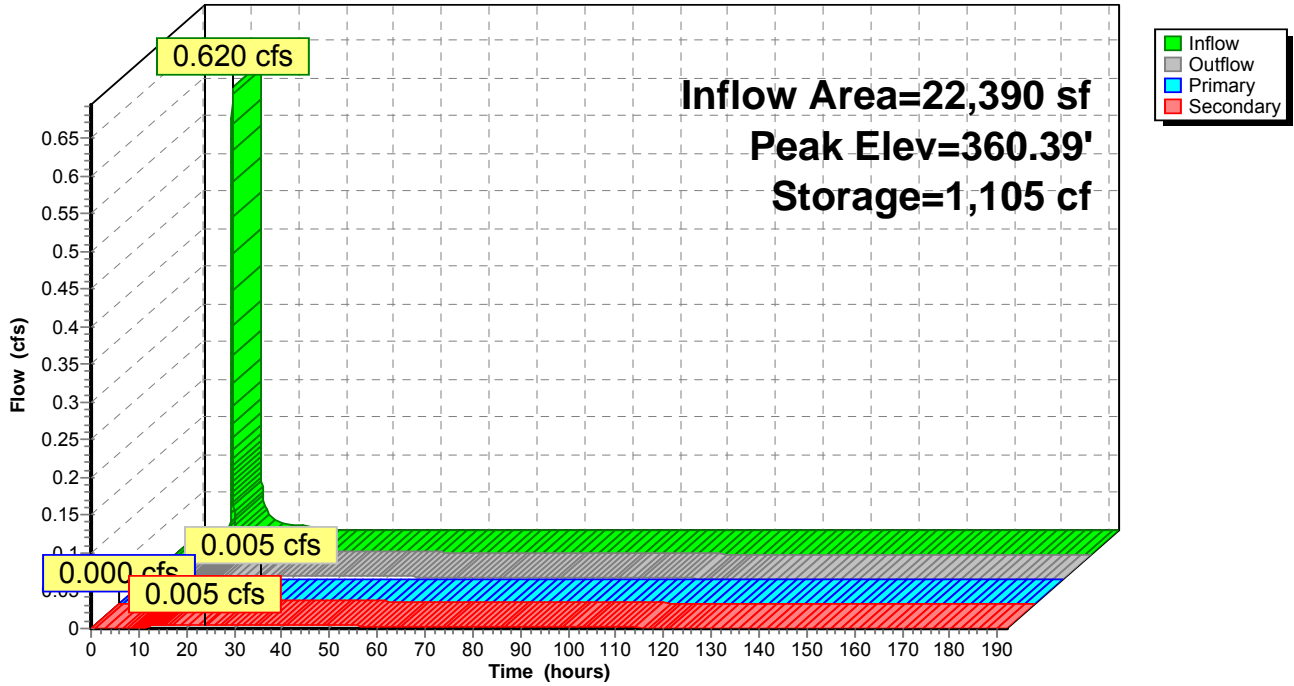
Subcatchment 5S: Post POI#2

Hydrograph



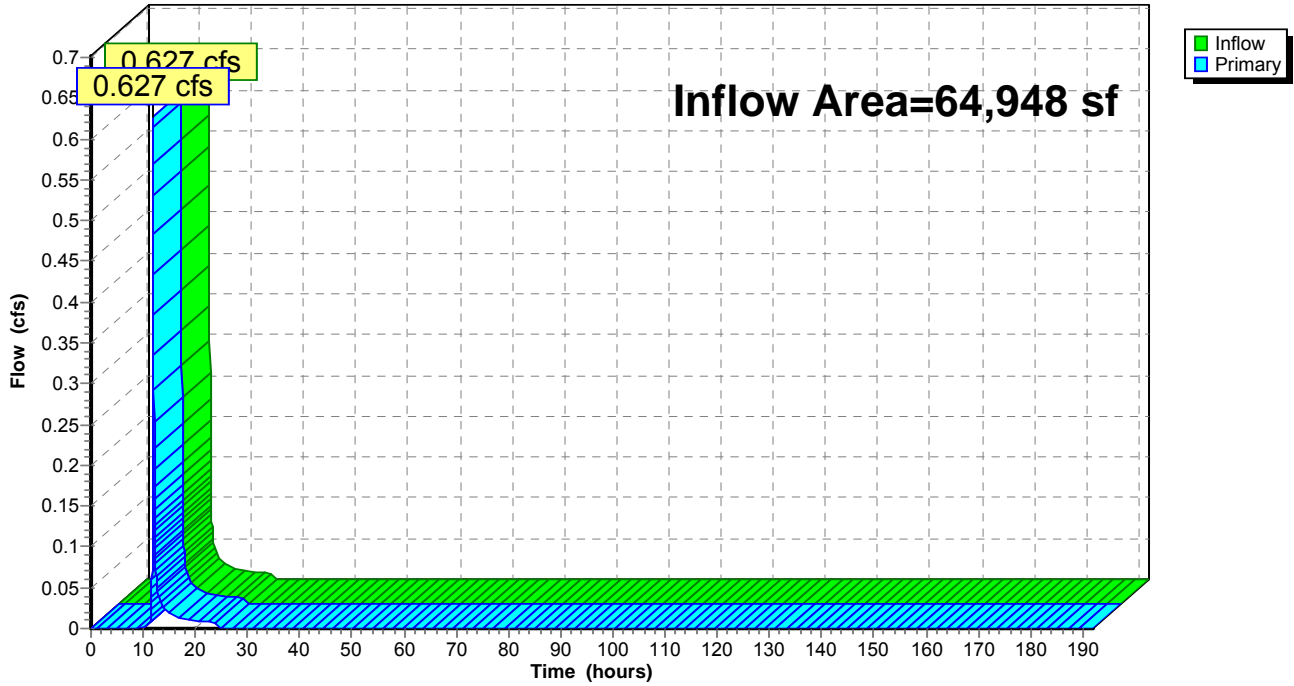
Pond 6P: UGB 1

Hydrograph



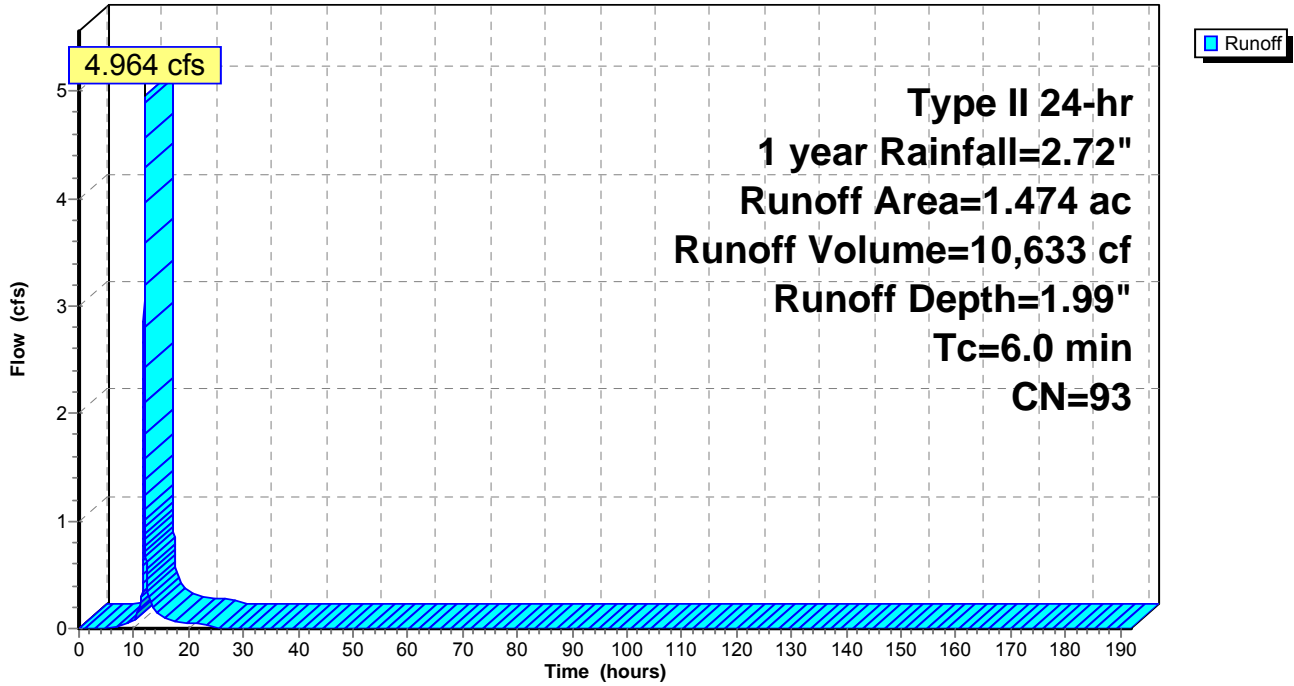
Link 7L: POI#1 Total

Hydrograph



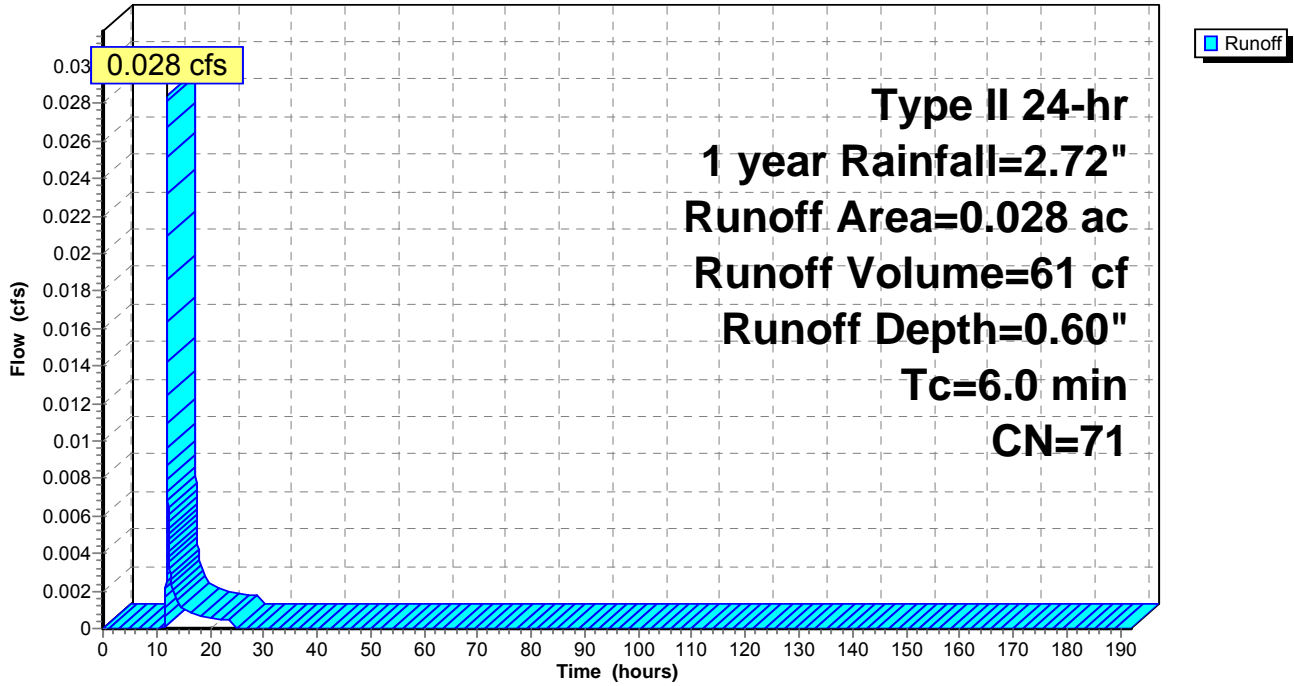
Subcatchment 1S: Pre POI#1

Hydrograph



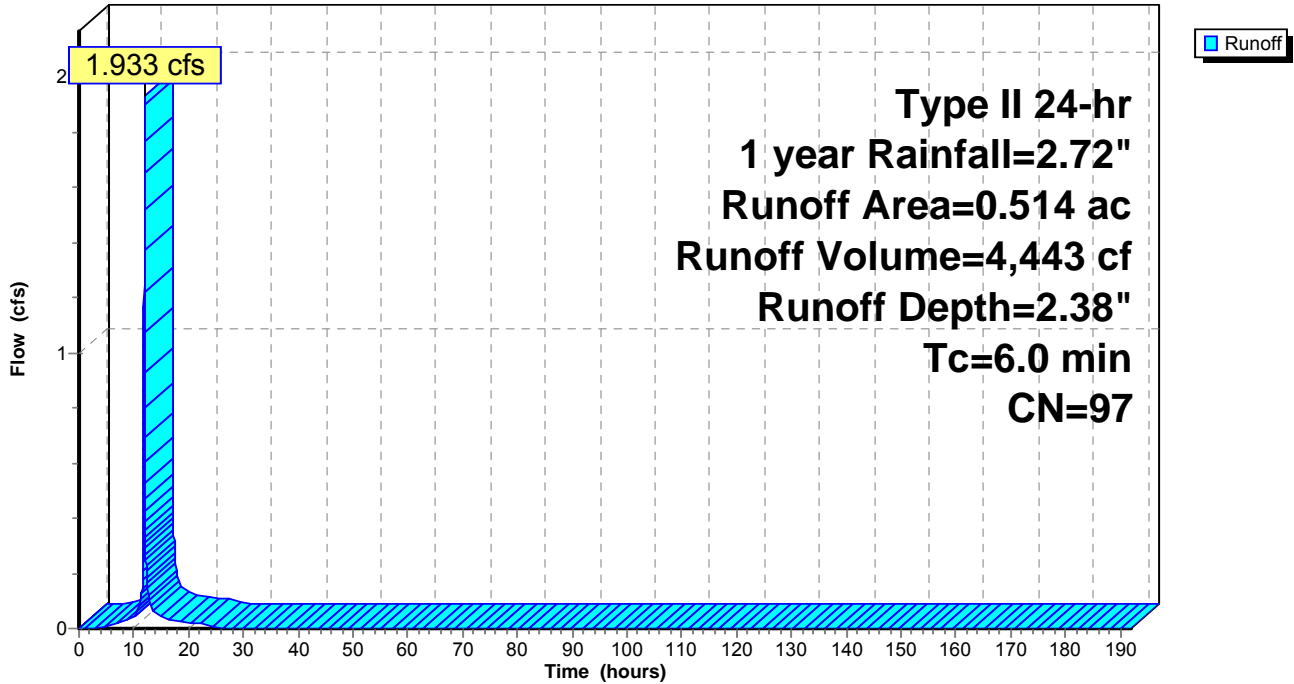
Subcatchment 2S: Pre POI#2

Hydrograph



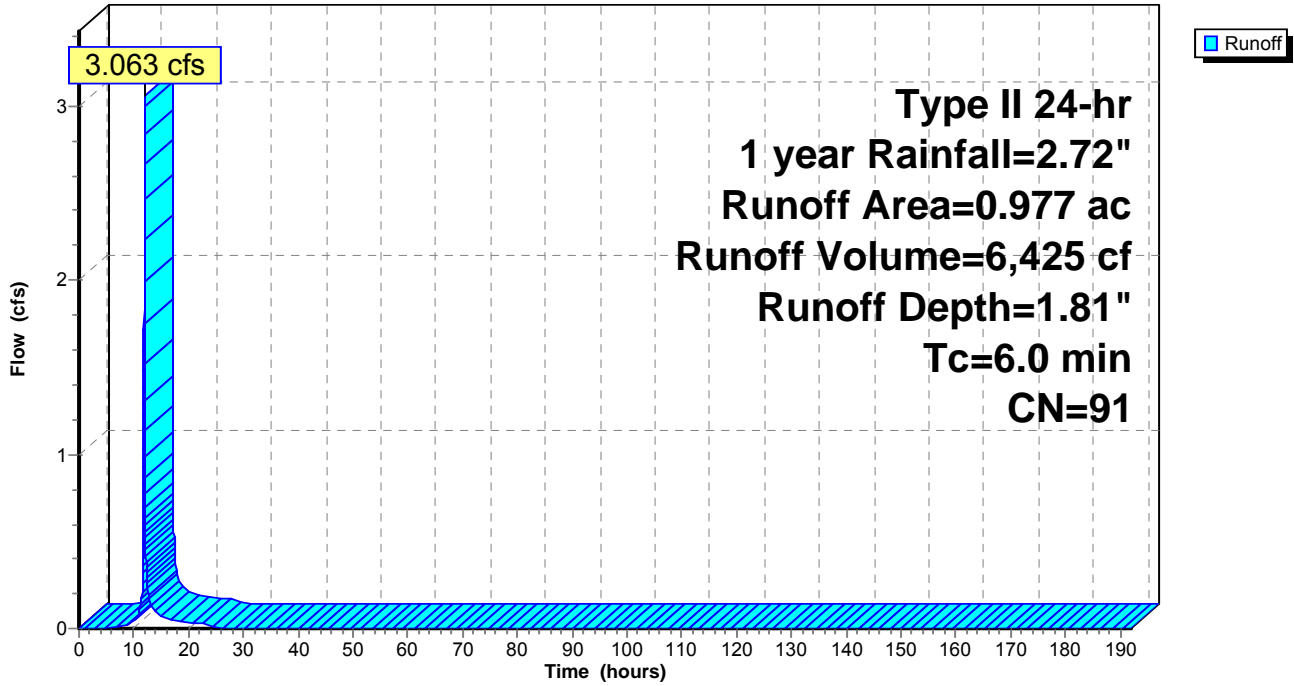
Subcatchment 3S: Post POI#1 to Basin

Hydrograph



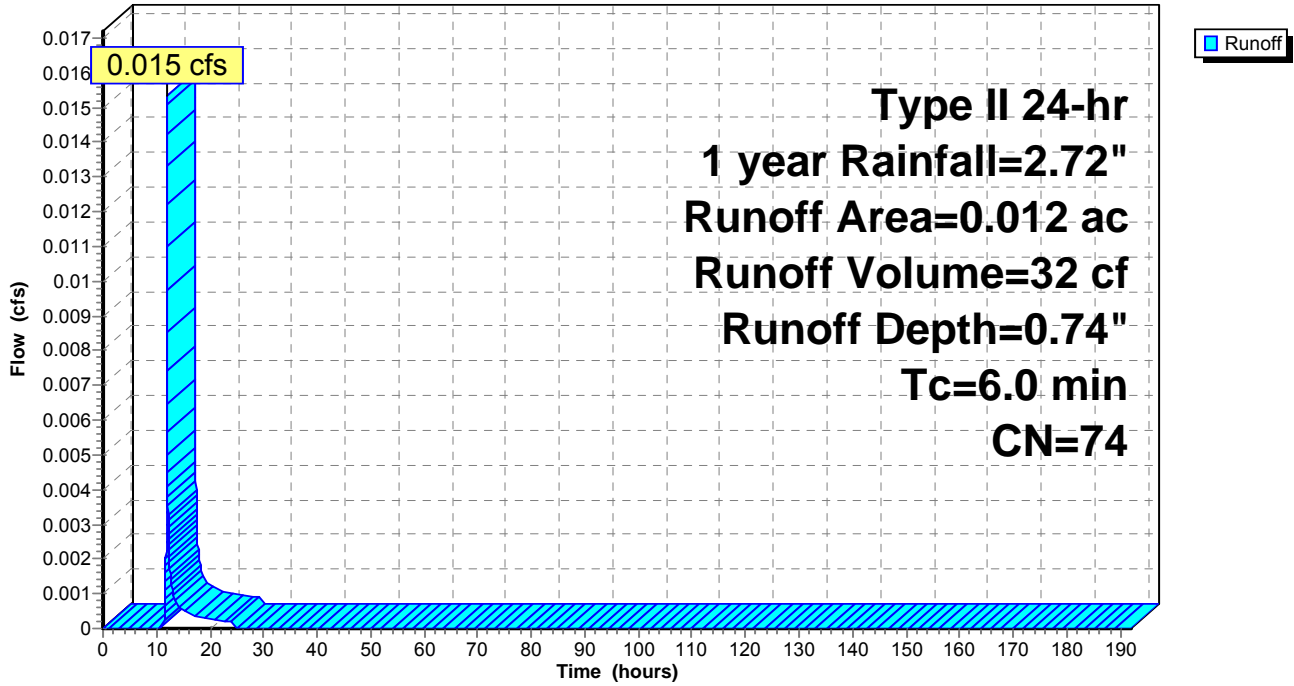
Subcatchment 4S: Post POI#1 Bypass

Hydrograph



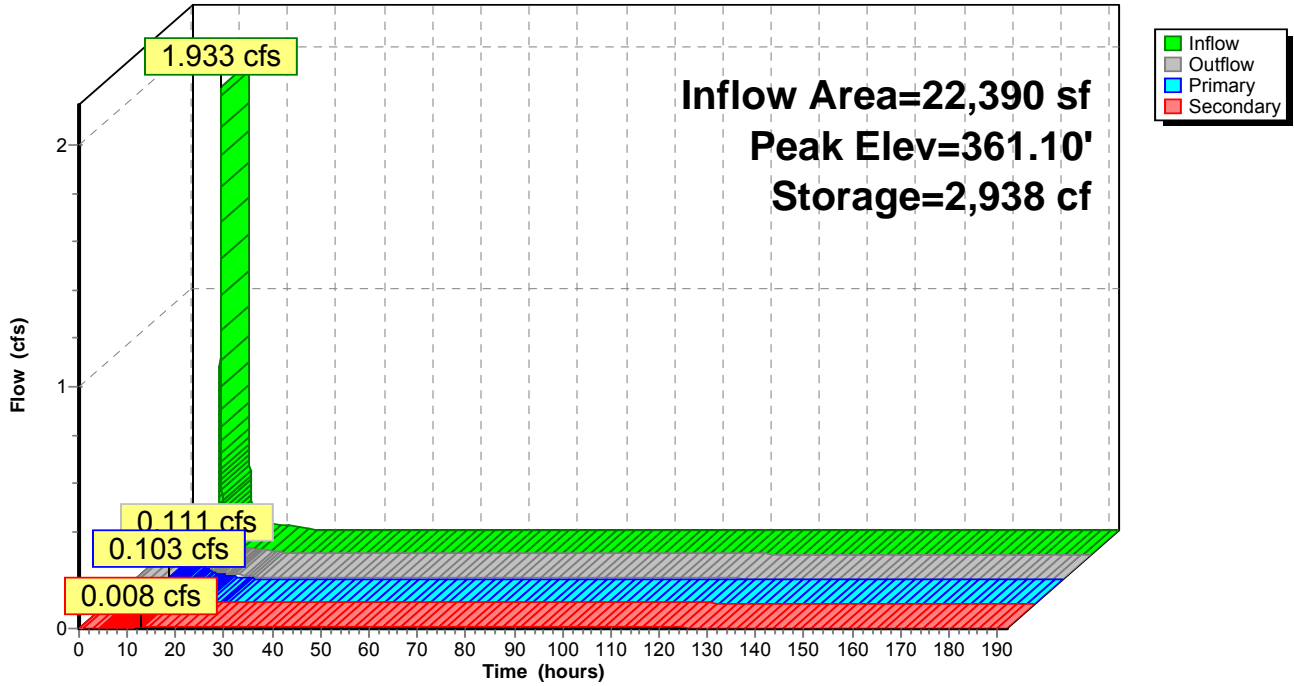
Subcatchment 5S: Post POI#2

Hydrograph



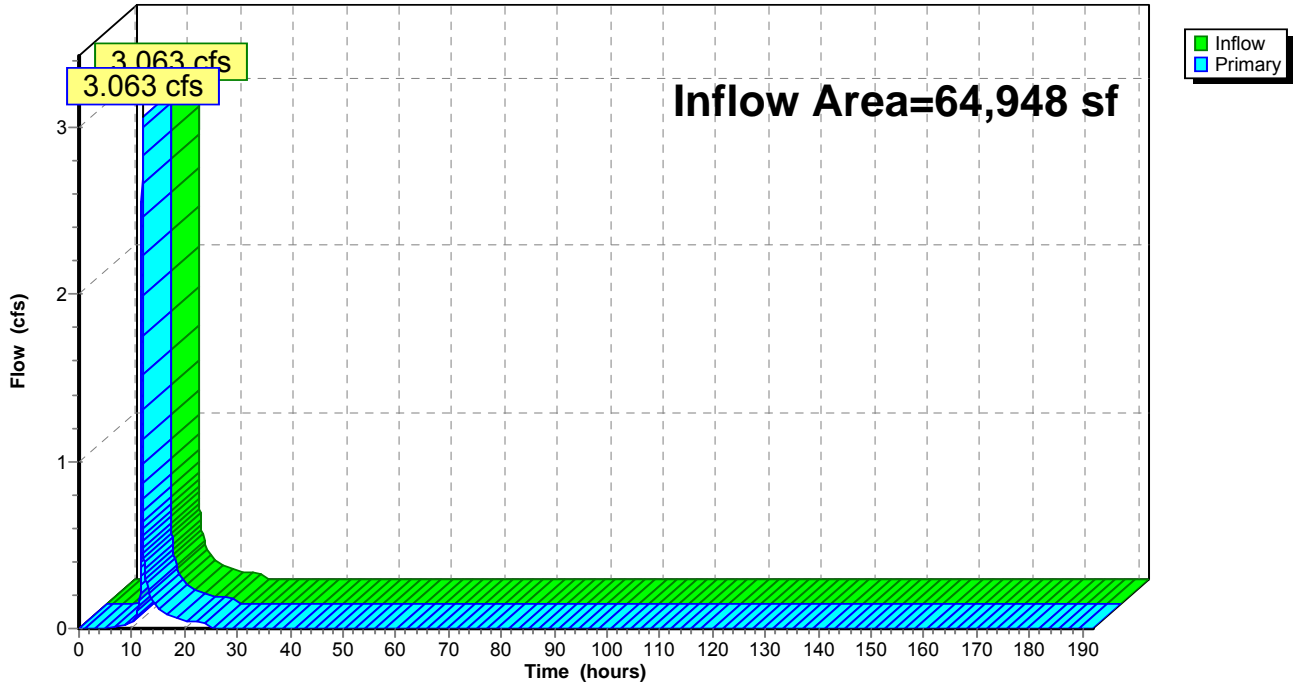
Pond 6P: UGB 1

Hydrograph



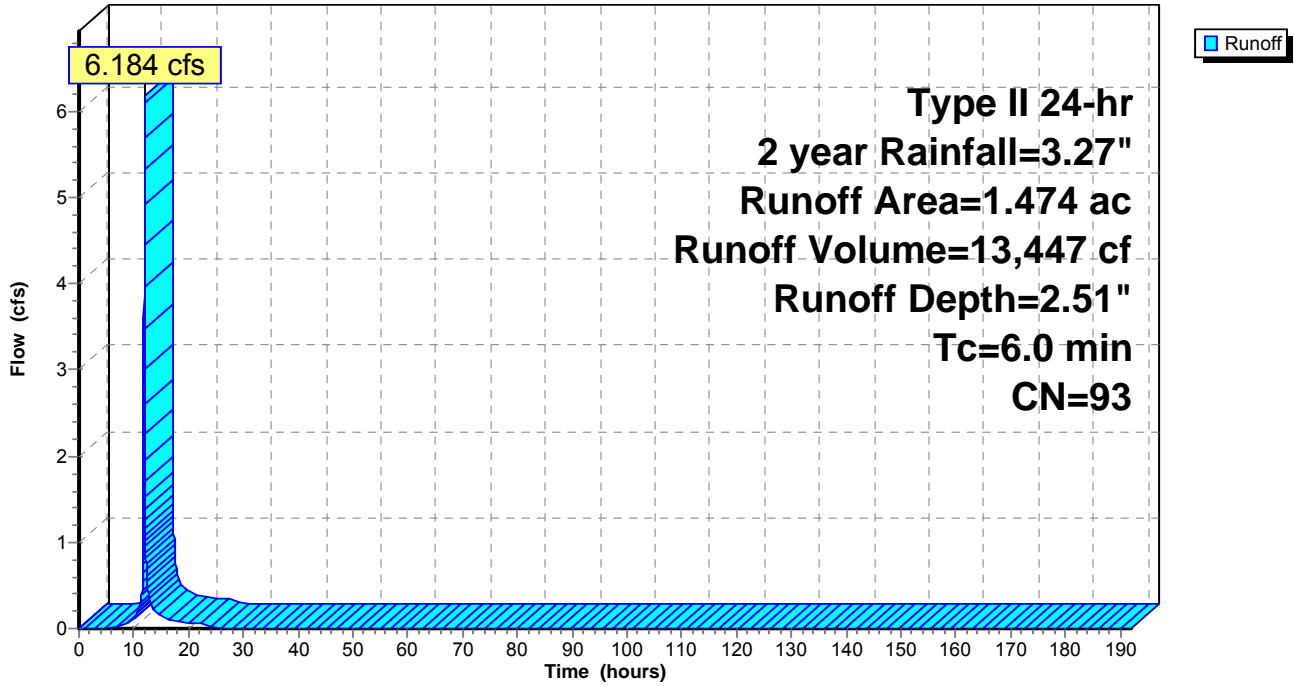
Link 7L: POI#1 Total

Hydrograph



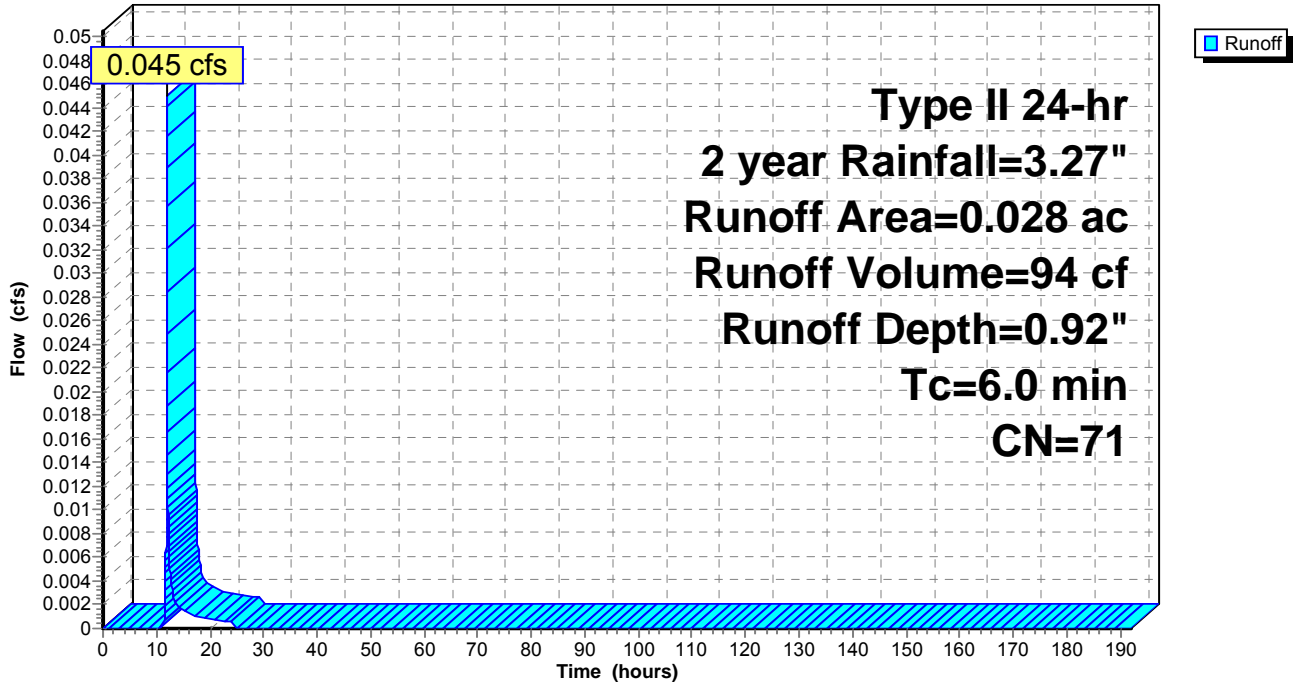
Subcatchment 1S: Pre POI#1

Hydrograph



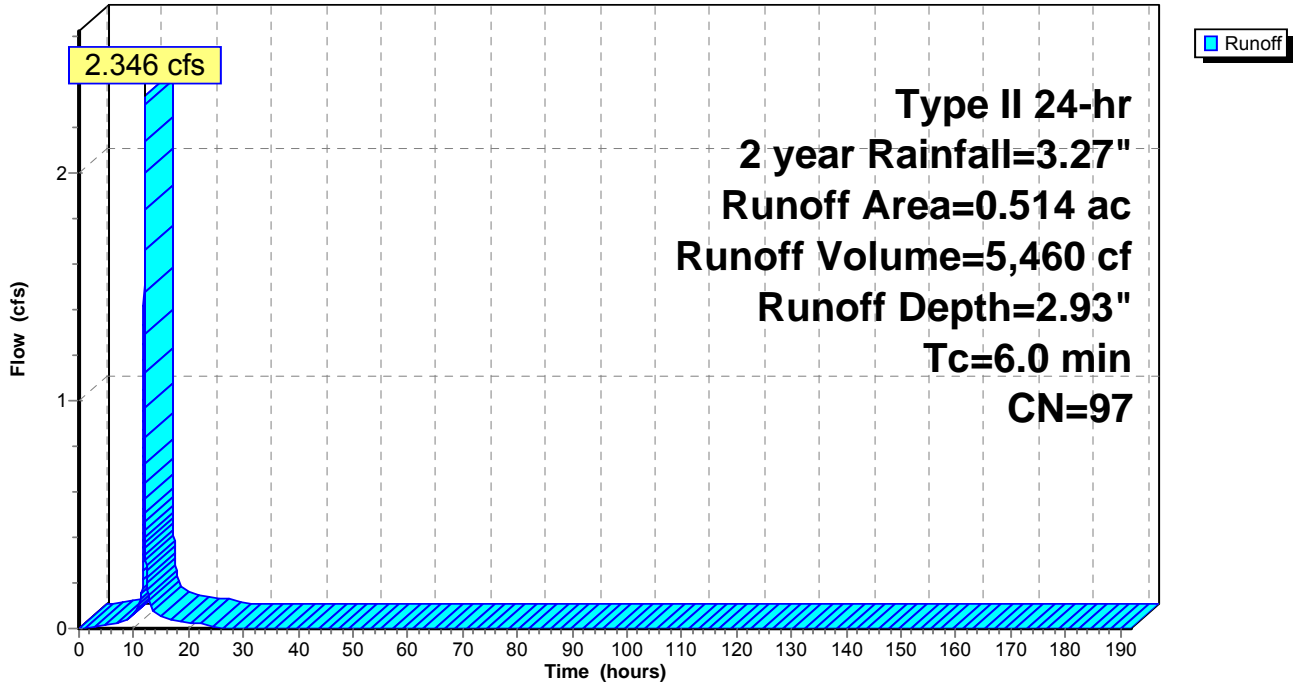
Subcatchment 2S: Pre POI#2

Hydrograph



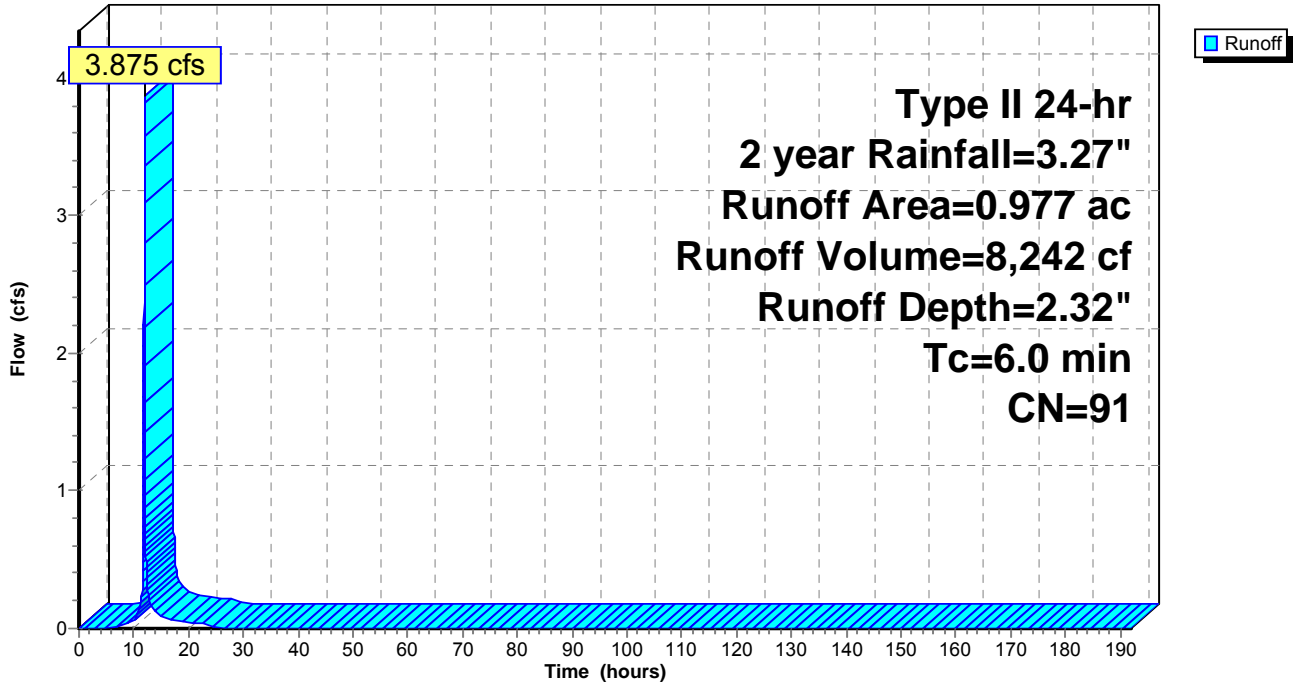
Subcatchment 3S: Post POI#1 to Basin

Hydrograph



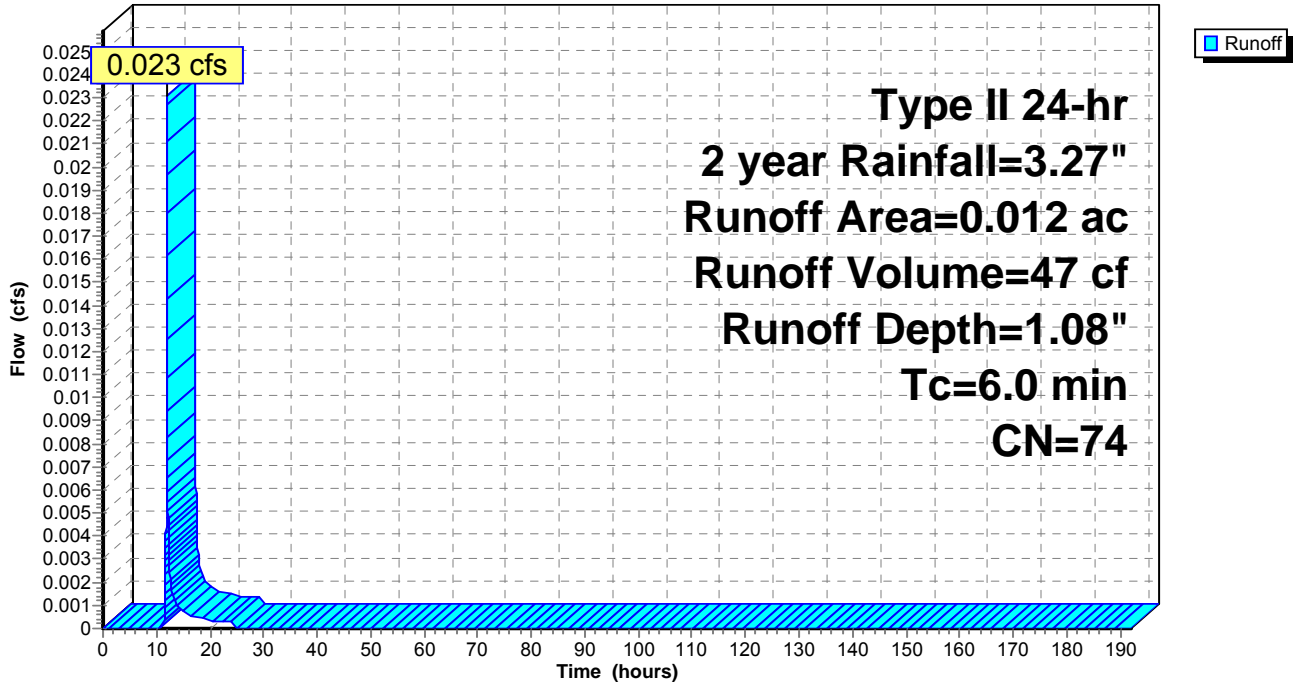
Subcatchment 4S: Post POI#1 Bypass

Hydrograph



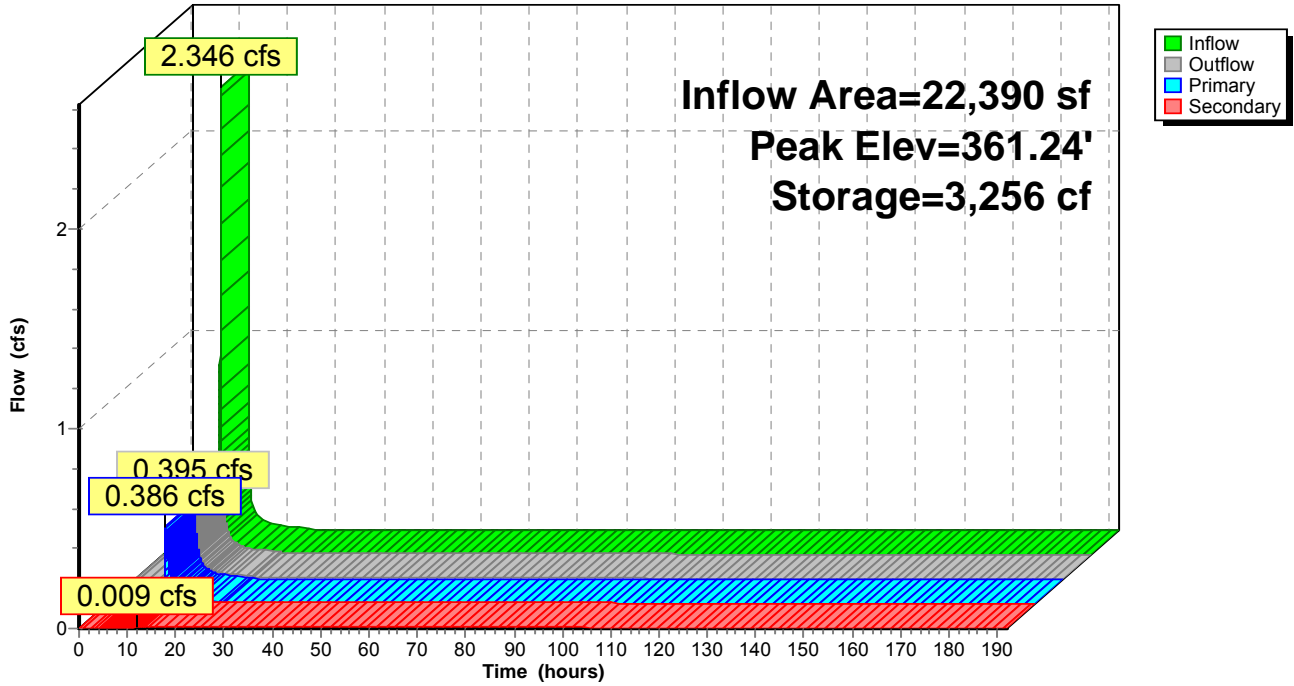
Subcatchment 5S: Post POI#2

Hydrograph



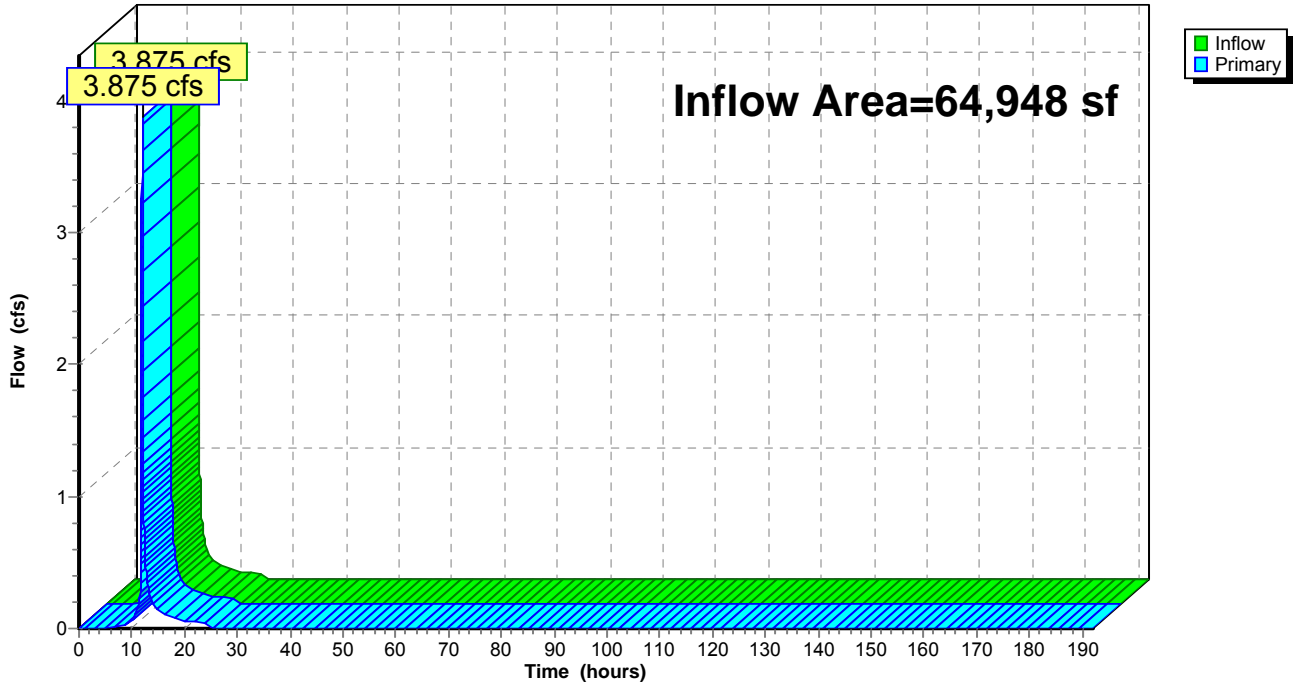
Pond 6P: UGB 1

Hydrograph



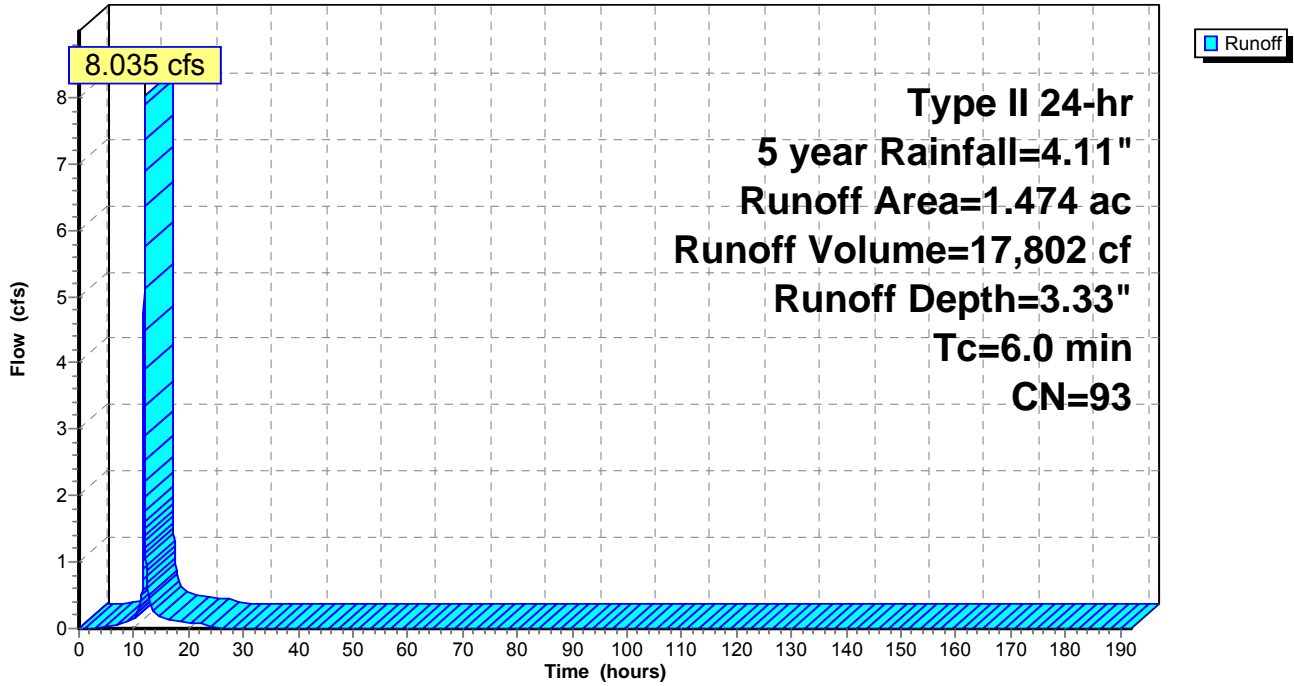
Link 7L: POI#1 Total

Hydrograph



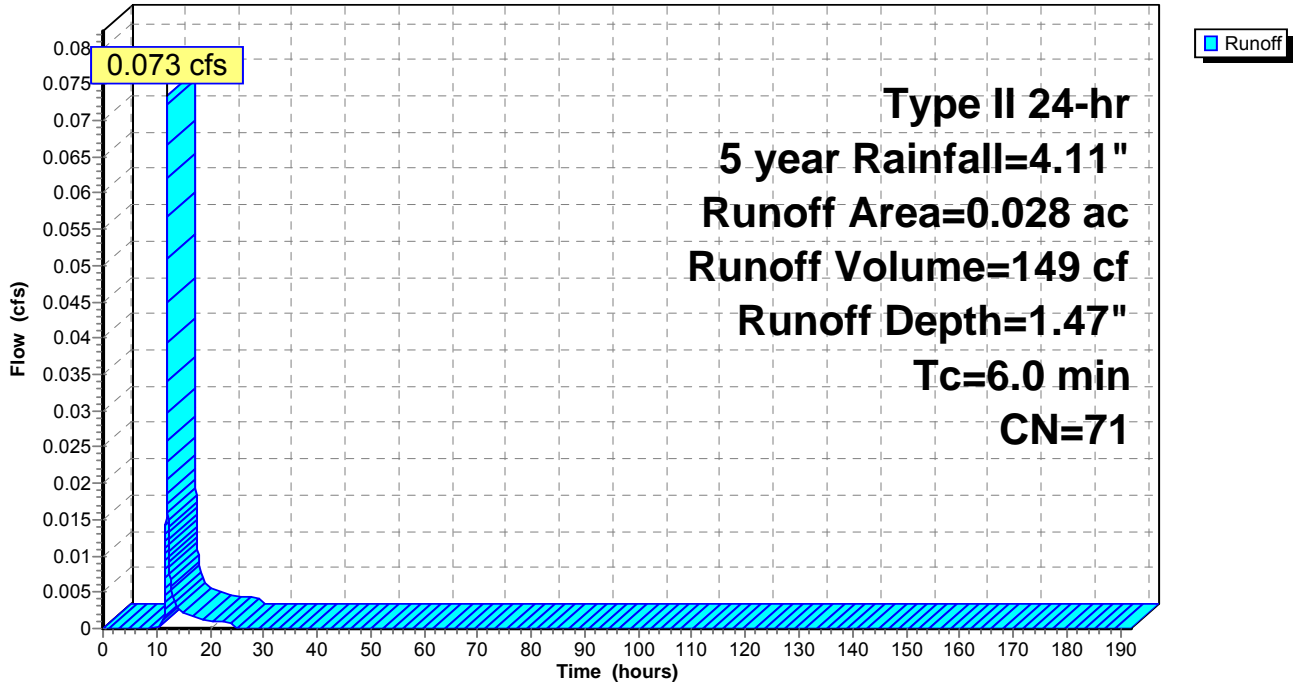
Subcatchment 1S: Pre POI#1

Hydrograph



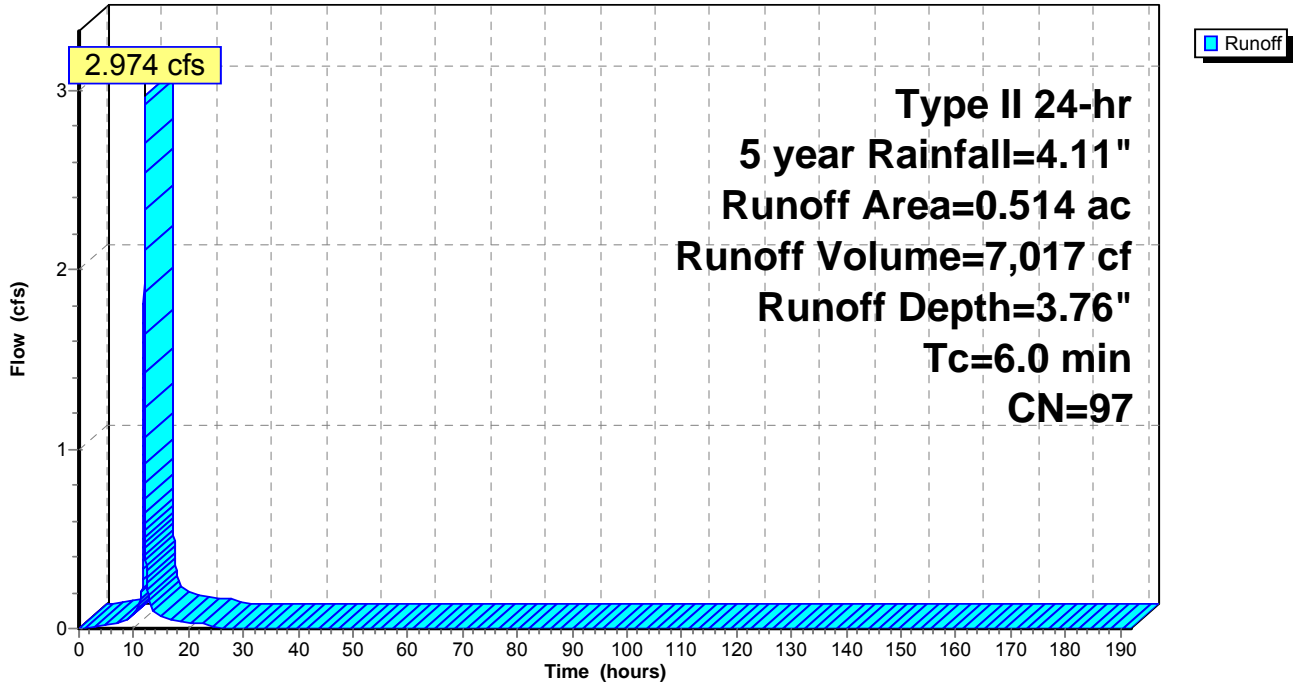
Subcatchment 2S: Pre POI#2

Hydrograph



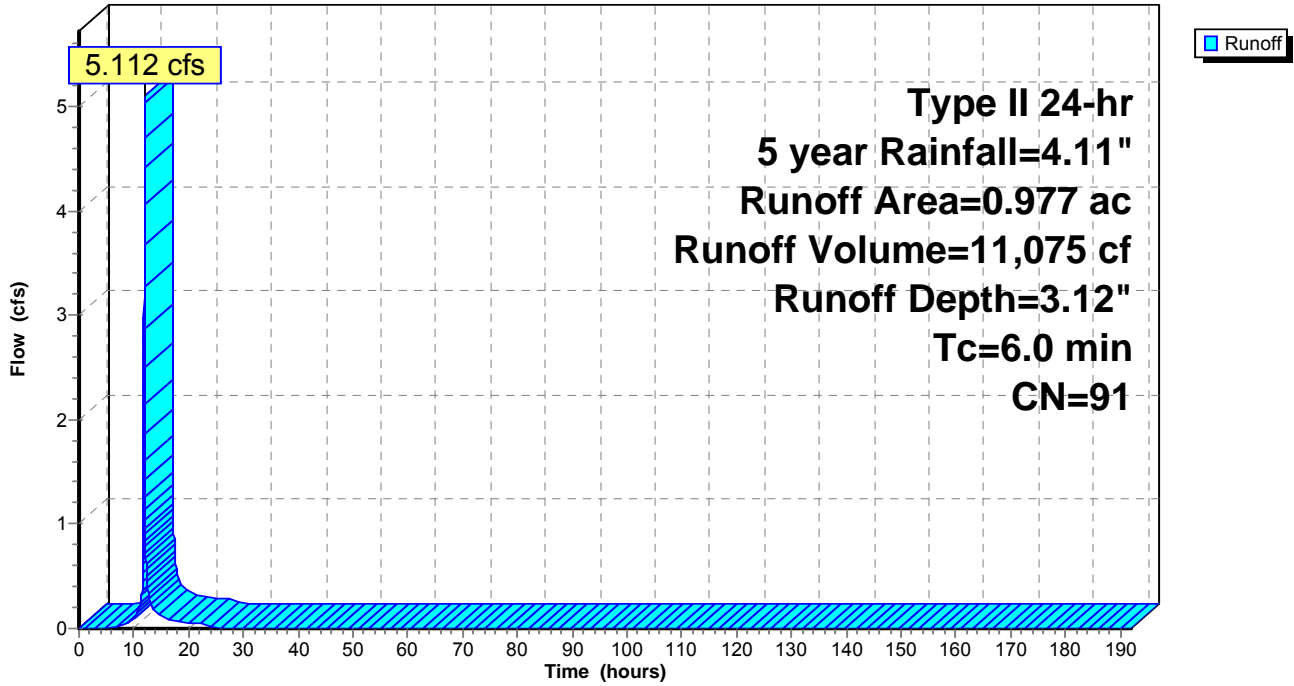
Subcatchment 3S: Post POI#1 to Basin

Hydrograph



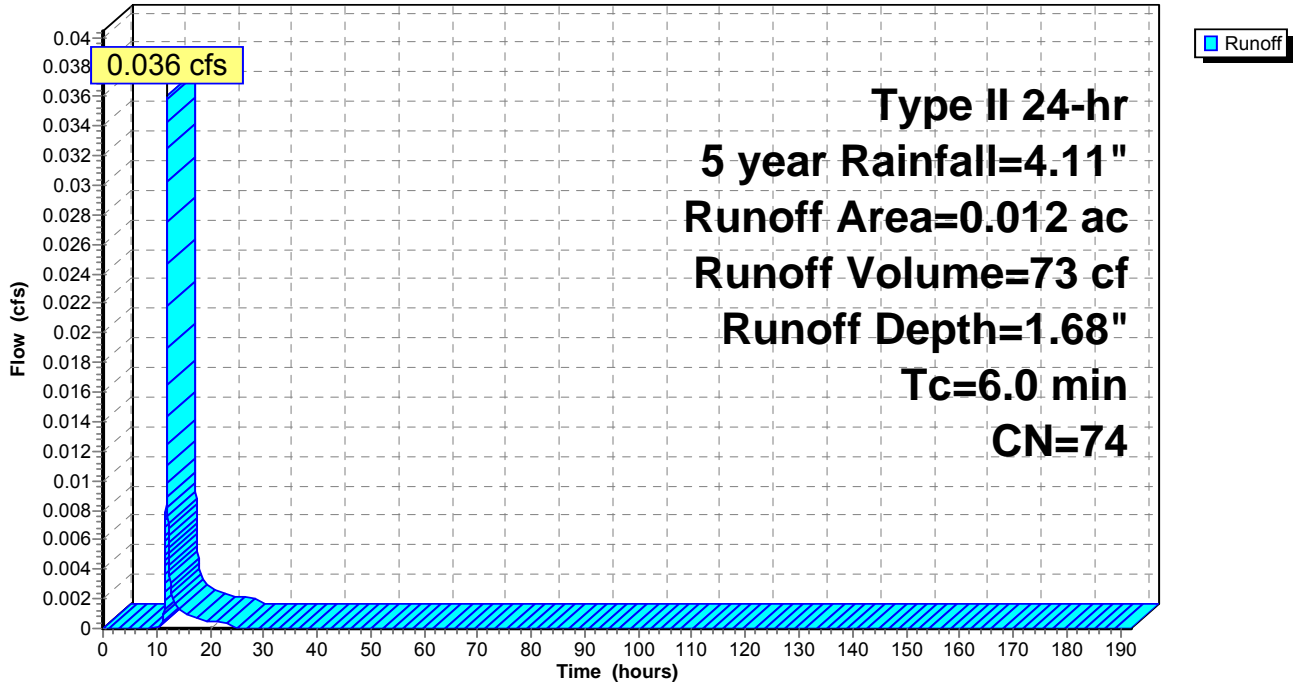
Subcatchment 4S: Post POI#1 Bypass

Hydrograph



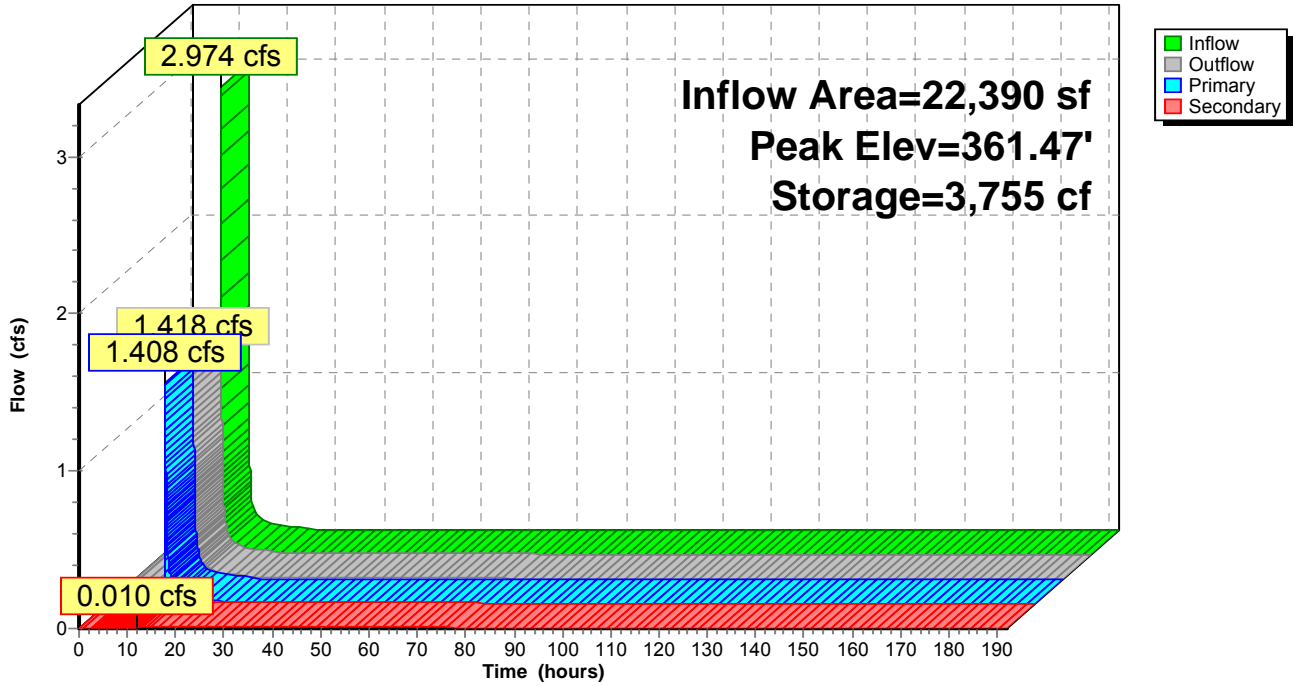
Subcatchment 5S: Post POI#2

Hydrograph



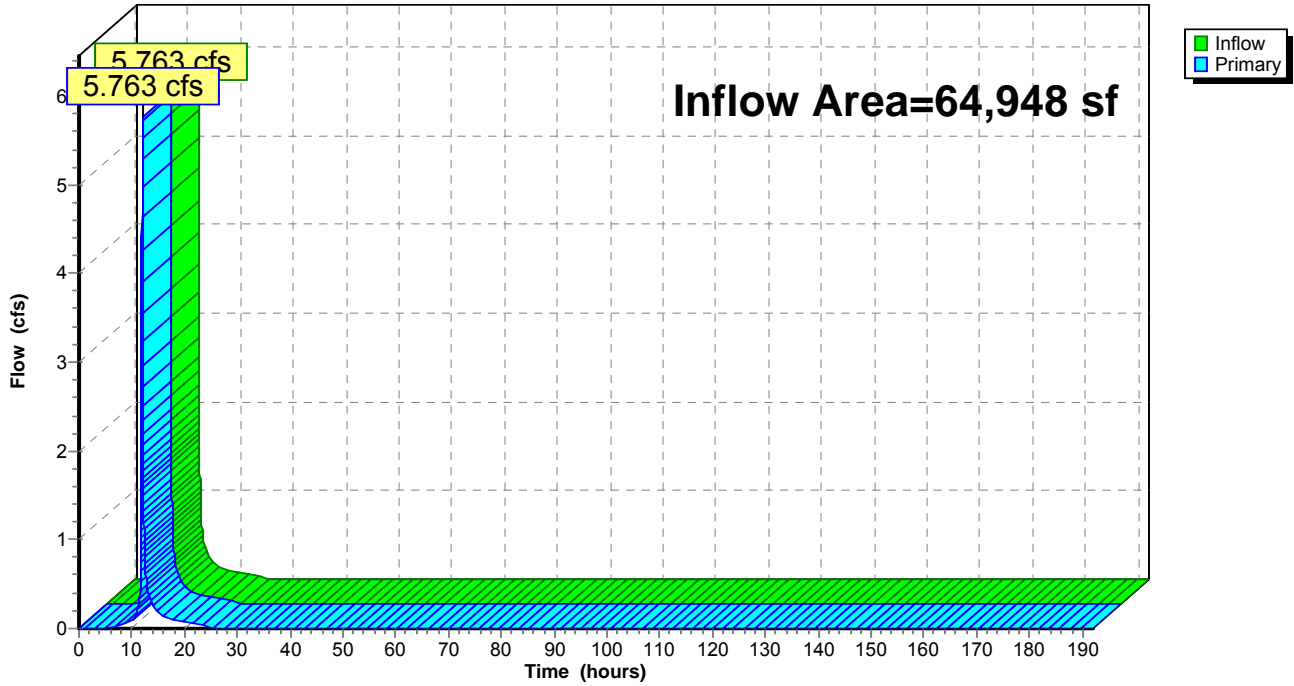
Pond 6P: UGB 1

Hydrograph



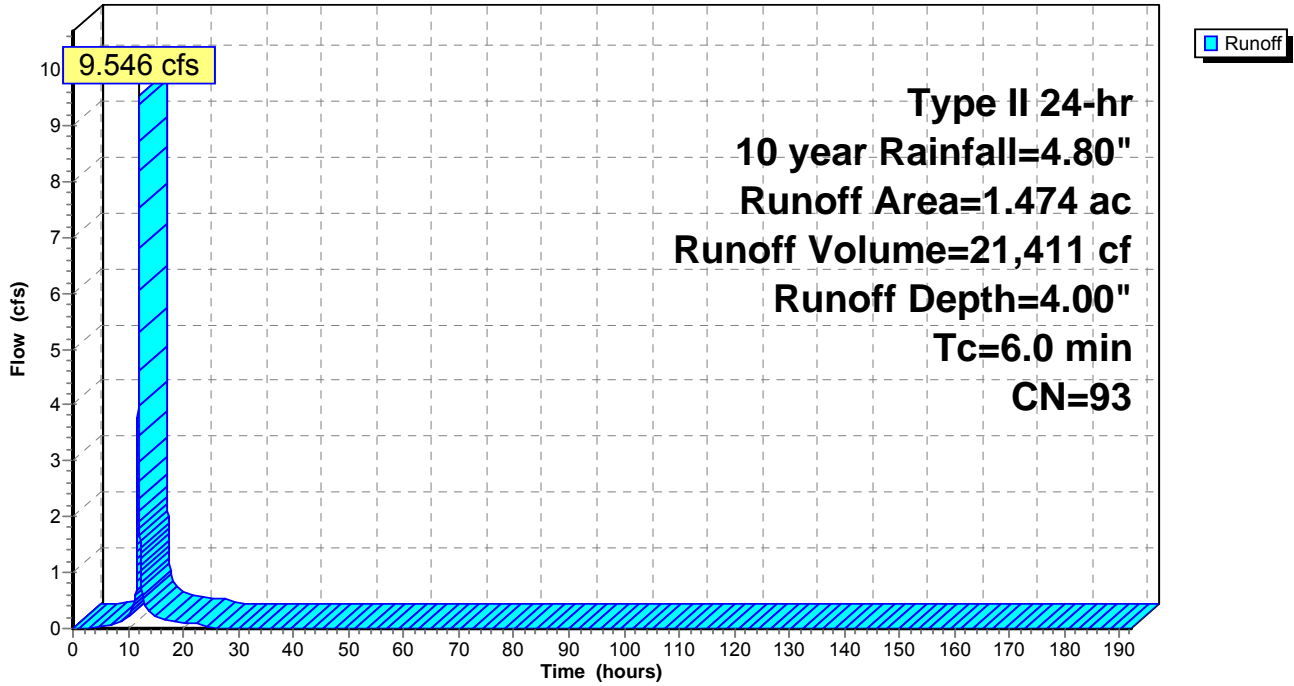
Link 7L: POI#1 Total

Hydrograph



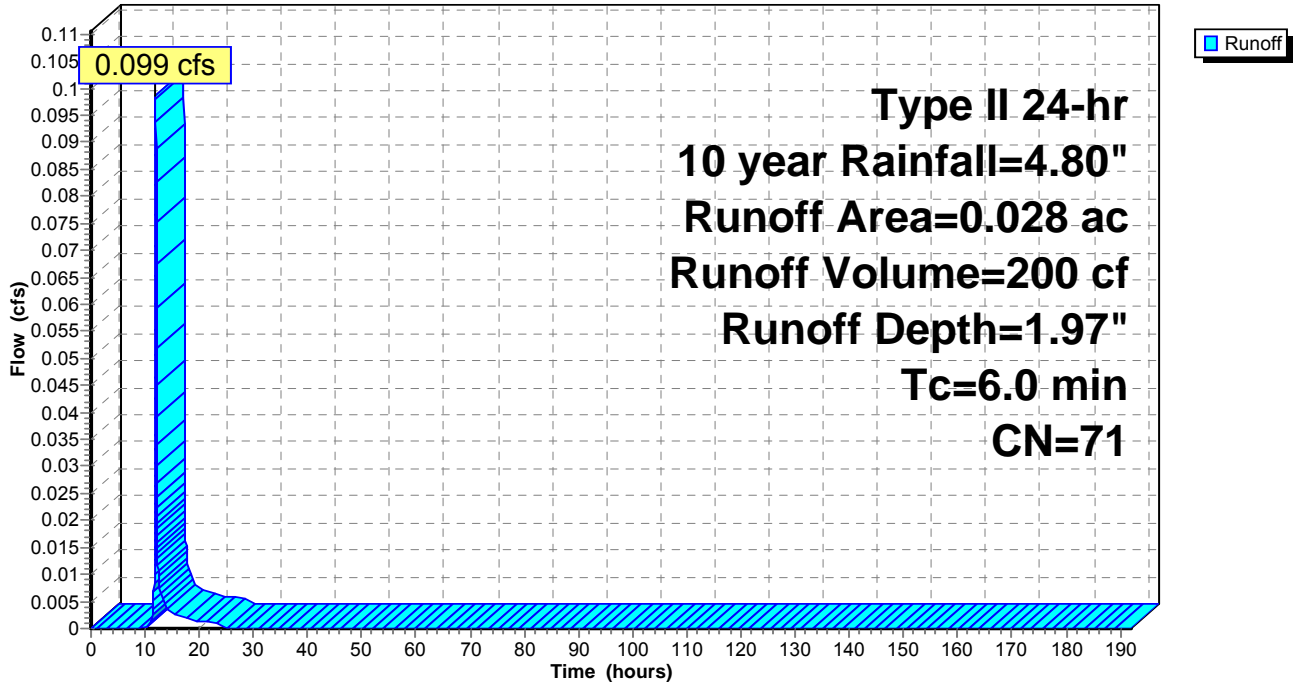
Subcatchment 1S: Pre POI#1

Hydrograph



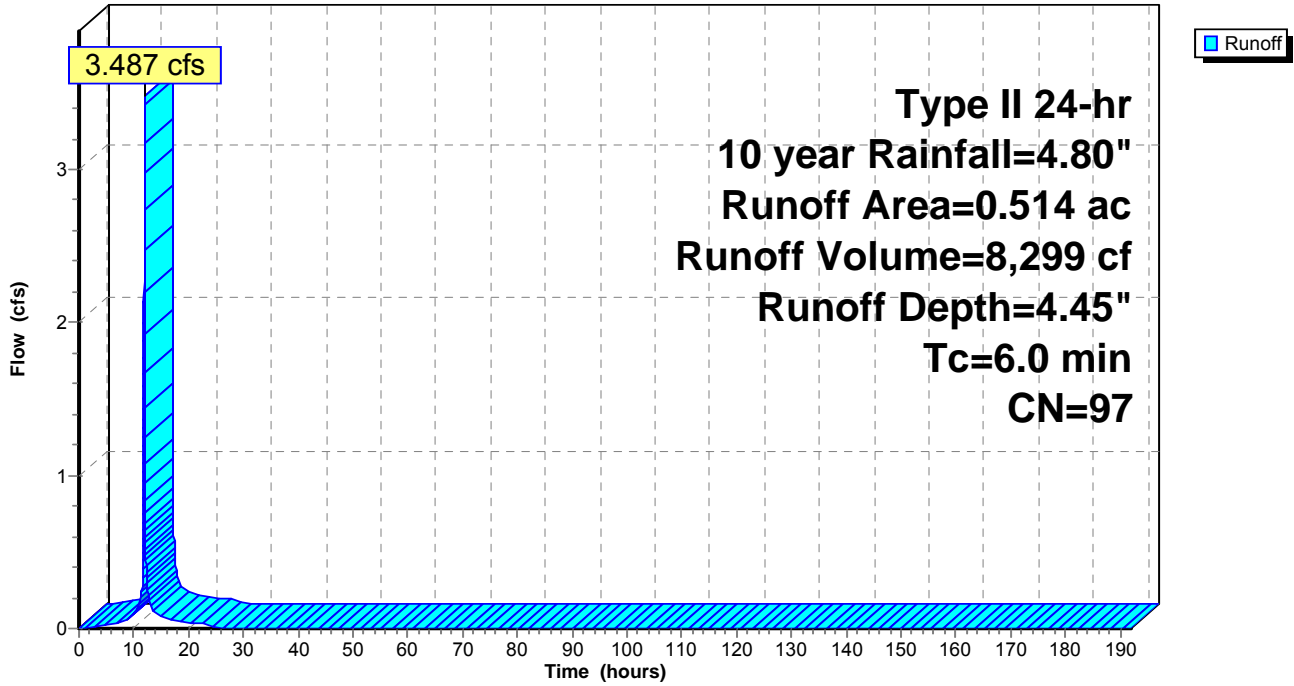
Subcatchment 2S: Pre POI#2

Hydrograph



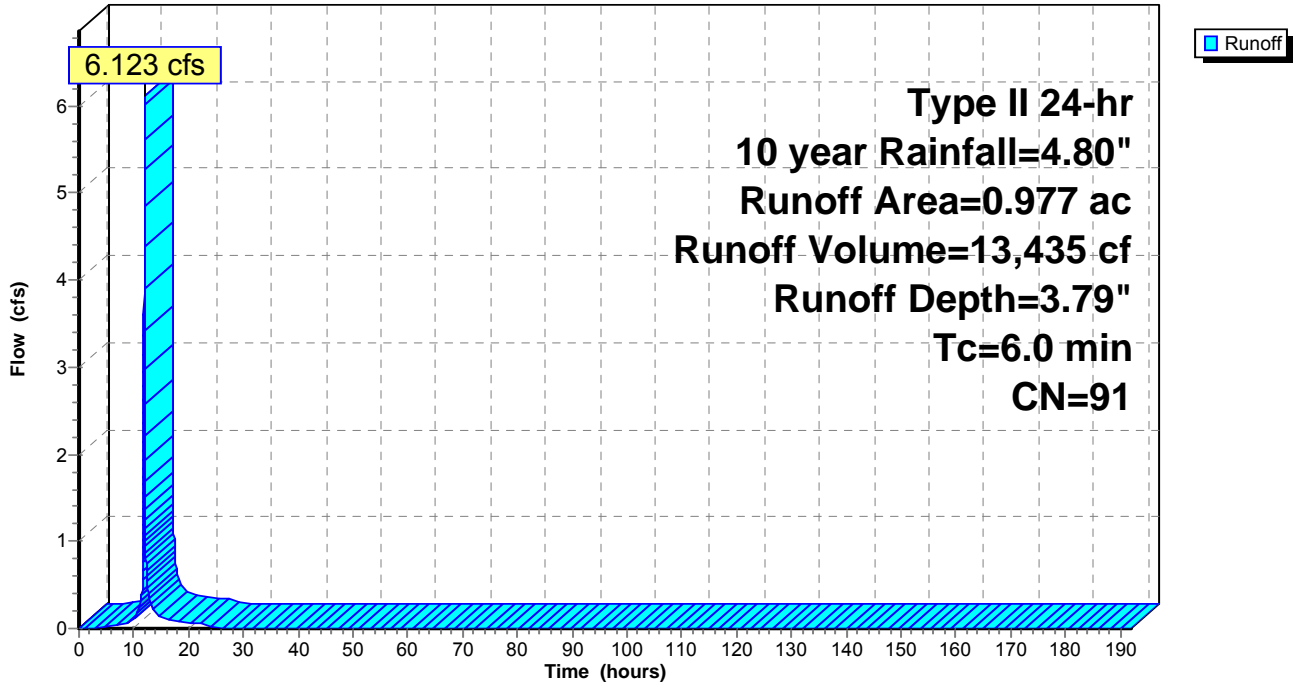
Subcatchment 3S: Post POI#1 to Basin

Hydrograph



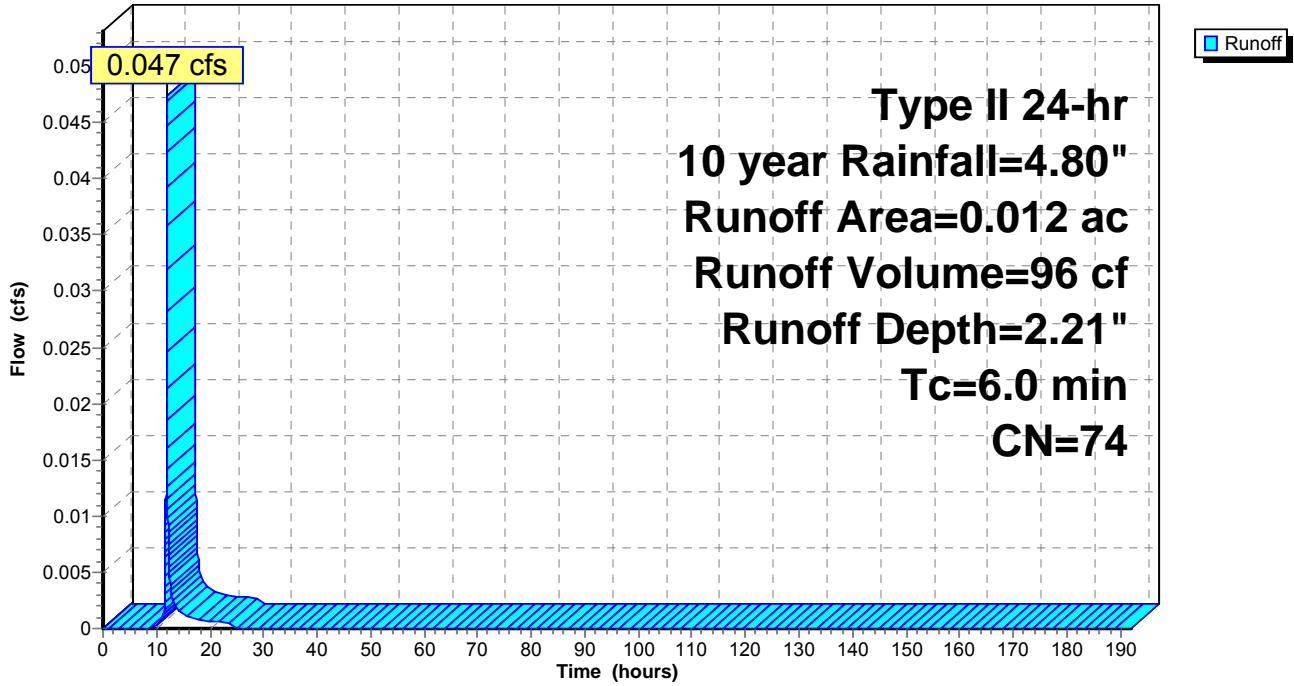
Subcatchment 4S: Post POI#1 Bypass

Hydrograph



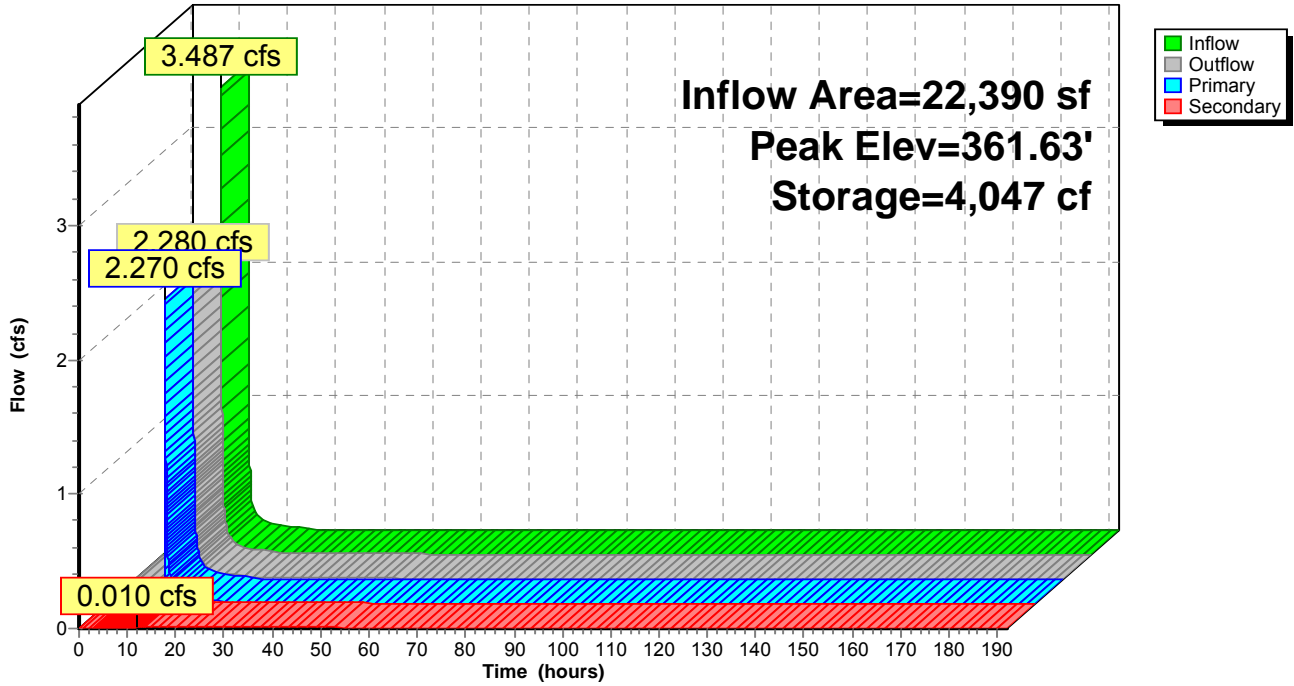
Subcatchment 5S: Post POI#2

Hydrograph



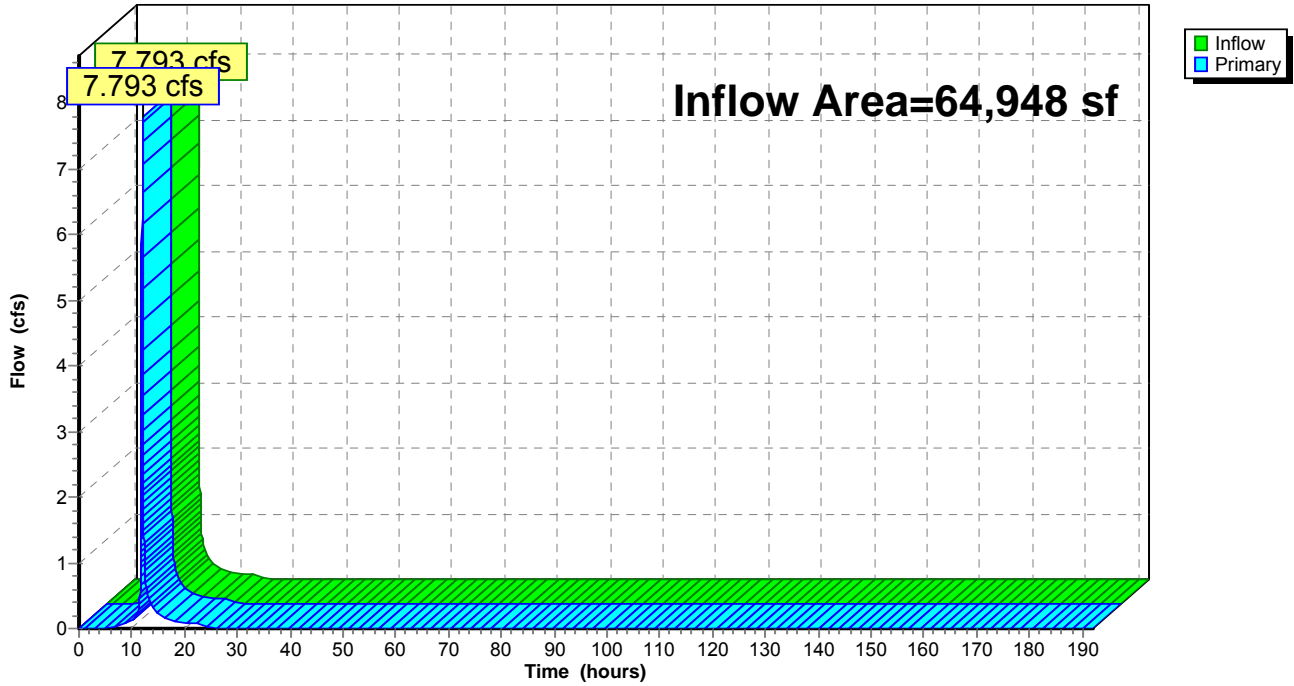
Pond 6P: UGB 1

Hydrograph



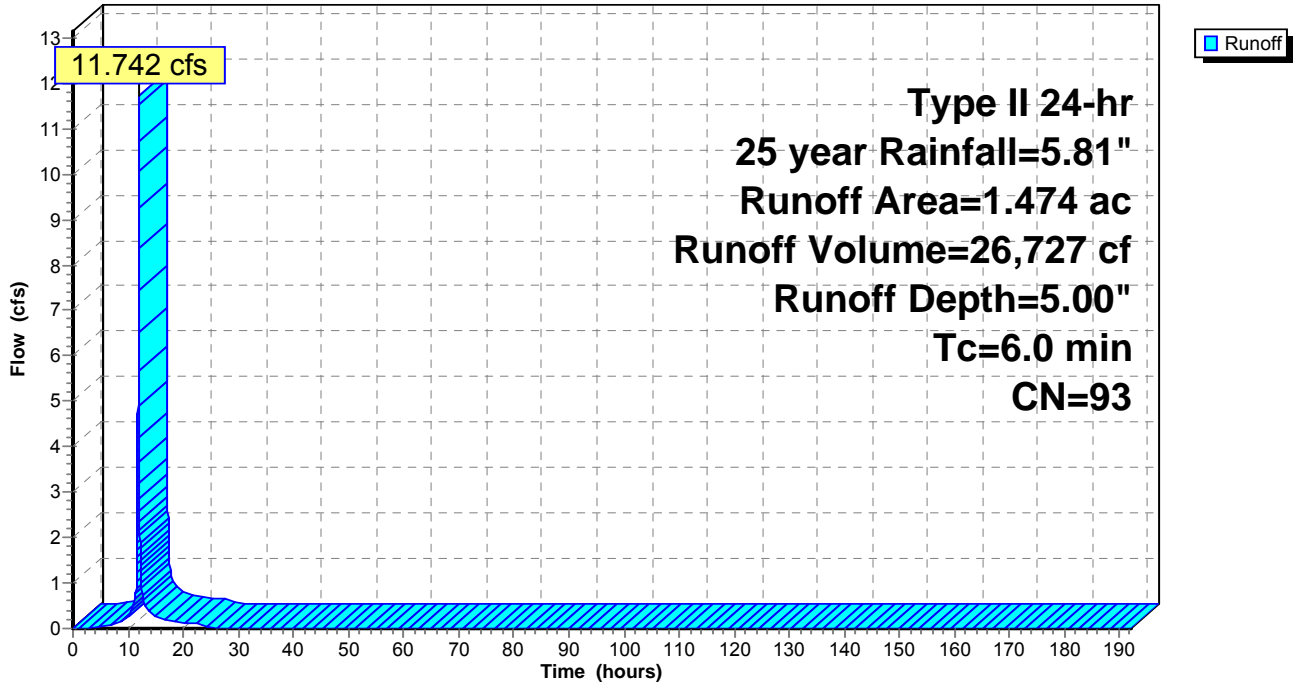
Link 7L: POI#1 Total

Hydrograph



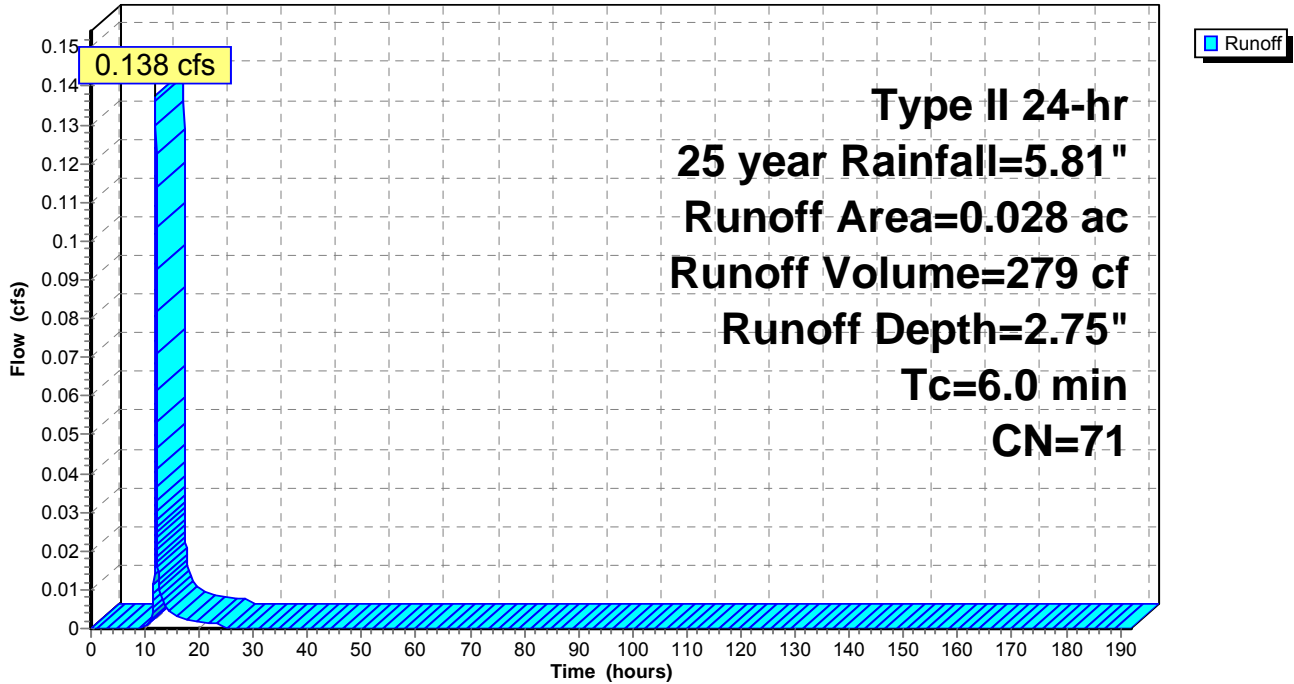
Subcatchment 1S: Pre POI#1

Hydrograph



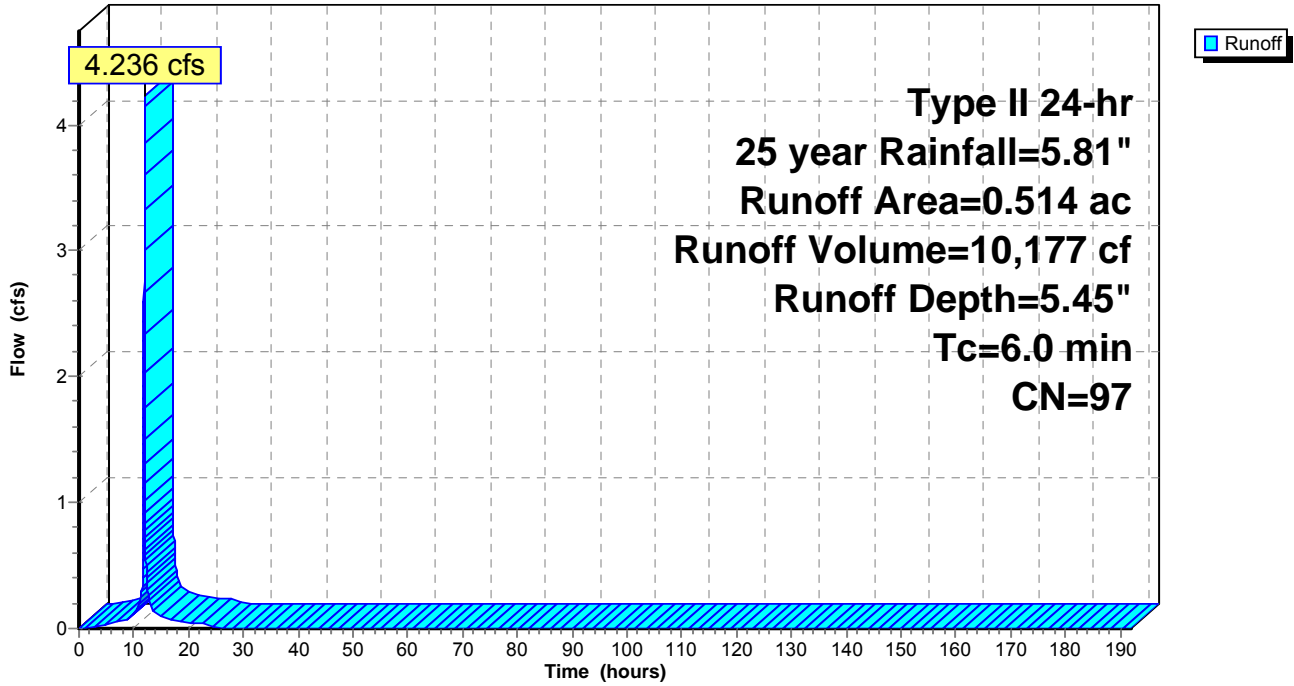
Subcatchment 2S: Pre POI#2

Hydrograph



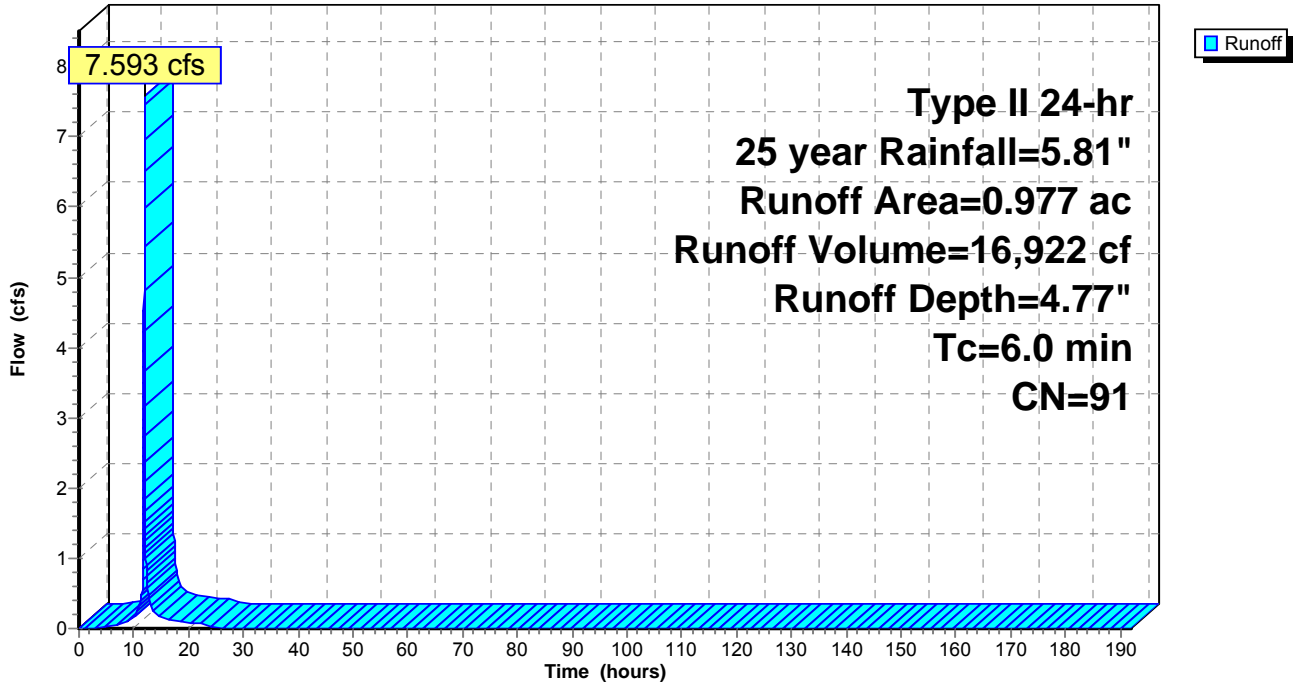
Subcatchment 3S: Post POI#1 to Basin

Hydrograph



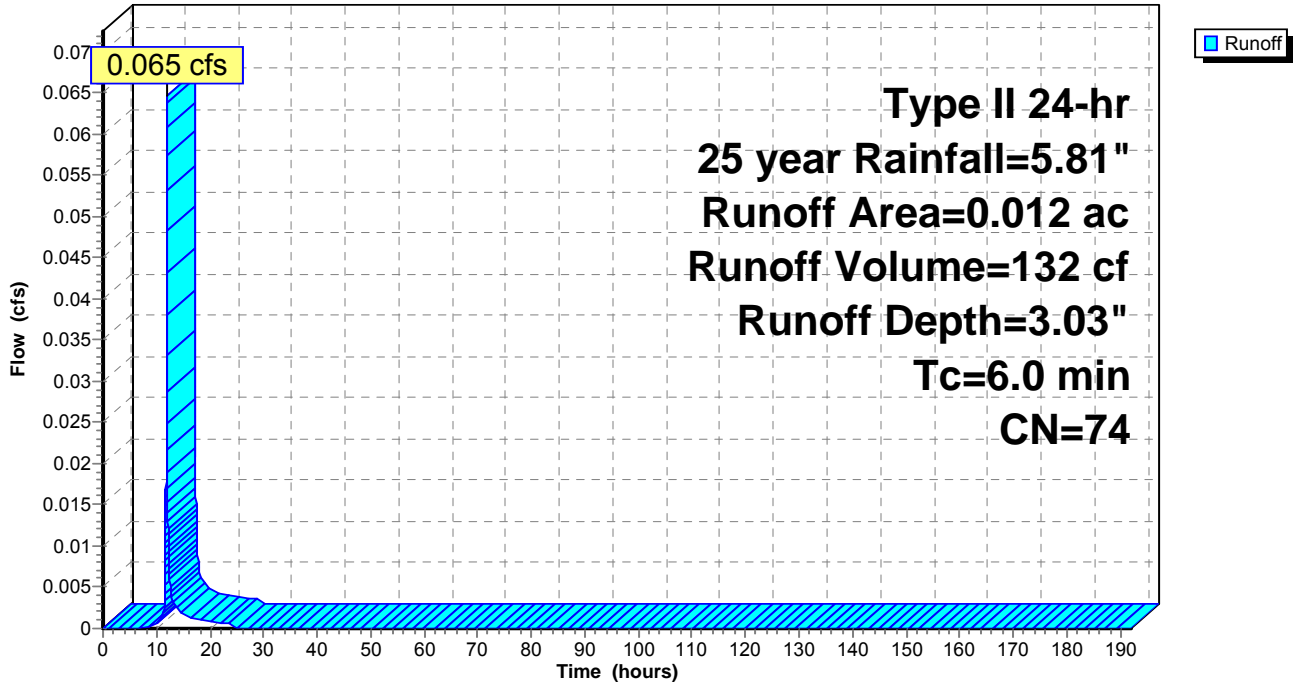
Subcatchment 4S: Post POI#1 Bypass

Hydrograph



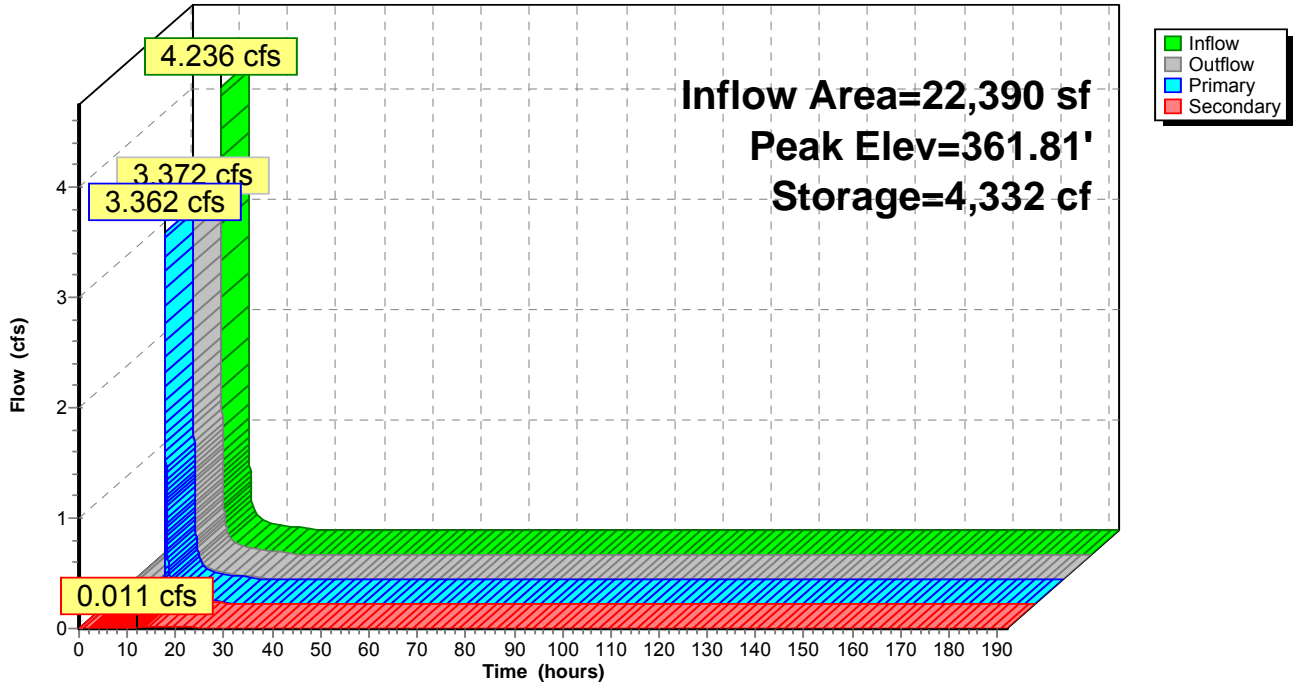
Subcatchment 5S: Post POI#2

Hydrograph



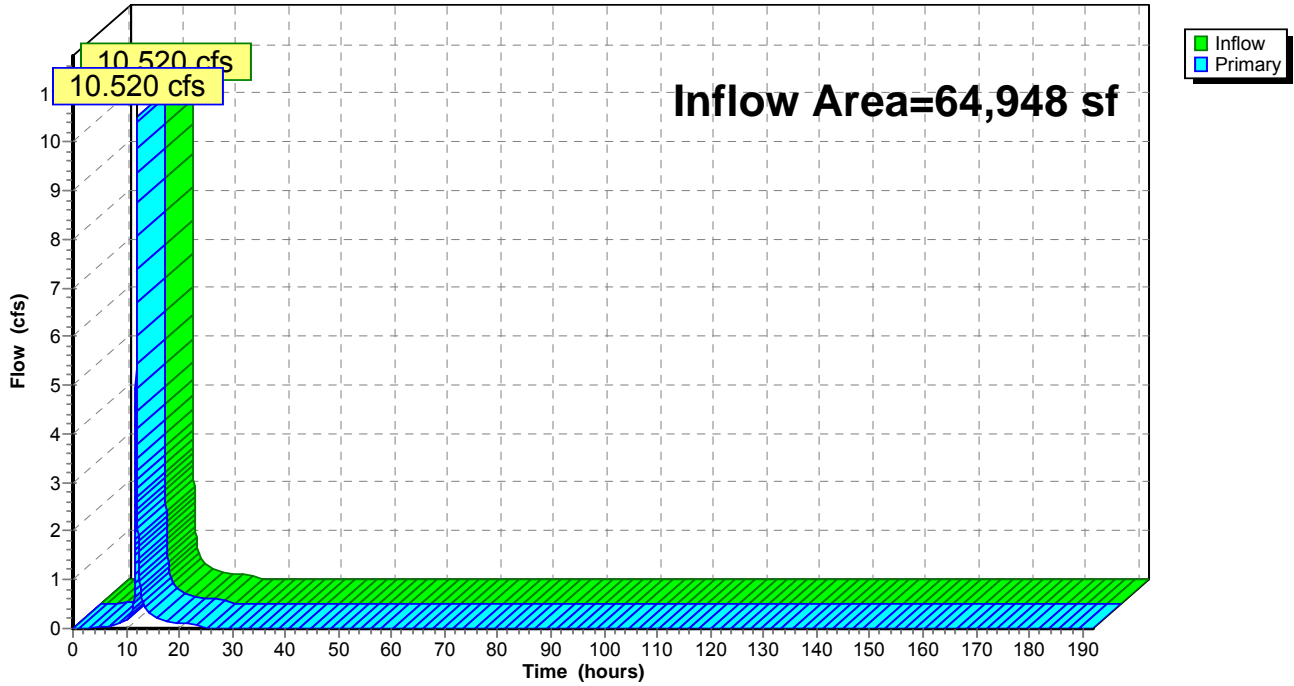
Pond 6P: UGB 1

Hydrograph



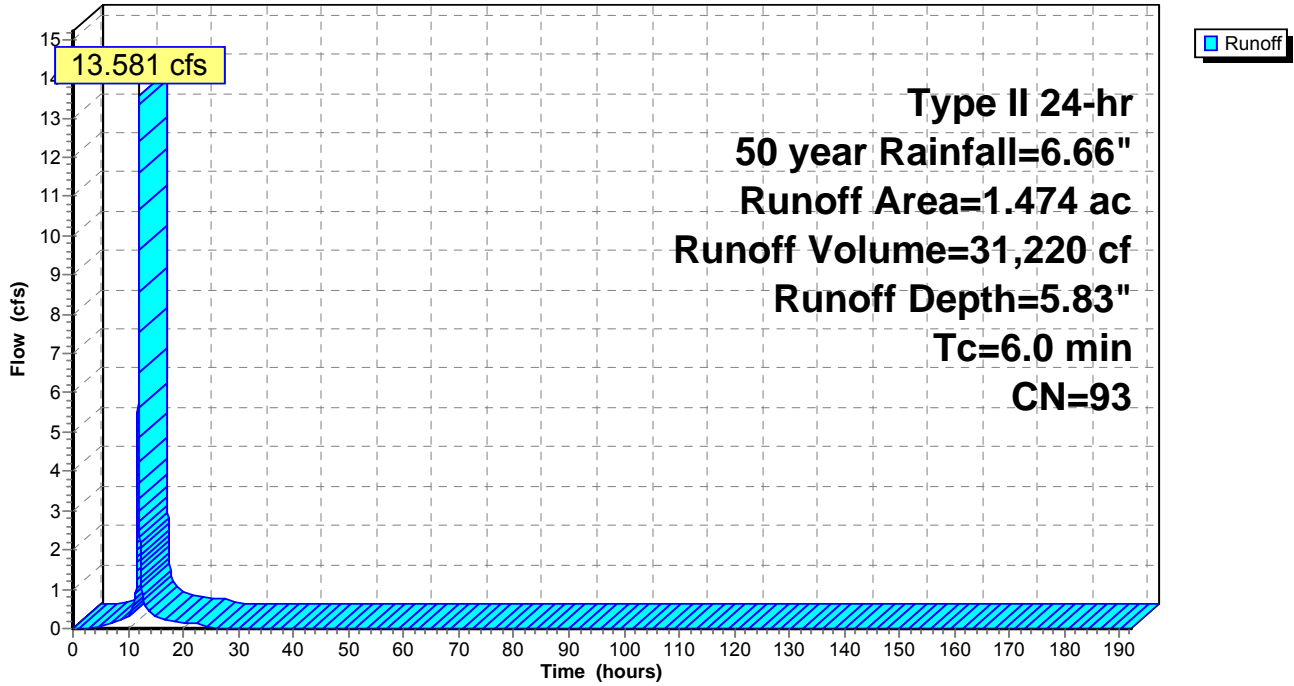
Link 7L: POI#1 Total

Hydrograph



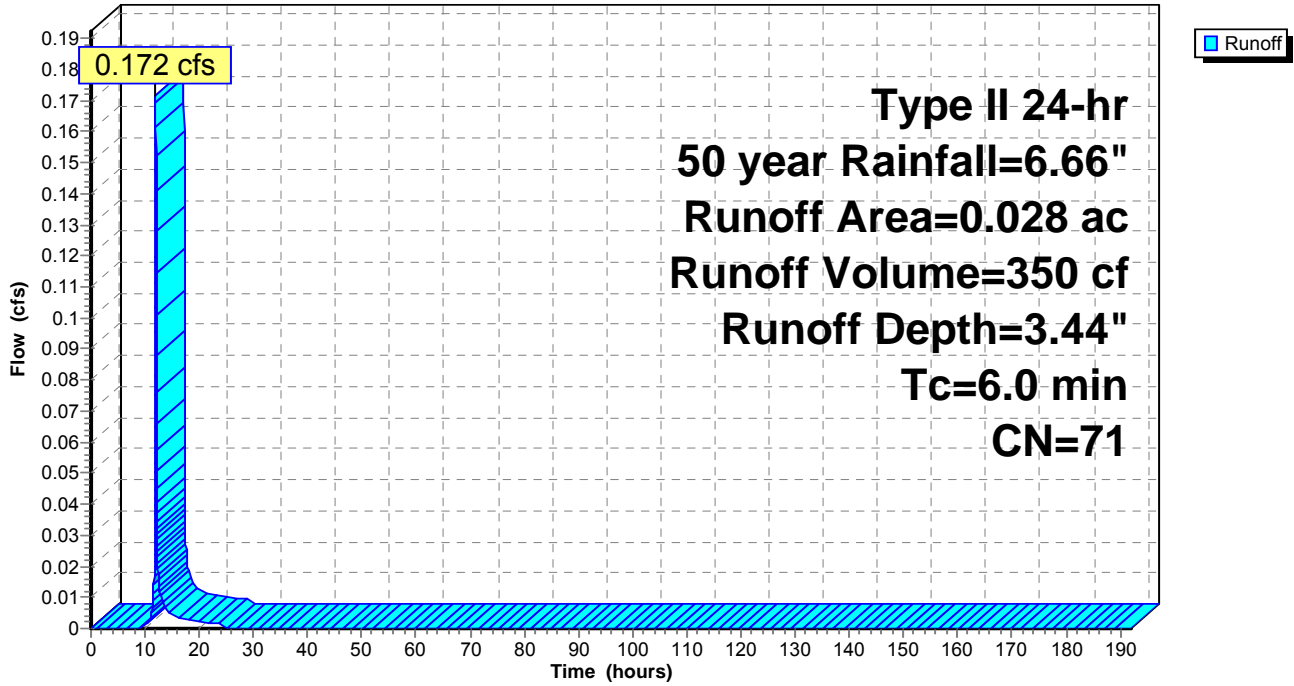
Subcatchment 1S: Pre POI#1

Hydrograph



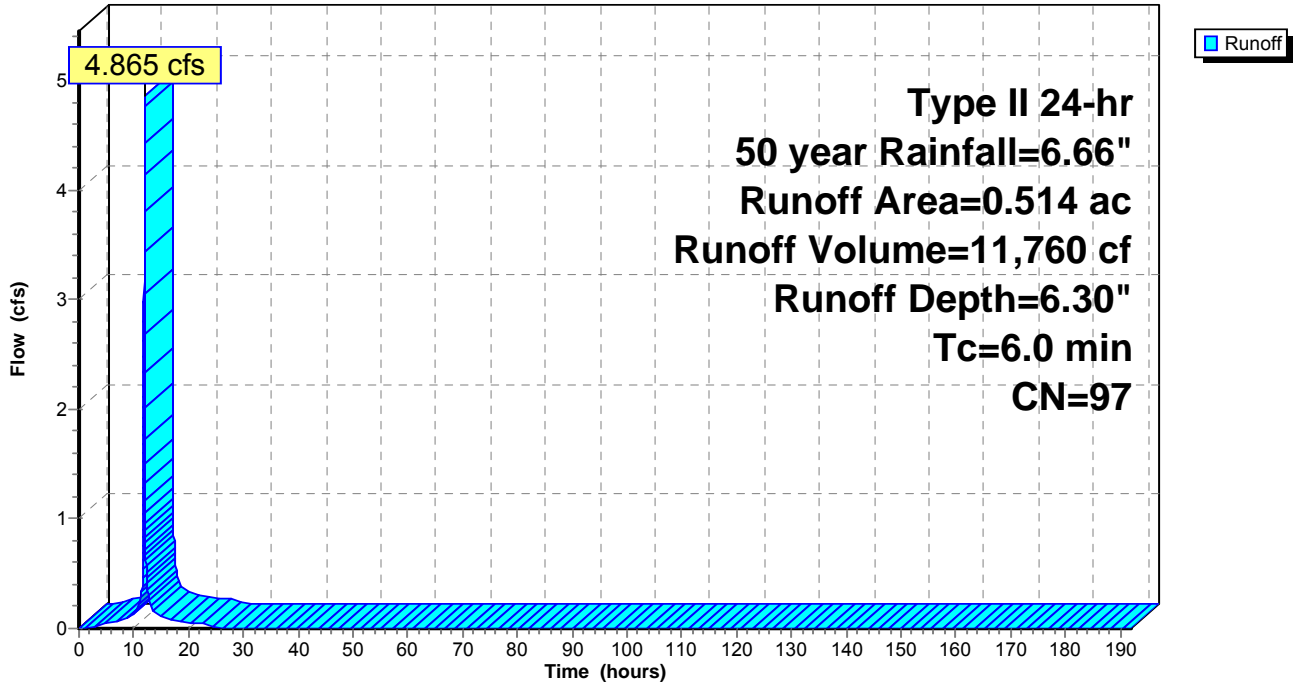
Subcatchment 2S: Pre POI#2

Hydrograph



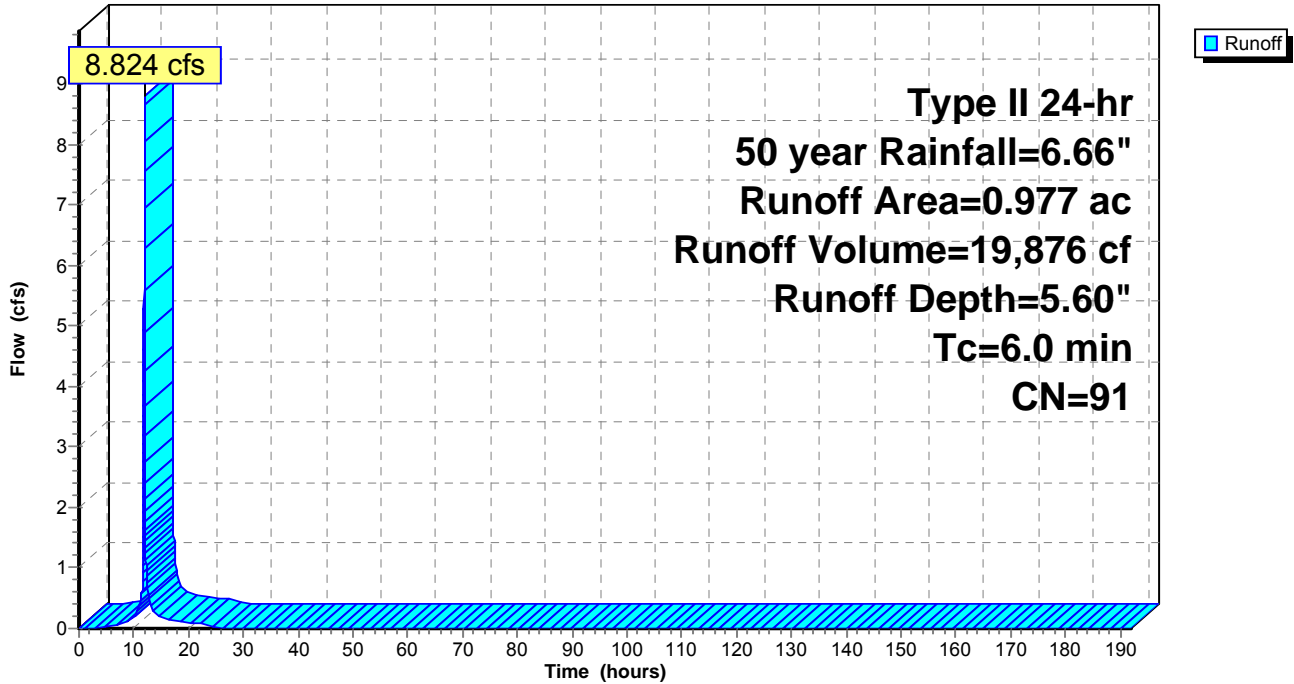
Subcatchment 3S: Post POI#1 to Basin

Hydrograph



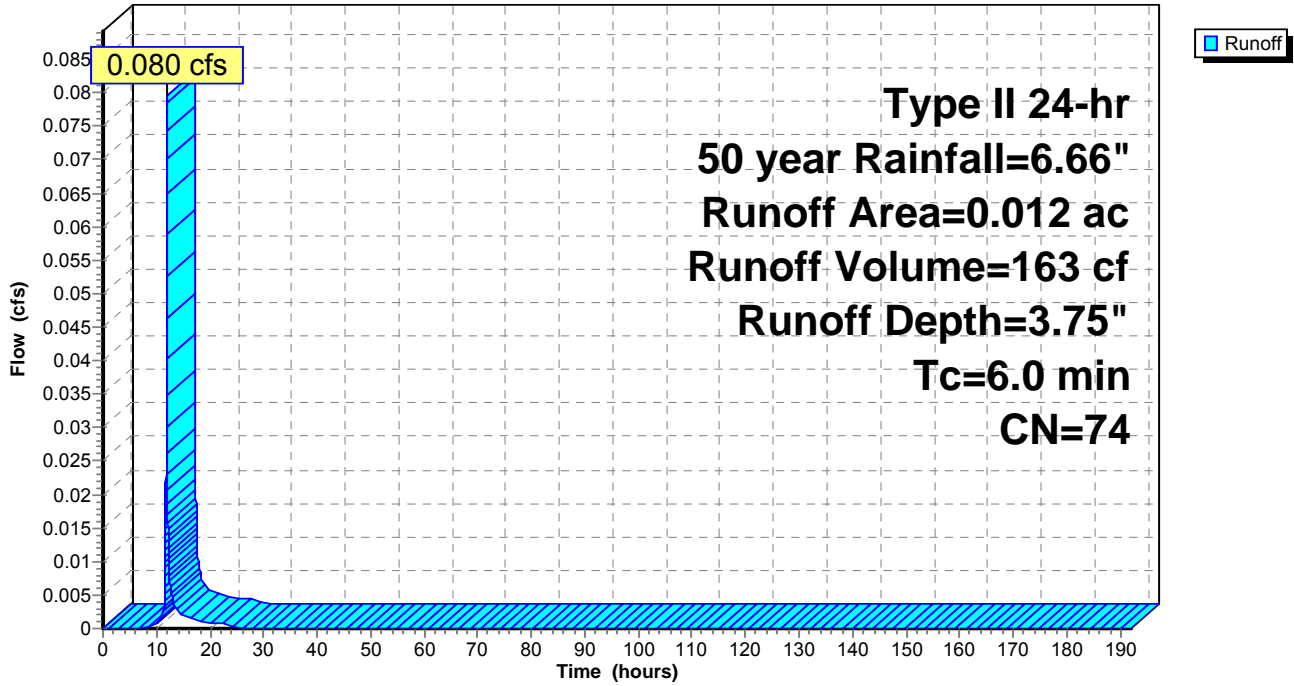
Subcatchment 4S: Post POI#1 Bypass

Hydrograph



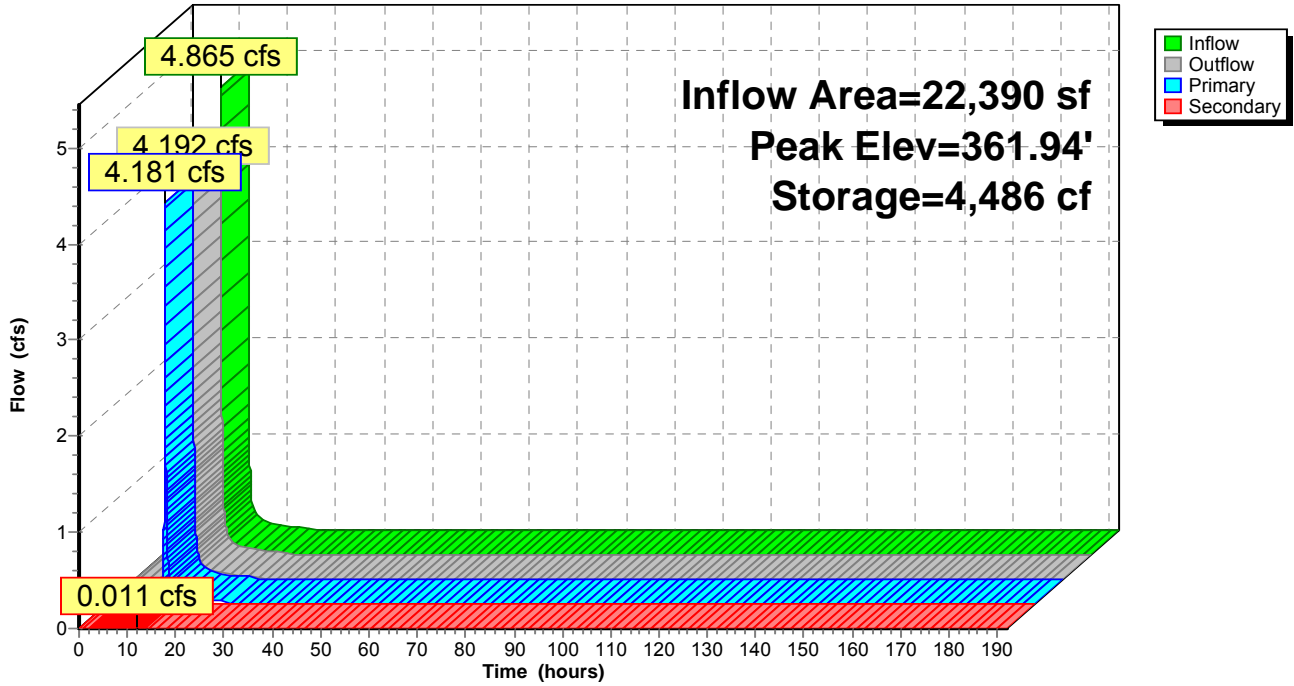
Subcatchment 5S: Post POI#2

Hydrograph



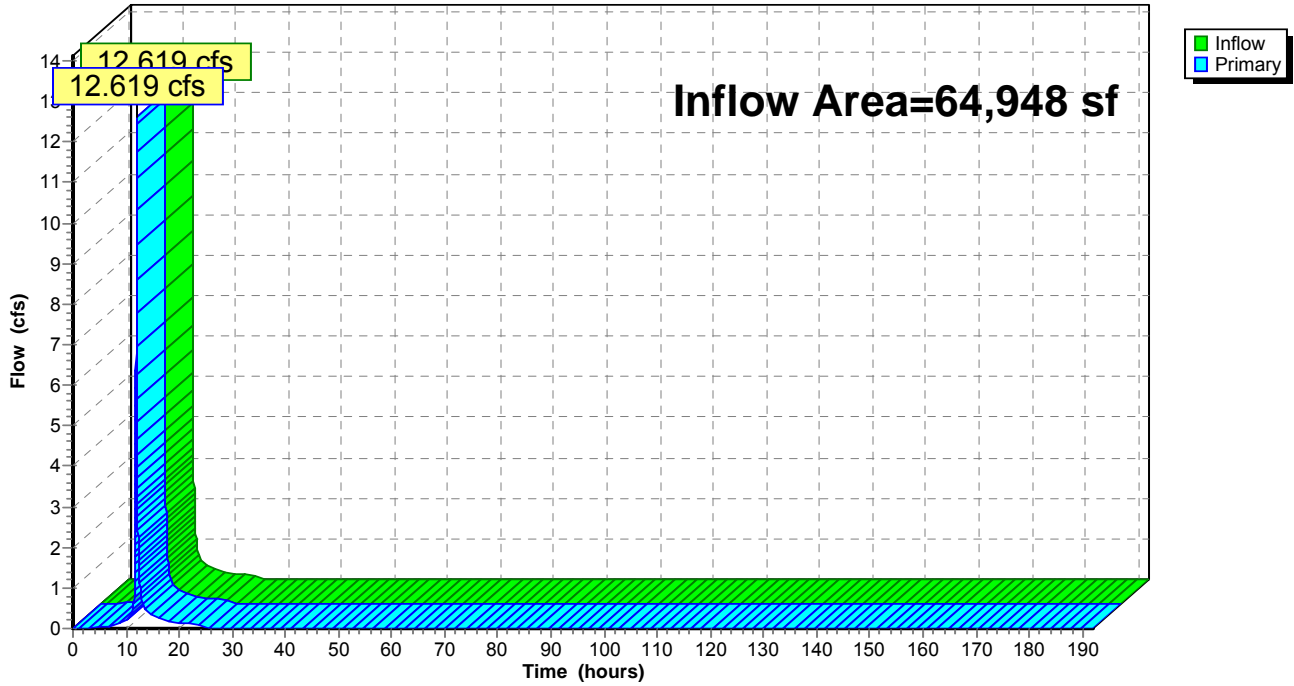
Pond 6P: UGB 1

Hydrograph



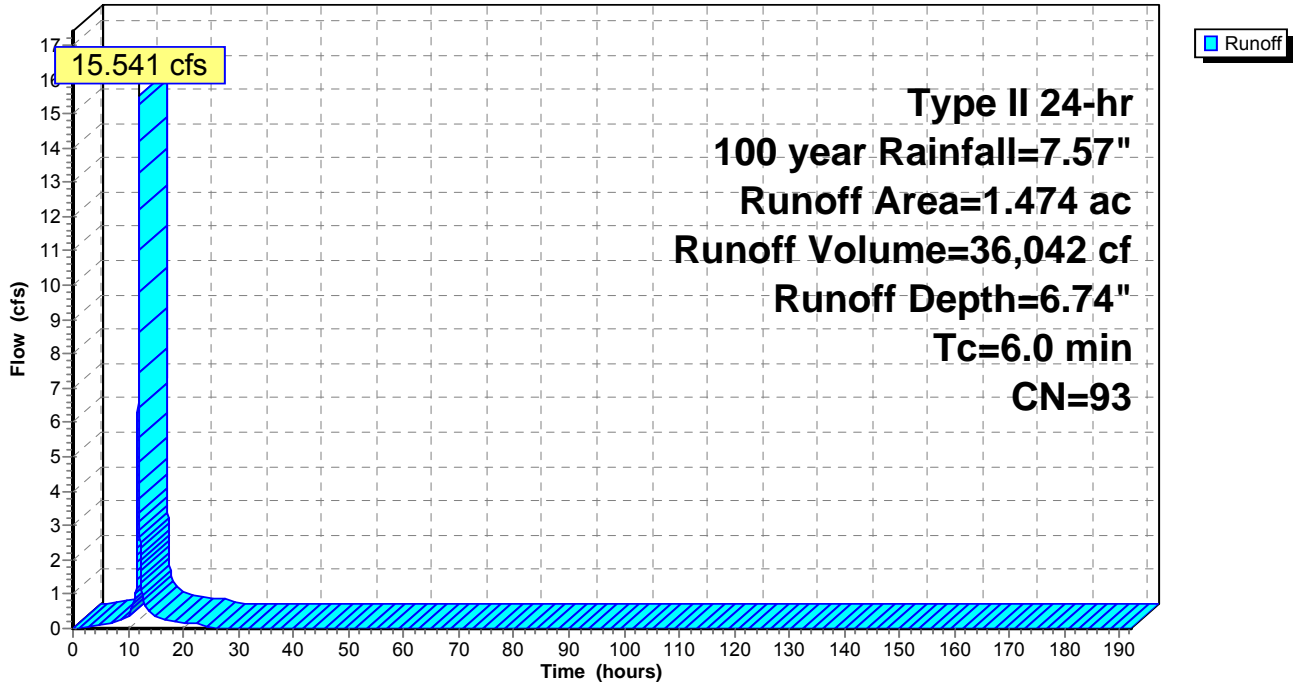
Link 7L: POI#1 Total

Hydrograph



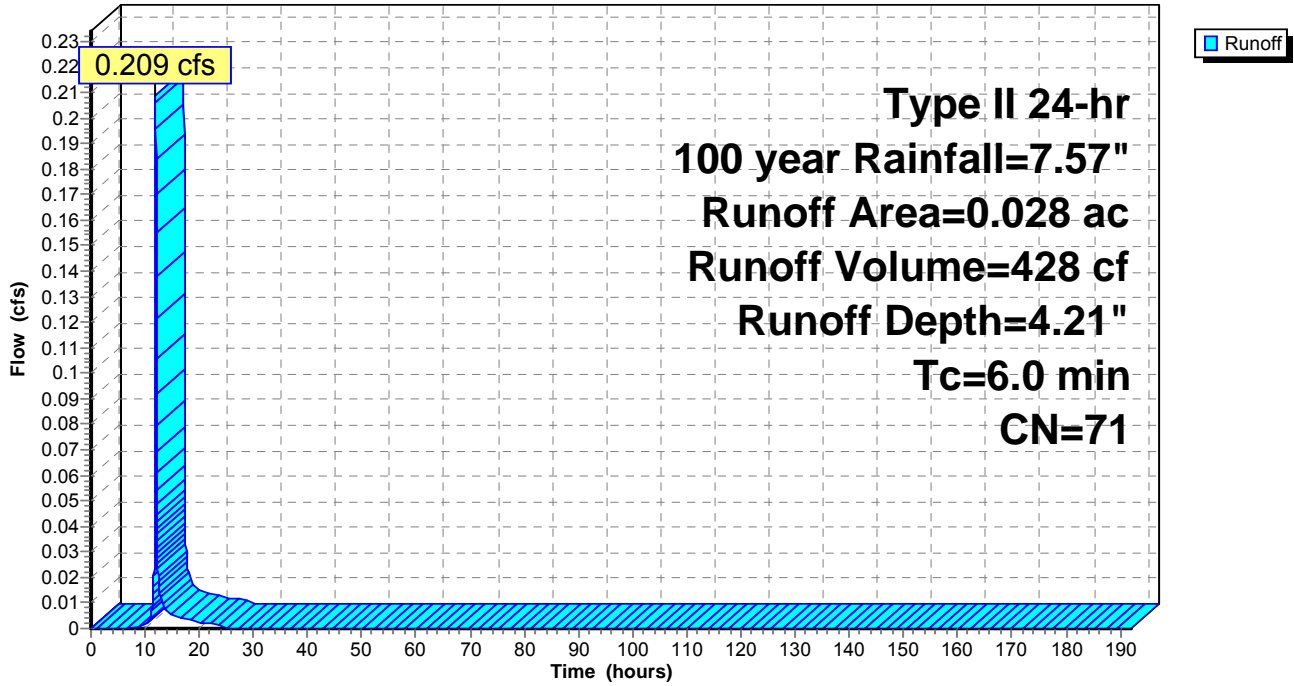
Subcatchment 1S: Pre POI#1

Hydrograph



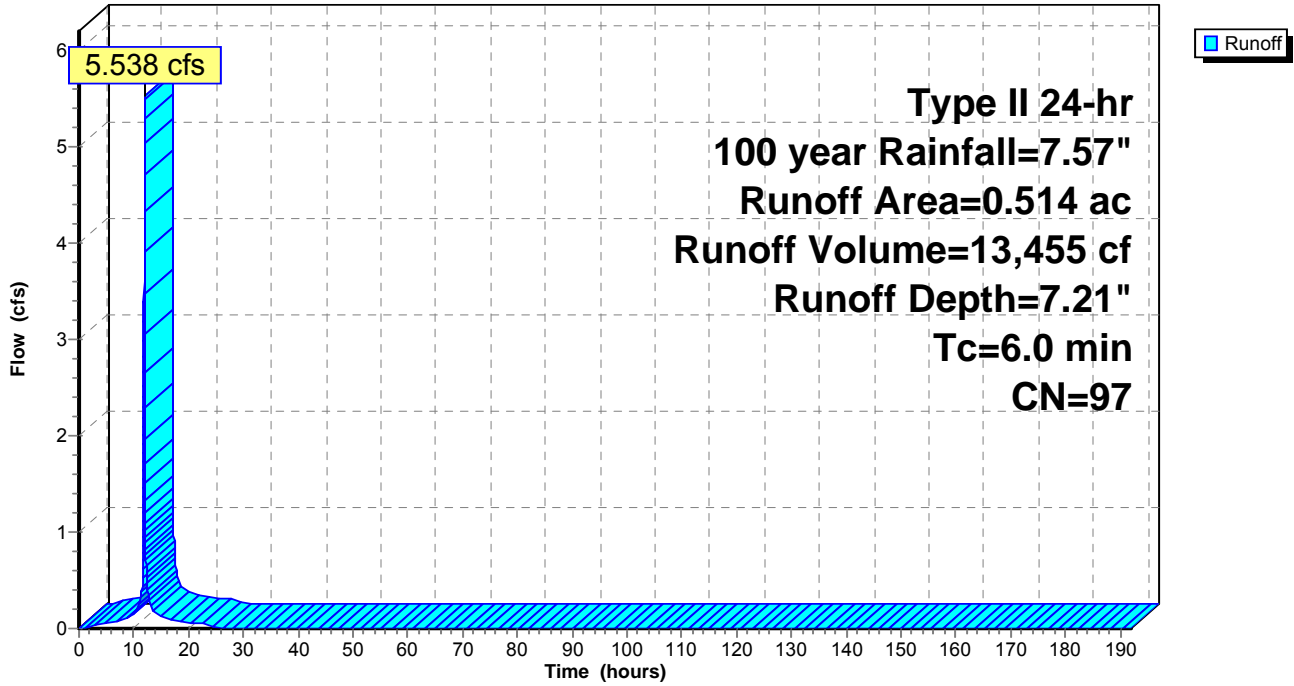
Subcatchment 2S: Pre POI#2

Hydrograph



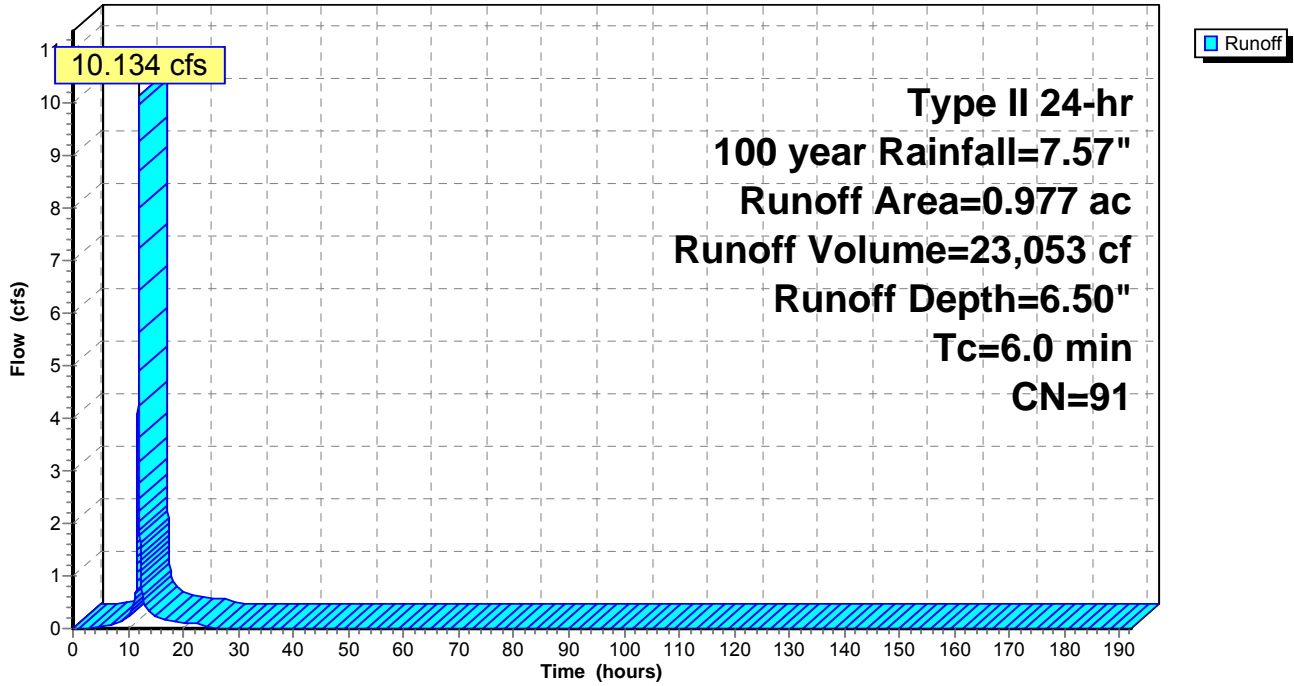
Subcatchment 3S: Post POI#1 to Basin

Hydrograph



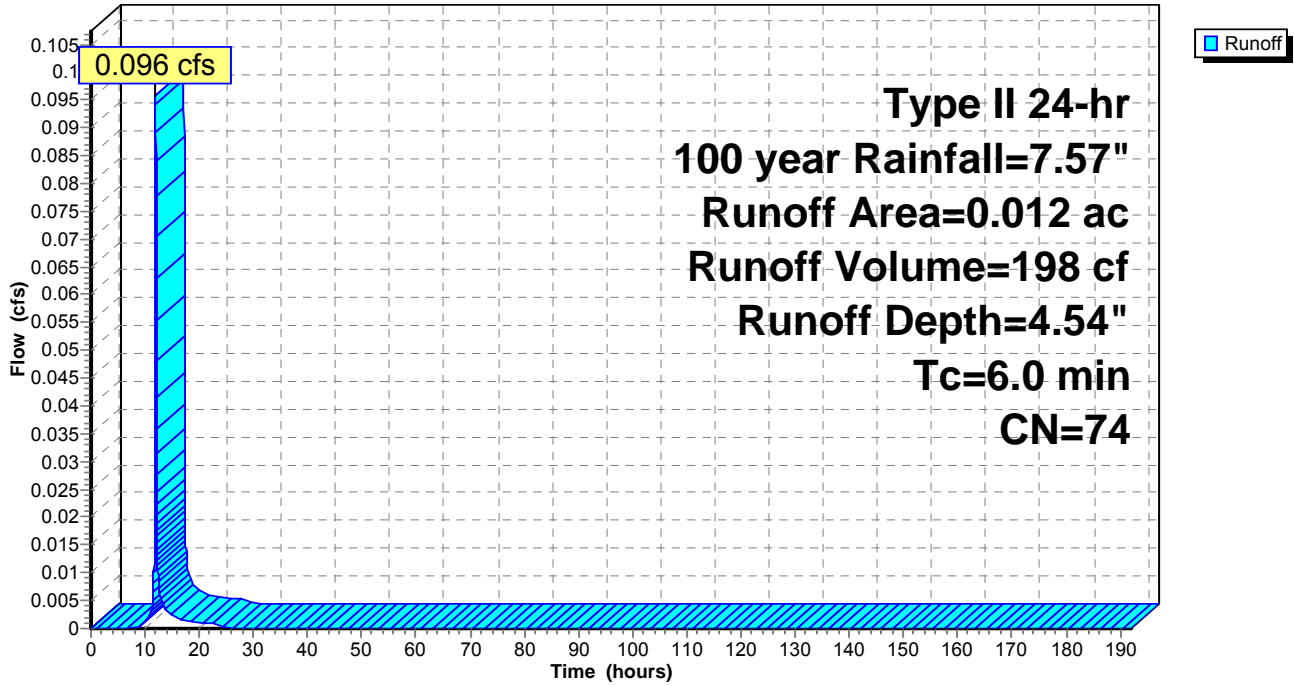
Subcatchment 4S: Post POI#1 Bypass

Hydrograph



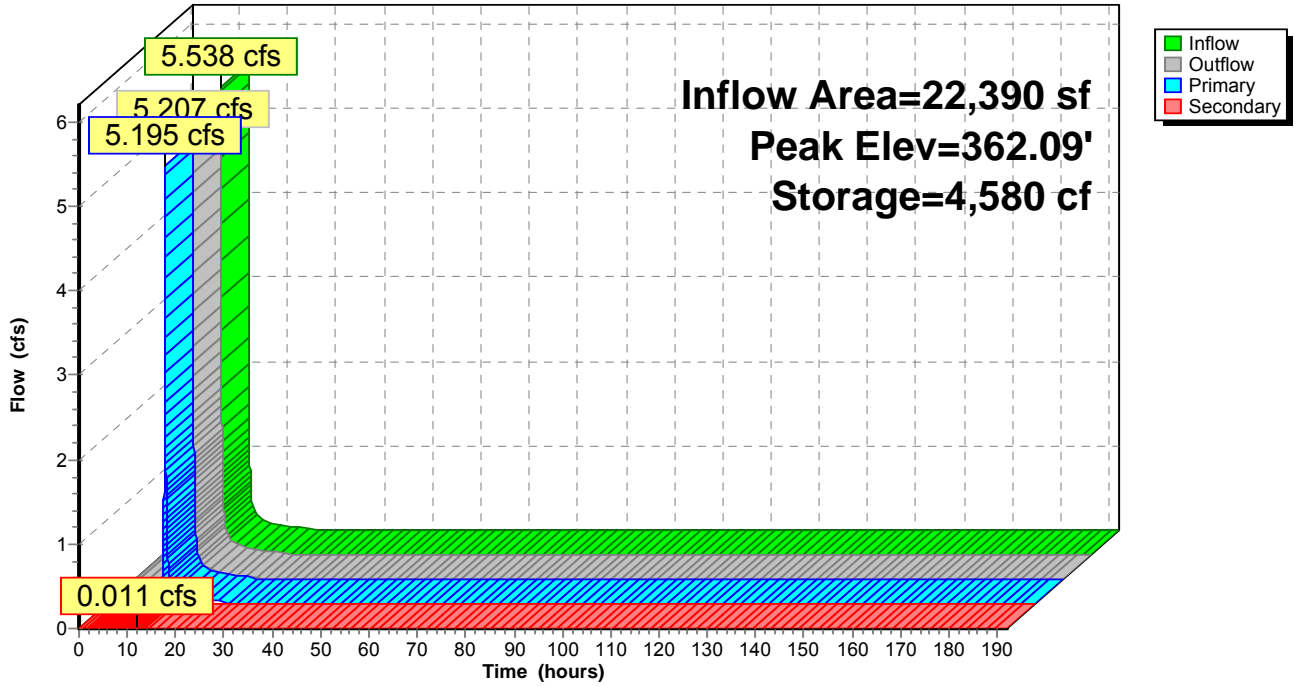
Subcatchment 5S: Post POI#2

Hydrograph



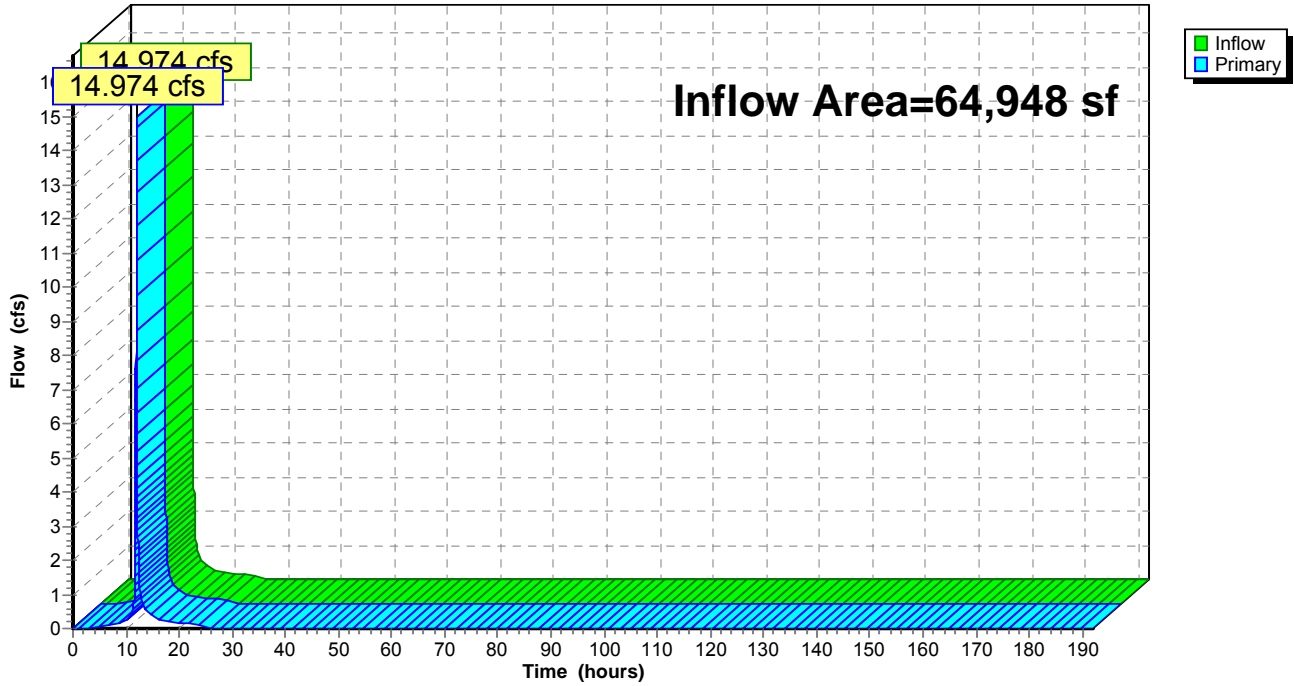
Pond 6P: UGB 1

Hydrograph



Link 7L: POI#1 Total

Hydrograph



Hydrograph for Pond 6P: UGB 1

| Time (hours) | Inflow (cfs) | Storage (cubic-feet) | Elevation (feet) | Outflow (cfs) | Primary (cfs) | Secondary (cfs) |
|--------------|--------------|----------------------|------------------|---------------|---------------|-----------------|
| 0.00 | 0.000 | 0 | 360.00 | 0.000 | 0.000 | 0.000 |
| 0.50 | 0.000 | 0 | 360.00 | 0.000 | 0.000 | 0.000 |
| 1.00 | 0.000 | 0 | 360.00 | 0.000 | 0.000 | 0.000 |
| 1.50 | 0.000 | 0 | 360.00 | 0.000 | 0.000 | 0.000 |
| 2.00 | 0.001 | 0 | 360.00 | 0.000 | 0.000 | 0.000 |
| 2.50 | 0.003 | 4 | 360.00 | 0.000 | 0.000 | 0.000 |
| 3.00 | 0.005 | 11 | 360.00 | 0.000 | 0.000 | 0.000 |
| 3.50 | 0.007 | 23 | 360.01 | 0.000 | 0.000 | 0.000 |
| 4.00 | 0.009 | 38 | 360.01 | 0.000 | 0.000 | 0.000 |
| 4.50 | 0.012 | 56 | 360.02 | 0.000 | 0.000 | 0.000 |
| 5.00 | 0.014 | 79 | 360.03 | 0.001 | 0.000 | 0.001 |
| 5.50 | 0.016 | 105 | 360.04 | 0.001 | 0.000 | 0.001 |
| 6.00 | 0.019 | 135 | 360.05 | 0.001 | 0.000 | 0.001 |
| 6.50 | 0.021 | 168 | 360.06 | 0.001 | 0.000 | 0.001 |
| 7.00 | 0.024 | 206 | 360.07 | 0.002 | 0.000 | 0.002 |
| 7.50 | 0.026 | 247 | 360.08 | 0.002 | 0.000 | 0.002 |
| 8.00 | 0.028 | 292 | 360.10 | 0.002 | 0.000 | 0.002 |
| 8.50 | 0.035 | 344 | 360.12 | 0.002 | 0.000 | 0.002 |
| 9.00 | 0.043 | 409 | 360.14 | 0.003 | 0.000 | 0.003 |
| 9.50 | 0.046 | 484 | 360.17 | 0.003 | 0.000 | 0.003 |
| 10.00 | 0.056 | 568 | 360.20 | 0.003 | 0.000 | 0.003 |
| 10.50 | 0.074 | 679 | 360.24 | 0.004 | 0.000 | 0.004 |
| 11.00 | 0.105 | 831 | 360.29 | 0.004 | 0.000 | 0.004 |
| 11.50 | 0.174 | 1,068 | 360.38 | 0.005 | 0.000 | 0.005 |
| 12.00 | 2.139 | 2,840 | 361.06 | 0.056 | 0.047 | 0.008 |
| 12.50 | 0.181 | 3,154 | 361.19 | 0.276 | 0.267 | 0.009 |
| 13.00 | 0.110 | 3,016 | 361.13 | 0.164 | 0.156 | 0.008 |
| 13.50 | 0.083 | 2,943 | 361.10 | 0.114 | 0.106 | 0.008 |
| 14.00 | 0.065 | 2,897 | 361.08 | 0.086 | 0.078 | 0.008 |
| 14.50 | 0.057 | 2,867 | 361.07 | 0.070 | 0.062 | 0.008 |
| 15.00 | 0.051 | 2,848 | 361.06 | 0.060 | 0.052 | 0.008 |
| 15.50 | 0.046 | 2,834 | 361.06 | 0.053 | 0.045 | 0.008 |
| 16.00 | 0.040 | 2,821 | 361.05 | 0.047 | 0.039 | 0.008 |
| 16.50 | 0.037 | 2,809 | 361.05 | 0.042 | 0.034 | 0.008 |
| 17.00 | 0.035 | 2,802 | 361.04 | 0.038 | 0.030 | 0.008 |
| 17.50 | 0.033 | 2,796 | 361.04 | 0.036 | 0.028 | 0.008 |
| 18.00 | 0.031 | 2,790 | 361.04 | 0.034 | 0.026 | 0.008 |
| 18.50 | 0.029 | 2,785 | 361.04 | 0.032 | 0.024 | 0.008 |
| 19.00 | 0.026 | 2,779 | 361.03 | 0.030 | 0.022 | 0.008 |
| 19.50 | 0.024 | 2,773 | 361.03 | 0.028 | 0.020 | 0.008 |
| 20.00 | 0.022 | 2,767 | 361.03 | 0.026 | 0.018 | 0.008 |
| 20.50 | 0.022 | 2,762 | 361.03 | 0.024 | 0.016 | 0.008 |
| 21.00 | 0.021 | 2,759 | 361.03 | 0.023 | 0.015 | 0.008 |
| 21.50 | 0.021 | 2,756 | 361.03 | 0.022 | 0.014 | 0.008 |
| 22.00 | 0.020 | 2,754 | 361.02 | 0.021 | 0.013 | 0.008 |
| 22.50 | 0.020 | 2,753 | 361.02 | 0.021 | 0.013 | 0.008 |
| 23.00 | 0.019 | 2,751 | 361.02 | 0.020 | 0.012 | 0.008 |
| 23.50 | 0.019 | 2,750 | 361.02 | 0.020 | 0.012 | 0.008 |
| 24.00 | 0.019 | 2,749 | 361.02 | 0.019 | 0.011 | 0.008 |
| 24.50 | 0.000 | 2,725 | 361.01 | 0.014 | 0.006 | 0.008 |
| 25.00 | 0.000 | 2,705 | 361.00 | 0.010 | 0.002 | 0.008 |
| 25.50 | 0.000 | 2,689 | 361.00 | 0.008 | 0.000 | 0.008 |
| 26.00 | 0.000 | 2,675 | 360.99 | 0.008 | 0.000 | 0.008 |

Hydrograph for Pond 6P: UGB 1 (continued)

| Time (hours) | Inflow (cfs) | Storage (cubic-feet) | Elevation (feet) | Outflow (cfs) | Primary (cfs) | Secondary (cfs) |
|--------------|--------------|----------------------|------------------|---------------|---------------|-----------------|
| 26.50 | 0.000 | 2,661 | 360.99 | 0.008 | 0.000 | 0.008 |
| 27.00 | 0.000 | 2,647 | 360.98 | 0.008 | 0.000 | 0.008 |
| 27.50 | 0.000 | 2,633 | 360.98 | 0.008 | 0.000 | 0.008 |
| 28.00 | 0.000 | 2,619 | 360.97 | 0.008 | 0.000 | 0.008 |
| 28.50 | 0.000 | 2,605 | 360.96 | 0.008 | 0.000 | 0.008 |
| 29.00 | 0.000 | 2,592 | 360.96 | 0.008 | 0.000 | 0.008 |
| 29.50 | 0.000 | 2,578 | 360.95 | 0.008 | 0.000 | 0.008 |
| 30.00 | 0.000 | 2,564 | 360.95 | 0.008 | 0.000 | 0.008 |
| 30.50 | 0.000 | 2,550 | 360.94 | 0.008 | 0.000 | 0.008 |
| 31.00 | 0.000 | 2,537 | 360.94 | 0.008 | 0.000 | 0.008 |
| 31.50 | 0.000 | 2,523 | 360.93 | 0.008 | 0.000 | 0.008 |
| 32.00 | 0.000 | 2,509 | 360.92 | 0.008 | 0.000 | 0.008 |
| 32.50 | 0.000 | 2,496 | 360.92 | 0.008 | 0.000 | 0.008 |
| 33.00 | 0.000 | 2,482 | 360.91 | 0.007 | 0.000 | 0.007 |
| 33.50 | 0.000 | 2,469 | 360.91 | 0.007 | 0.000 | 0.007 |
| 34.00 | 0.000 | 2,455 | 360.90 | 0.007 | 0.000 | 0.007 |
| 34.50 | 0.000 | 2,442 | 360.90 | 0.007 | 0.000 | 0.007 |
| 35.00 | 0.000 | 2,429 | 360.89 | 0.007 | 0.000 | 0.007 |
| 35.50 | 0.000 | 2,415 | 360.89 | 0.007 | 0.000 | 0.007 |
| 36.00 | 0.000 | 2,402 | 360.88 | 0.007 | 0.000 | 0.007 |
| 36.50 | 0.000 | 2,389 | 360.88 | 0.007 | 0.000 | 0.007 |
| 37.00 | 0.000 | 2,376 | 360.87 | 0.007 | 0.000 | 0.007 |
| 37.50 | 0.000 | 2,363 | 360.87 | 0.007 | 0.000 | 0.007 |
| 38.00 | 0.000 | 2,349 | 360.86 | 0.007 | 0.000 | 0.007 |
| 38.50 | 0.000 | 2,336 | 360.86 | 0.007 | 0.000 | 0.007 |
| 39.00 | 0.000 | 2,323 | 360.85 | 0.007 | 0.000 | 0.007 |
| 39.50 | 0.000 | 2,310 | 360.84 | 0.007 | 0.000 | 0.007 |
| 40.00 | 0.000 | 2,297 | 360.84 | 0.007 | 0.000 | 0.007 |
| 40.50 | 0.000 | 2,285 | 360.83 | 0.007 | 0.000 | 0.007 |
| 41.00 | 0.000 | 2,272 | 360.83 | 0.007 | 0.000 | 0.007 |
| 41.50 | 0.000 | 2,259 | 360.82 | 0.007 | 0.000 | 0.007 |
| 42.00 | 0.000 | 2,246 | 360.82 | 0.007 | 0.000 | 0.007 |
| 42.50 | 0.000 | 2,233 | 360.81 | 0.007 | 0.000 | 0.007 |
| 43.00 | 0.000 | 2,221 | 360.81 | 0.007 | 0.000 | 0.007 |
| 43.50 | 0.000 | 2,208 | 360.80 | 0.007 | 0.000 | 0.007 |
| 44.00 | 0.000 | 2,195 | 360.80 | 0.007 | 0.000 | 0.007 |
| 44.50 | 0.000 | 2,183 | 360.79 | 0.007 | 0.000 | 0.007 |
| 45.00 | 0.000 | 2,170 | 360.79 | 0.007 | 0.000 | 0.007 |
| 45.50 | 0.000 | 2,158 | 360.78 | 0.007 | 0.000 | 0.007 |
| 46.00 | 0.000 | 2,145 | 360.78 | 0.007 | 0.000 | 0.007 |
| 46.50 | 0.000 | 2,133 | 360.77 | 0.007 | 0.000 | 0.007 |
| 47.00 | 0.000 | 2,120 | 360.77 | 0.007 | 0.000 | 0.007 |
| 47.50 | 0.000 | 2,108 | 360.76 | 0.007 | 0.000 | 0.007 |
| 48.00 | 0.000 | 2,096 | 360.76 | 0.007 | 0.000 | 0.007 |
| 48.50 | 0.000 | 2,084 | 360.76 | 0.007 | 0.000 | 0.007 |
| 49.00 | 0.000 | 2,071 | 360.75 | 0.007 | 0.000 | 0.007 |
| 49.50 | 0.000 | 2,059 | 360.75 | 0.007 | 0.000 | 0.007 |
| 50.00 | 0.000 | 2,047 | 360.74 | 0.007 | 0.000 | 0.007 |
| 50.50 | 0.000 | 2,035 | 360.74 | 0.007 | 0.000 | 0.007 |
| 51.00 | 0.000 | 2,023 | 360.73 | 0.007 | 0.000 | 0.007 |
| 51.50 | 0.000 | 2,011 | 360.73 | 0.007 | 0.000 | 0.007 |
| 52.00 | 0.000 | 1,999 | 360.72 | 0.007 | 0.000 | 0.007 |
| 52.50 | 0.000 | 1,987 | 360.72 | 0.007 | 0.000 | 0.007 |

Hydrograph for Pond 6P: UGB 1 (continued)

| Time (hours) | Inflow (cfs) | Storage (cubic-feet) | Elevation (feet) | Outflow (cfs) | Primary (cfs) | Secondary (cfs) |
|--------------|--------------|----------------------|------------------|---------------|---------------|-----------------|
| 53.00 | 0.000 | 1,975 | 360.71 | 0.007 | 0.000 | 0.007 |
| 53.50 | 0.000 | 1,963 | 360.71 | 0.007 | 0.000 | 0.007 |
| 54.00 | 0.000 | 1,951 | 360.70 | 0.007 | 0.000 | 0.007 |
| 54.50 | 0.000 | 1,940 | 360.70 | 0.007 | 0.000 | 0.007 |
| 55.00 | 0.000 | 1,928 | 360.70 | 0.007 | 0.000 | 0.007 |
| 55.50 | 0.000 | 1,916 | 360.69 | 0.006 | 0.000 | 0.006 |
| 56.00 | 0.000 | 1,904 | 360.69 | 0.006 | 0.000 | 0.006 |
| 56.50 | 0.000 | 1,893 | 360.68 | 0.006 | 0.000 | 0.006 |
| 57.00 | 0.000 | 1,881 | 360.68 | 0.006 | 0.000 | 0.006 |
| 57.50 | 0.000 | 1,870 | 360.67 | 0.006 | 0.000 | 0.006 |
| 58.00 | 0.000 | 1,858 | 360.67 | 0.006 | 0.000 | 0.006 |
| 58.50 | 0.000 | 1,847 | 360.66 | 0.006 | 0.000 | 0.006 |
| 59.00 | 0.000 | 1,835 | 360.66 | 0.006 | 0.000 | 0.006 |
| 59.50 | 0.000 | 1,824 | 360.66 | 0.006 | 0.000 | 0.006 |
| 60.00 | 0.000 | 1,813 | 360.65 | 0.006 | 0.000 | 0.006 |
| 60.50 | 0.000 | 1,801 | 360.65 | 0.006 | 0.000 | 0.006 |
| 61.00 | 0.000 | 1,790 | 360.64 | 0.006 | 0.000 | 0.006 |
| 61.50 | 0.000 | 1,779 | 360.64 | 0.006 | 0.000 | 0.006 |
| 62.00 | 0.000 | 1,768 | 360.63 | 0.006 | 0.000 | 0.006 |
| 62.50 | 0.000 | 1,756 | 360.63 | 0.006 | 0.000 | 0.006 |
| 63.00 | 0.000 | 1,745 | 360.63 | 0.006 | 0.000 | 0.006 |
| 63.50 | 0.000 | 1,734 | 360.62 | 0.006 | 0.000 | 0.006 |
| 64.00 | 0.000 | 1,723 | 360.62 | 0.006 | 0.000 | 0.006 |
| 64.50 | 0.000 | 1,712 | 360.61 | 0.006 | 0.000 | 0.006 |
| 65.00 | 0.000 | 1,701 | 360.61 | 0.006 | 0.000 | 0.006 |
| 65.50 | 0.000 | 1,690 | 360.60 | 0.006 | 0.000 | 0.006 |
| 66.00 | 0.000 | 1,679 | 360.60 | 0.006 | 0.000 | 0.006 |
| 66.50 | 0.000 | 1,668 | 360.60 | 0.006 | 0.000 | 0.006 |
| 67.00 | 0.000 | 1,658 | 360.59 | 0.006 | 0.000 | 0.006 |
| 67.50 | 0.000 | 1,647 | 360.59 | 0.006 | 0.000 | 0.006 |
| 68.00 | 0.000 | 1,636 | 360.58 | 0.006 | 0.000 | 0.006 |
| 68.50 | 0.000 | 1,625 | 360.58 | 0.006 | 0.000 | 0.006 |
| 69.00 | 0.000 | 1,615 | 360.58 | 0.006 | 0.000 | 0.006 |
| 69.50 | 0.000 | 1,604 | 360.57 | 0.006 | 0.000 | 0.006 |
| 70.00 | 0.000 | 1,594 | 360.57 | 0.006 | 0.000 | 0.006 |
| 70.50 | 0.000 | 1,583 | 360.56 | 0.006 | 0.000 | 0.006 |
| 71.00 | 0.000 | 1,573 | 360.56 | 0.006 | 0.000 | 0.006 |
| 71.50 | 0.000 | 1,562 | 360.56 | 0.006 | 0.000 | 0.006 |
| 72.00 | 0.000 | 1,552 | 360.55 | 0.006 | 0.000 | 0.006 |
| 72.50 | 0.000 | 1,541 | 360.55 | 0.006 | 0.000 | 0.006 |
| 73.00 | 0.000 | 1,531 | 360.55 | 0.006 | 0.000 | 0.006 |
| 73.50 | 0.000 | 1,521 | 360.54 | 0.006 | 0.000 | 0.006 |
| 74.00 | 0.000 | 1,510 | 360.54 | 0.006 | 0.000 | 0.006 |
| 74.50 | 0.000 | 1,500 | 360.53 | 0.006 | 0.000 | 0.006 |
| 75.00 | 0.000 | 1,490 | 360.53 | 0.006 | 0.000 | 0.006 |
| 75.50 | 0.000 | 1,480 | 360.53 | 0.006 | 0.000 | 0.006 |
| 76.00 | 0.000 | 1,470 | 360.52 | 0.006 | 0.000 | 0.006 |
| 76.50 | 0.000 | 1,460 | 360.52 | 0.006 | 0.000 | 0.006 |
| 77.00 | 0.000 | 1,450 | 360.51 | 0.006 | 0.000 | 0.006 |
| 77.50 | 0.000 | 1,439 | 360.51 | 0.006 | 0.000 | 0.006 |
| 78.00 | 0.000 | 1,430 | 360.51 | 0.006 | 0.000 | 0.006 |
| 78.50 | 0.000 | 1,420 | 360.50 | 0.006 | 0.000 | 0.006 |
| 79.00 | 0.000 | 1,410 | 360.50 | 0.005 | 0.000 | 0.005 |

Hydrograph for Pond 6P: UGB 1 (continued)

| Time (hours) | Inflow (cfs) | Storage (cubic-feet) | Elevation (feet) | Outflow (cfs) | Primary (cfs) | Secondary (cfs) |
|--------------|--------------|----------------------|------------------|---------------|---------------|-----------------|
| 79.50 | 0.000 | 1,400 | 360.50 | 0.005 | 0.000 | 0.005 |
| 80.00 | 0.000 | 1,390 | 360.49 | 0.005 | 0.000 | 0.005 |
| 80.50 | 0.000 | 1,380 | 360.49 | 0.005 | 0.000 | 0.005 |
| 81.00 | 0.000 | 1,370 | 360.49 | 0.005 | 0.000 | 0.005 |
| 81.50 | 0.000 | 1,361 | 360.48 | 0.005 | 0.000 | 0.005 |
| 82.00 | 0.000 | 1,351 | 360.48 | 0.005 | 0.000 | 0.005 |
| 82.50 | 0.000 | 1,341 | 360.48 | 0.005 | 0.000 | 0.005 |
| 83.00 | 0.000 | 1,332 | 360.47 | 0.005 | 0.000 | 0.005 |
| 83.50 | 0.000 | 1,322 | 360.47 | 0.005 | 0.000 | 0.005 |
| 84.00 | 0.000 | 1,313 | 360.46 | 0.005 | 0.000 | 0.005 |
| 84.50 | 0.000 | 1,303 | 360.46 | 0.005 | 0.000 | 0.005 |
| 85.00 | 0.000 | 1,294 | 360.46 | 0.005 | 0.000 | 0.005 |
| 85.50 | 0.000 | 1,284 | 360.45 | 0.005 | 0.000 | 0.005 |
| 86.00 | 0.000 | 1,275 | 360.45 | 0.005 | 0.000 | 0.005 |
| 86.50 | 0.000 | 1,266 | 360.45 | 0.005 | 0.000 | 0.005 |
| 87.00 | 0.000 | 1,256 | 360.44 | 0.005 | 0.000 | 0.005 |
| 87.50 | 0.000 | 1,247 | 360.44 | 0.005 | 0.000 | 0.005 |
| 88.00 | 0.000 | 1,238 | 360.44 | 0.005 | 0.000 | 0.005 |
| 88.50 | 0.000 | 1,229 | 360.43 | 0.005 | 0.000 | 0.005 |
| 89.00 | 0.000 | 1,220 | 360.43 | 0.005 | 0.000 | 0.005 |
| 89.50 | 0.000 | 1,211 | 360.43 | 0.005 | 0.000 | 0.005 |
| 90.00 | 0.000 | 1,201 | 360.42 | 0.005 | 0.000 | 0.005 |
| 90.50 | 0.000 | 1,192 | 360.42 | 0.005 | 0.000 | 0.005 |
| 91.00 | 0.000 | 1,183 | 360.42 | 0.005 | 0.000 | 0.005 |
| 91.50 | 0.000 | 1,174 | 360.41 | 0.005 | 0.000 | 0.005 |
| 92.00 | 0.000 | 1,166 | 360.41 | 0.005 | 0.000 | 0.005 |
| 92.50 | 0.000 | 1,157 | 360.41 | 0.005 | 0.000 | 0.005 |
| 93.00 | 0.000 | 1,148 | 360.40 | 0.005 | 0.000 | 0.005 |
| 93.50 | 0.000 | 1,139 | 360.40 | 0.005 | 0.000 | 0.005 |
| 94.00 | 0.000 | 1,130 | 360.40 | 0.005 | 0.000 | 0.005 |
| 94.50 | 0.000 | 1,121 | 360.40 | 0.005 | 0.000 | 0.005 |
| 95.00 | 0.000 | 1,113 | 360.39 | 0.005 | 0.000 | 0.005 |
| 95.50 | 0.000 | 1,104 | 360.39 | 0.005 | 0.000 | 0.005 |
| 96.00 | 0.000 | 1,095 | 360.39 | 0.005 | 0.000 | 0.005 |
| 96.50 | 0.000 | 1,087 | 360.38 | 0.005 | 0.000 | 0.005 |
| 97.00 | 0.000 | 1,078 | 360.38 | 0.005 | 0.000 | 0.005 |
| 97.50 | 0.000 | 1,070 | 360.38 | 0.005 | 0.000 | 0.005 |
| 98.00 | 0.000 | 1,061 | 360.37 | 0.005 | 0.000 | 0.005 |
| 98.50 | 0.000 | 1,053 | 360.37 | 0.005 | 0.000 | 0.005 |
| 99.00 | 0.000 | 1,044 | 360.37 | 0.005 | 0.000 | 0.005 |
| 99.50 | 0.000 | 1,036 | 360.36 | 0.005 | 0.000 | 0.005 |
| 100.00 | 0.000 | 1,028 | 360.36 | 0.005 | 0.000 | 0.005 |
| 100.50 | 0.000 | 1,019 | 360.36 | 0.005 | 0.000 | 0.005 |
| 101.00 | 0.000 | 1,011 | 360.36 | 0.005 | 0.000 | 0.005 |
| 101.50 | 0.000 | 1,003 | 360.35 | 0.005 | 0.000 | 0.005 |
| 102.00 | 0.000 | 995 | 360.35 | 0.005 | 0.000 | 0.005 |
| 102.50 | 0.000 | 987 | 360.35 | 0.005 | 0.000 | 0.005 |
| 103.00 | 0.000 | 978 | 360.34 | 0.005 | 0.000 | 0.005 |
| 103.50 | 0.000 | 970 | 360.34 | 0.004 | 0.000 | 0.004 |
| 104.00 | 0.000 | 962 | 360.34 | 0.004 | 0.000 | 0.004 |
| 104.50 | 0.000 | 954 | 360.34 | 0.004 | 0.000 | 0.004 |
| 105.00 | 0.000 | 946 | 360.33 | 0.004 | 0.000 | 0.004 |
| 105.50 | 0.000 | 938 | 360.33 | 0.004 | 0.000 | 0.004 |

Hydrograph for Pond 6P: UGB 1 (continued)

| Time (hours) | Inflow (cfs) | Storage (cubic-feet) | Elevation (feet) | Outflow (cfs) | Primary (cfs) | Secondary (cfs) |
|--------------|--------------|----------------------|------------------|---------------|---------------|-----------------|
| 106.00 | 0.000 | 930 | 360.33 | 0.004 | 0.000 | 0.004 |
| 106.50 | 0.000 | 923 | 360.32 | 0.004 | 0.000 | 0.004 |
| 107.00 | 0.000 | 915 | 360.32 | 0.004 | 0.000 | 0.004 |
| 107.50 | 0.000 | 907 | 360.32 | 0.004 | 0.000 | 0.004 |
| 108.00 | 0.000 | 899 | 360.32 | 0.004 | 0.000 | 0.004 |
| 108.50 | 0.000 | 892 | 360.31 | 0.004 | 0.000 | 0.004 |
| 109.00 | 0.000 | 884 | 360.31 | 0.004 | 0.000 | 0.004 |
| 109.50 | 0.000 | 876 | 360.31 | 0.004 | 0.000 | 0.004 |
| 110.00 | 0.000 | 869 | 360.30 | 0.004 | 0.000 | 0.004 |
| 110.50 | 0.000 | 861 | 360.30 | 0.004 | 0.000 | 0.004 |
| 111.00 | 0.000 | 853 | 360.30 | 0.004 | 0.000 | 0.004 |
| 111.50 | 0.000 | 846 | 360.30 | 0.004 | 0.000 | 0.004 |
| 112.00 | 0.000 | 839 | 360.29 | 0.004 | 0.000 | 0.004 |
| 112.50 | 0.000 | 831 | 360.29 | 0.004 | 0.000 | 0.004 |
| 113.00 | 0.000 | 824 | 360.29 | 0.004 | 0.000 | 0.004 |
| 113.50 | 0.000 | 816 | 360.29 | 0.004 | 0.000 | 0.004 |
| 114.00 | 0.000 | 809 | 360.28 | 0.004 | 0.000 | 0.004 |
| 114.50 | 0.000 | 802 | 360.28 | 0.004 | 0.000 | 0.004 |
| 115.00 | 0.000 | 795 | 360.28 | 0.004 | 0.000 | 0.004 |
| 115.50 | 0.000 | 787 | 360.28 | 0.004 | 0.000 | 0.004 |
| 116.00 | 0.000 | 780 | 360.27 | 0.004 | 0.000 | 0.004 |
| 116.50 | 0.000 | 773 | 360.27 | 0.004 | 0.000 | 0.004 |
| 117.00 | 0.000 | 766 | 360.27 | 0.004 | 0.000 | 0.004 |
| 117.50 | 0.000 | 759 | 360.27 | 0.004 | 0.000 | 0.004 |
| 118.00 | 0.000 | 752 | 360.26 | 0.004 | 0.000 | 0.004 |
| 118.50 | 0.000 | 745 | 360.26 | 0.004 | 0.000 | 0.004 |
| 119.00 | 0.000 | 738 | 360.26 | 0.004 | 0.000 | 0.004 |
| 119.50 | 0.000 | 731 | 360.26 | 0.004 | 0.000 | 0.004 |
| 120.00 | 0.000 | 724 | 360.25 | 0.004 | 0.000 | 0.004 |
| 120.50 | 0.000 | 717 | 360.25 | 0.004 | 0.000 | 0.004 |
| 121.00 | 0.000 | 711 | 360.25 | 0.004 | 0.000 | 0.004 |
| 121.50 | 0.000 | 704 | 360.25 | 0.004 | 0.000 | 0.004 |
| 122.00 | 0.000 | 697 | 360.24 | 0.004 | 0.000 | 0.004 |
| 122.50 | 0.000 | 690 | 360.24 | 0.004 | 0.000 | 0.004 |
| 123.00 | 0.000 | 684 | 360.24 | 0.004 | 0.000 | 0.004 |
| 123.50 | 0.000 | 677 | 360.24 | 0.004 | 0.000 | 0.004 |
| 124.00 | 0.000 | 671 | 360.23 | 0.004 | 0.000 | 0.004 |
| 124.50 | 0.000 | 664 | 360.23 | 0.004 | 0.000 | 0.004 |
| 125.00 | 0.000 | 657 | 360.23 | 0.004 | 0.000 | 0.004 |
| 125.50 | 0.000 | 651 | 360.23 | 0.004 | 0.000 | 0.004 |
| 126.00 | 0.000 | 645 | 360.22 | 0.004 | 0.000 | 0.004 |
| 126.50 | 0.000 | 638 | 360.22 | 0.004 | 0.000 | 0.004 |
| 127.00 | 0.000 | 632 | 360.22 | 0.004 | 0.000 | 0.004 |
| 127.50 | 0.000 | 625 | 360.22 | 0.004 | 0.000 | 0.004 |
| 128.00 | 0.000 | 619 | 360.22 | 0.003 | 0.000 | 0.003 |
| 128.50 | 0.000 | 613 | 360.21 | 0.003 | 0.000 | 0.003 |
| 129.00 | 0.000 | 607 | 360.21 | 0.003 | 0.000 | 0.003 |
| 129.50 | 0.000 | 601 | 360.21 | 0.003 | 0.000 | 0.003 |
| 130.00 | 0.000 | 594 | 360.21 | 0.003 | 0.000 | 0.003 |
| 130.50 | 0.000 | 588 | 360.20 | 0.003 | 0.000 | 0.003 |
| 131.00 | 0.000 | 582 | 360.20 | 0.003 | 0.000 | 0.003 |
| 131.50 | 0.000 | 576 | 360.20 | 0.003 | 0.000 | 0.003 |
| 132.00 | 0.000 | 570 | 360.20 | 0.003 | 0.000 | 0.003 |

Hydrograph for Pond 6P: UGB 1 (continued)

| Time (hours) | Inflow (cfs) | Storage (cubic-feet) | Elevation (feet) | Outflow (cfs) | Primary (cfs) | Secondary (cfs) |
|--------------|--------------|----------------------|------------------|---------------|---------------|-----------------|
| 132.50 | 0.000 | 564 | 360.20 | 0.003 | 0.000 | 0.003 |
| 133.00 | 0.000 | 558 | 360.19 | 0.003 | 0.000 | 0.003 |
| 133.50 | 0.000 | 552 | 360.19 | 0.003 | 0.000 | 0.003 |
| 134.00 | 0.000 | 547 | 360.19 | 0.003 | 0.000 | 0.003 |
| 134.50 | 0.000 | 541 | 360.19 | 0.003 | 0.000 | 0.003 |
| 135.00 | 0.000 | 535 | 360.19 | 0.003 | 0.000 | 0.003 |
| 135.50 | 0.000 | 529 | 360.18 | 0.003 | 0.000 | 0.003 |
| 136.00 | 0.000 | 523 | 360.18 | 0.003 | 0.000 | 0.003 |
| 136.50 | 0.000 | 518 | 360.18 | 0.003 | 0.000 | 0.003 |
| 137.00 | 0.000 | 512 | 360.18 | 0.003 | 0.000 | 0.003 |
| 137.50 | 0.000 | 507 | 360.18 | 0.003 | 0.000 | 0.003 |
| 138.00 | 0.000 | 501 | 360.17 | 0.003 | 0.000 | 0.003 |
| 138.50 | 0.000 | 495 | 360.17 | 0.003 | 0.000 | 0.003 |
| 139.00 | 0.000 | 490 | 360.17 | 0.003 | 0.000 | 0.003 |
| 139.50 | 0.000 | 485 | 360.17 | 0.003 | 0.000 | 0.003 |
| 140.00 | 0.000 | 479 | 360.17 | 0.003 | 0.000 | 0.003 |
| 140.50 | 0.000 | 474 | 360.16 | 0.003 | 0.000 | 0.003 |
| 141.00 | 0.000 | 468 | 360.16 | 0.003 | 0.000 | 0.003 |
| 141.50 | 0.000 | 463 | 360.16 | 0.003 | 0.000 | 0.003 |
| 142.00 | 0.000 | 458 | 360.16 | 0.003 | 0.000 | 0.003 |
| 142.50 | 0.000 | 453 | 360.16 | 0.003 | 0.000 | 0.003 |
| 143.00 | 0.000 | 447 | 360.15 | 0.003 | 0.000 | 0.003 |
| 143.50 | 0.000 | 442 | 360.15 | 0.003 | 0.000 | 0.003 |
| 144.00 | 0.000 | 437 | 360.15 | 0.003 | 0.000 | 0.003 |
| 144.50 | 0.000 | 432 | 360.15 | 0.003 | 0.000 | 0.003 |
| 145.00 | 0.000 | 427 | 360.15 | 0.003 | 0.000 | 0.003 |
| 145.50 | 0.000 | 422 | 360.15 | 0.003 | 0.000 | 0.003 |
| 146.00 | 0.000 | 417 | 360.14 | 0.003 | 0.000 | 0.003 |
| 146.50 | 0.000 | 412 | 360.14 | 0.003 | 0.000 | 0.003 |
| 147.00 | 0.000 | 407 | 360.14 | 0.003 | 0.000 | 0.003 |
| 147.50 | 0.000 | 402 | 360.14 | 0.003 | 0.000 | 0.003 |
| 148.00 | 0.000 | 397 | 360.14 | 0.003 | 0.000 | 0.003 |
| 148.50 | 0.000 | 393 | 360.14 | 0.003 | 0.000 | 0.003 |
| 149.00 | 0.000 | 388 | 360.13 | 0.003 | 0.000 | 0.003 |
| 149.50 | 0.000 | 383 | 360.13 | 0.003 | 0.000 | 0.003 |
| 150.00 | 0.000 | 378 | 360.13 | 0.003 | 0.000 | 0.003 |
| 150.50 | 0.000 | 374 | 360.13 | 0.003 | 0.000 | 0.003 |
| 151.00 | 0.000 | 369 | 360.13 | 0.003 | 0.000 | 0.003 |
| 151.50 | 0.000 | 364 | 360.13 | 0.003 | 0.000 | 0.003 |
| 152.00 | 0.000 | 360 | 360.12 | 0.003 | 0.000 | 0.003 |
| 152.50 | 0.000 | 355 | 360.12 | 0.002 | 0.000 | 0.002 |
| 153.00 | 0.000 | 351 | 360.12 | 0.002 | 0.000 | 0.002 |
| 153.50 | 0.000 | 346 | 360.12 | 0.002 | 0.000 | 0.002 |
| 154.00 | 0.000 | 342 | 360.12 | 0.002 | 0.000 | 0.002 |
| 154.50 | 0.000 | 338 | 360.12 | 0.002 | 0.000 | 0.002 |
| 155.00 | 0.000 | 333 | 360.11 | 0.002 | 0.000 | 0.002 |
| 155.50 | 0.000 | 329 | 360.11 | 0.002 | 0.000 | 0.002 |
| 156.00 | 0.000 | 325 | 360.11 | 0.002 | 0.000 | 0.002 |
| 156.50 | 0.000 | 321 | 360.11 | 0.002 | 0.000 | 0.002 |
| 157.00 | 0.000 | 316 | 360.11 | 0.002 | 0.000 | 0.002 |
| 157.50 | 0.000 | 312 | 360.11 | 0.002 | 0.000 | 0.002 |
| 158.00 | 0.000 | 308 | 360.11 | 0.002 | 0.000 | 0.002 |
| 158.50 | 0.000 | 304 | 360.10 | 0.002 | 0.000 | 0.002 |

Hydrograph for Pond 6P: UGB 1 (continued)

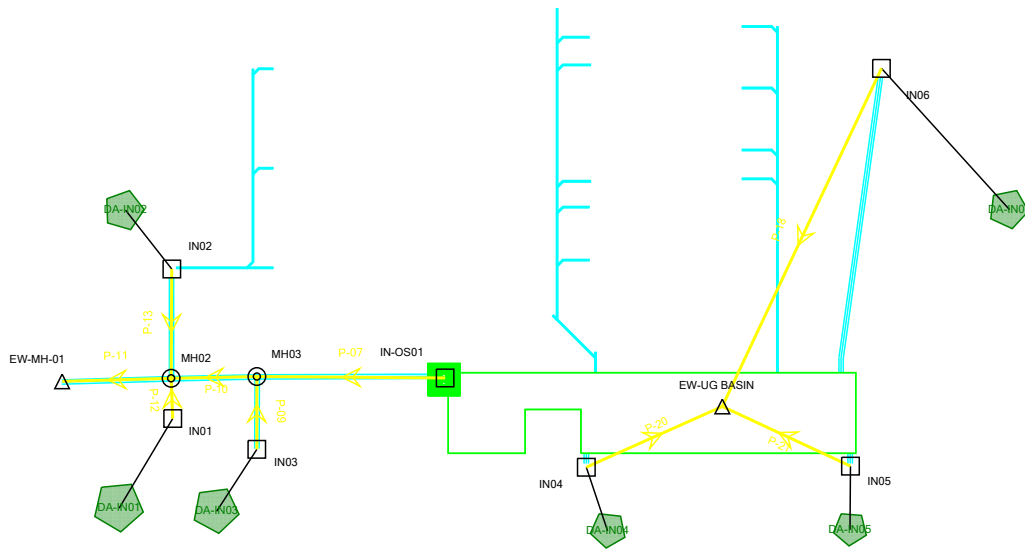
| Time (hours) | Inflow (cfs) | Storage (cubic-feet) | Elevation (feet) | Outflow (cfs) | Primary (cfs) | Secondary (cfs) |
|--------------|--------------|----------------------|------------------|---------------|---------------|-----------------|
| 159.00 | 0.000 | 300 | 360.10 | 0.002 | 0.000 | 0.002 |
| 159.50 | 0.000 | 296 | 360.10 | 0.002 | 0.000 | 0.002 |
| 160.00 | 0.000 | 292 | 360.10 | 0.002 | 0.000 | 0.002 |
| 160.50 | 0.000 | 288 | 360.10 | 0.002 | 0.000 | 0.002 |
| 161.00 | 0.000 | 284 | 360.10 | 0.002 | 0.000 | 0.002 |
| 161.50 | 0.000 | 280 | 360.10 | 0.002 | 0.000 | 0.002 |
| 162.00 | 0.000 | 276 | 360.09 | 0.002 | 0.000 | 0.002 |
| 162.50 | 0.000 | 273 | 360.09 | 0.002 | 0.000 | 0.002 |
| 163.00 | 0.000 | 269 | 360.09 | 0.002 | 0.000 | 0.002 |
| 163.50 | 0.000 | 265 | 360.09 | 0.002 | 0.000 | 0.002 |
| 164.00 | 0.000 | 261 | 360.09 | 0.002 | 0.000 | 0.002 |
| 164.50 | 0.000 | 258 | 360.09 | 0.002 | 0.000 | 0.002 |
| 165.00 | 0.000 | 254 | 360.09 | 0.002 | 0.000 | 0.002 |
| 165.50 | 0.000 | 250 | 360.09 | 0.002 | 0.000 | 0.002 |
| 166.00 | 0.000 | 247 | 360.08 | 0.002 | 0.000 | 0.002 |
| 166.50 | 0.000 | 243 | 360.08 | 0.002 | 0.000 | 0.002 |
| 167.00 | 0.000 | 240 | 360.08 | 0.002 | 0.000 | 0.002 |
| 167.50 | 0.000 | 236 | 360.08 | 0.002 | 0.000 | 0.002 |
| 168.00 | 0.000 | 233 | 360.08 | 0.002 | 0.000 | 0.002 |
| 168.50 | 0.000 | 230 | 360.08 | 0.002 | 0.000 | 0.002 |
| 169.00 | 0.000 | 226 | 360.08 | 0.002 | 0.000 | 0.002 |
| 169.50 | 0.000 | 223 | 360.08 | 0.002 | 0.000 | 0.002 |
| 170.00 | 0.000 | 220 | 360.08 | 0.002 | 0.000 | 0.002 |
| 170.50 | 0.000 | 216 | 360.07 | 0.002 | 0.000 | 0.002 |
| 171.00 | 0.000 | 213 | 360.07 | 0.002 | 0.000 | 0.002 |
| 171.50 | 0.000 | 210 | 360.07 | 0.002 | 0.000 | 0.002 |
| 172.00 | 0.000 | 207 | 360.07 | 0.002 | 0.000 | 0.002 |
| 172.50 | 0.000 | 204 | 360.07 | 0.002 | 0.000 | 0.002 |
| 173.00 | 0.000 | 201 | 360.07 | 0.002 | 0.000 | 0.002 |
| 173.50 | 0.000 | 198 | 360.07 | 0.002 | 0.000 | 0.002 |
| 174.00 | 0.000 | 195 | 360.07 | 0.002 | 0.000 | 0.002 |
| 174.50 | 0.000 | 192 | 360.07 | 0.002 | 0.000 | 0.002 |
| 175.00 | 0.000 | 189 | 360.06 | 0.002 | 0.000 | 0.002 |
| 175.50 | 0.000 | 186 | 360.06 | 0.002 | 0.000 | 0.002 |
| 176.00 | 0.000 | 183 | 360.06 | 0.002 | 0.000 | 0.002 |
| 176.50 | 0.000 | 180 | 360.06 | 0.002 | 0.000 | 0.002 |
| 177.00 | 0.000 | 178 | 360.06 | 0.002 | 0.000 | 0.002 |
| 177.50 | 0.000 | 175 | 360.06 | 0.002 | 0.000 | 0.002 |
| 178.00 | 0.000 | 172 | 360.06 | 0.001 | 0.000 | 0.001 |
| 178.50 | 0.000 | 169 | 360.06 | 0.001 | 0.000 | 0.001 |
| 179.00 | 0.000 | 167 | 360.06 | 0.001 | 0.000 | 0.001 |
| 179.50 | 0.000 | 164 | 360.06 | 0.001 | 0.000 | 0.001 |
| 180.00 | 0.000 | 162 | 360.06 | 0.001 | 0.000 | 0.001 |
| 180.50 | 0.000 | 159 | 360.05 | 0.001 | 0.000 | 0.001 |
| 181.00 | 0.000 | 157 | 360.05 | 0.001 | 0.000 | 0.001 |
| 181.50 | 0.000 | 154 | 360.05 | 0.001 | 0.000 | 0.001 |
| 182.00 | 0.000 | 152 | 360.05 | 0.001 | 0.000 | 0.001 |
| 182.50 | 0.000 | 149 | 360.05 | 0.001 | 0.000 | 0.001 |
| 183.00 | 0.000 | 147 | 360.05 | 0.001 | 0.000 | 0.001 |
| 183.50 | 0.000 | 145 | 360.05 | 0.001 | 0.000 | 0.001 |
| 184.00 | 0.000 | 143 | 360.05 | 0.001 | 0.000 | 0.001 |
| 184.50 | 0.000 | 140 | 360.05 | 0.001 | 0.000 | 0.001 |
| 185.00 | 0.000 | 138 | 360.05 | 0.001 | 0.000 | 0.001 |

Hydrograph for Pond 6P: UGB 1 (continued)

| Time (hours) | Inflow (cfs) | Storage (cubic-feet) | Elevation (feet) | Outflow (cfs) | Primary (cfs) | Secondary (cfs) |
|--------------|--------------|----------------------|------------------|---------------|---------------|-----------------|
| 185.50 | 0.000 | 136 | 360.05 | 0.001 | 0.000 | 0.001 |
| 186.00 | 0.000 | 134 | 360.05 | 0.001 | 0.000 | 0.001 |
| 186.50 | 0.000 | 132 | 360.04 | 0.001 | 0.000 | 0.001 |
| 187.00 | 0.000 | 129 | 360.04 | 0.001 | 0.000 | 0.001 |
| 187.50 | 0.000 | 127 | 360.04 | 0.001 | 0.000 | 0.001 |
| 188.00 | 0.000 | 125 | 360.04 | 0.001 | 0.000 | 0.001 |
| 188.50 | 0.000 | 123 | 360.04 | 0.001 | 0.000 | 0.001 |
| 189.00 | 0.000 | 121 | 360.04 | 0.001 | 0.000 | 0.001 |
| 189.50 | 0.000 | 120 | 360.04 | 0.001 | 0.000 | 0.001 |
| 190.00 | 0.000 | 118 | 360.04 | 0.001 | 0.000 | 0.001 |
| 190.50 | 0.000 | 116 | 360.04 | 0.001 | 0.000 | 0.001 |
| 191.00 | 0.000 | 114 | 360.04 | 0.001 | 0.000 | 0.001 |
| 191.50 | 0.000 | 112 | 360.04 | 0.001 | 0.000 | 0.001 |
| 192.00 | 0.000 | 111 | 360.04 | 0.001 | 0.000 | 0.001 |

Conveyance Calculations

Scenario: 25-Year



Runoff Calculations C Worksheet

Project: Wawa Radnor

Description: Inlet Drainage Areas

| Drainage Area | Land Use Description | C | Area (Acres) | Total Area (Acres) | Weighted C |
|---------------|----------------------|------|--------------|--------------------|-------------|
| IN01 | Impervious | 0.99 | 0.11 | 0.11 | 0.99 |
| | | | | | |
| | | | | | |
| | | | | | |
| IN02 | Impervious | 0.99 | 0.27 | 0.27 | 0.99 |
| | | | | | |
| | | | | | |
| | | | | | |
| IN03 | Impervious | 0.99 | 0.07 | 0.07 | 0.99 |
| | | | | | |
| | | | | | |
| | | | | | |
| IN04 | Impervious | 0.99 | 0.05 | 0.05 | 0.99 |
| | | | | | |
| | | | | | |
| | | | | | |
| IN05 | Impervious | 0.99 | 0.19 | 0.20 | 0.97 |
| | Pervious | 0.51 | 0.01 | | |
| | | | | | |
| | | | | | |
| IN06 | Impervious | 0.99 | 0.14 | 0.15 | 0.96 |
| | Pervious | 0.51 | 0.01 | | |
| | | | | | |
| | | | | | |

Scenario: 25-Year
Current Time Step: 0.000Hr
Conduit FlexTable: Combined Pipe/Node Report

| Label | Start Node | Stop Node | Upstream Inlet C | Upstream Inlet Area (acres) | System CA (acres) | System Intensity (in/h) | Total Flow (ft ³ /s) | Diameter (in) | Capacity (Full Flow) (ft ³ /s) | Velocity (Average) (ft/s) | Invert (Upstream) (ft) | Invert (Downstream) (ft) | Slope (ft/ft) | Length (Unified) (ft) | Material |
|-------|------------|-------------|------------------|-----------------------------|-------------------|-------------------------|---------------------------------|---------------|---|---------------------------|------------------------|--------------------------|---------------|-----------------------|----------|
| P-07 | IN-OS01 | MH03 | (N/A) | (N/A) | 0.000 | 7.140 | 3.37 | 18.0 | 19.76 | 8.35 | 360.00 | 358.10 | 0.0302 | 63.0 | HDPE |
| P-09 | IN03 | MH03 | 0.990 | 0.070 | 0.069 | 7.140 | 0.50 | 18.0 | 12.47 | 3.44 | 358.25 | 357.95 | 0.0120 | 25.0 | HDPE |
| P-10 | MH03 | MH02 | (N/A) | (N/A) | 0.069 | 7.104 | 3.87 | 18.0 | 21.89 | 9.33 | 357.93 | 356.82 | 0.0370 | 30.0 | HDPE |
| P-11 | MH02 | EW-MH-01 | (N/A) | (N/A) | 0.445 | 7.088 | 6.55 | 18.0 | 18.55 | 9.59 | 356.63 | 355.62 | 0.0266 | 38.0 | HDPE |
| P-12 | IN01 | MH02 | 0.990 | 0.110 | 0.109 | 7.140 | 0.78 | 18.0 | 8.05 | 2.89 | 356.65 | 356.63 | 0.0050 | 4.0 | HDPE |
| P-13 | IN02 | MH02 | 0.990 | 0.270 | 0.267 | 7.140 | 1.92 | 18.0 | 20.45 | 7.27 | 357.83 | 356.70 | 0.0323 | 35.0 | HDPE |
| P-18 | IN06 | EW-UG BASIN | 0.960 | 0.150 | 0.144 | 7.140 | 1.04 | 18.0 | 15.12 | 4.90 | 362.00 | 360.20 | 0.0176 | 102.0 | HDPE |
| P-20 | IN04 | EW-UG BASIN | 0.990 | 0.050 | 0.049 | 7.140 | 0.36 | 18.0 | 17.99 | 4.02 | 360.10 | 360.00 | 0.0250 | 4.0 | HDPE |
| P-21 | IN05 | EW-UG BASIN | 0.970 | 0.200 | 0.194 | 7.140 | 1.40 | 18.0 | 17.99 | 6.05 | 360.10 | 360.00 | 0.0250 | 4.0 | HDPE |

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Scenario: 25-Year
Current Time Step: 0.000Hr
Catch Basin FlexTable: Node Report

| Label | Inlet | Inlet DA (acres) | Inlet C | Inlet CA (acres) | I (in/h) | System Tc (min) | Flow (Known) (ft ³ /s) | Flow (Total Out) (ft ³ /s) | Inlet Q (ft ³ /s) | RIM (ft) | Hydraulic Grade Line (In) (ft) | Hydraulic Grade Line (Out) (ft) | Capture Efficiency (%) |
|---------|----------------|---------------------|---------|---------------------|----------|--------------------|--------------------------------------|--|---------------------------------|----------|-----------------------------------|------------------------------------|------------------------|
| IN01 | PADOT Type 'C' | 0.110 | 0.990 | 0.109 | 7.140 | 5.000 | 0.00 | 0.78 | 0.78 | 360.15 | 357.65 | 357.65 | 100.00 |
| IN02 | PADOT Type 'C' | 0.270 | 0.990 | 0.267 | 7.140 | 5.000 | 0.00 | 1.92 | 1.92 | 361.33 | 358.35 | 358.35 | 100.00 |
| IN03 | PADOT Type 'C' | 0.070 | 0.990 | 0.069 | 7.140 | 5.000 | 0.00 | 0.50 | 0.50 | 361.75 | 358.69 | 358.69 | 100.00 |
| IN04 | PADOT Type 'C' | 0.050 | 0.990 | 0.049 | 7.140 | 5.000 | 0.00 | 0.36 | 0.36 | 365.00 | 361.19 | 361.19 | 100.00 |
| IN05 | PADOT Type 'C' | 0.200 | 0.970 | 0.194 | 7.140 | 5.000 | 0.00 | 1.40 | 1.40 | 364.67 | 361.19 | 361.19 | 100.00 |
| IN06 | PADOT Type 'M' | 0.150 | 0.960 | 0.144 | 7.140 | 5.000 | 0.00 | 1.04 | 1.04 | 365.50 | 362.38 | 362.38 | 100.00 |
| IN-OS01 | PADOT Type 'M' | (N/A) | (N/A) | 0.000 | 7.140 | 5.000 | 3.37 | 3.37 | 0.00 | 364.69 | 360.70 | 360.70 | 100.00 |

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Appendix A

July 12, 2018

via email

THE AUTOWASH GROUP
444 Egypt Road
Norristown, Pennsylvania 19403

Attention: Peter Karakelian, P.E.
President

**Regarding: PRELIMINARY STORMWATER MANAGEMENT AREA EVALUATION
PROPOSED WAWA FOOD MARKET
LANCASTER AVENUE & ABERDEEN AVENUE
RADNOR TOWNSHIP, CHESTER COUNTY, PENNSYLVANIA
WHITESTONE PROJECT NO.: GP1714612.000**

Dear Mr. Karakelian:

Whitestone Associates, Inc. (Whitestone) is pleased to submit this *Preliminary Stormwater Management (SWM) Area Evaluation* report for the above-referenced project. This assessment provides preliminary SWM area recommendations for the proposed Wawa Food Market redevelopment based on available groundwater information provided by The Autowash Group (TAG) and subsurface information presented in Whitestone's July 25, 2017 *Report of Geotechnical Investigation*, previously performed in support of the proposed site redevelopment.

1.0 PROJECT DESCRIPTION / SUBSURFACE DATA

Based on the project information provided by Bohler Engineering PA, LLC (Bohler), the site redevelopment potentially will include underground SWM facilities at an approximate elevation of 362 feet, as referenced from the North American Vertical Datum of 1988 (NAVD88). The final types, locations, and size of the proposed SWM facilities have not been determined at the time of this report.

The groundwater data provided by TAG included 17 monitoring well logs prepared by JK Environmental Services, LLC (JKES). Based on the monitoring well data, the groundwater table was recorded at relatively shallow depths that corresponding to elevations ranging between 356.6 feet and 361.0 feet.

Whitestone's subsurface data obtained from the geotechnical investigation revealed that the soil types encountered between the approximate elevations of 363 feet and 358 feet consist of a combination of generally fine-grained existing fill materials and fine-grained natural soils.

Other Office Locations:

WARREN, NJ
908.668.7777

SOUTHBOROUGH, MA
508.485.0755

ROCKY HILL, CT
860.726.7889

WALL, NJ
732.592.2101

STERLING, VA
703.464.5858

EVERGREEN, CO
303.670.6905

2.0 PRELIMINARY SWM RECOMMENDATIONS

Based on the groundwater information provided by TAG and subsurface data obtained from Whitestone's previously performed geotechnical investigation, the site generally appears not to be conducive for infiltration design.

A site specific investigation and testing may be required in order to confirm these preliminary conclusions.

Whitestone appreciates the opportunity to be of continued service to the Autowash Group. Please contact us with any questions or comments regarding this report addendum.

Sincerely,

WHITESTONE ASSOCIATES, INC.



James M. Morgan
Senior Project Manager



Laurence W. Keller, P.E.
Principal, Geotechnical Services

REPORT OF GEOTECHNICAL INVESTIGATION

PROPOSED WAWA FOOD MARKET & FUELING STATION
LANCASTER AVENUE & ABERDEEN AVENUE
WAYNE (RADNOR TOWNSHIP), CHESTER COUNTY, PENNSYLVANIA



Prepared for:

THE AUTOWASH GROUP
444 Egypt Road
Norristown, Pennsylvania 19403

Prepared by:

WHITESTONE ASSOCIATES, INC.
New Britain Corporate Center
1600 Manor Drive, Suite 220
Chalfont, Pennsylvania 18914

James M. Morgan
Senior Project Manager

Laurence W. Keller, P.E.
Principal, Geotechnical Services

Whitestone Project No.: GP1714612.000
July 25, 2017

July 25, 2017

via email

THE AUTOWASH GROUP
444 Egypt Road
Norristown, Pennsylvania 19403

Attention: Peter Karakelian, P.E.
President

**Regarding: REPORT OF GEOTECHNICAL INVESTIGATION
PROPOSED WAWA FOOD MARKET & FUELING STATION
LANCASTER AVENUE & ABERDEEN AVENUE
RADNOR TOWNSHIP (WAYNE), CHESTER COUNTY, PENNSYLVANIA
WHITESTONE PROJECT NO.: GP1714612.000**

Dear Mr. Karakelian:

Whitestone Associates, Inc. is pleased to submit the attached *Report of Geotechnical Investigation* for the above-referenced project. The attached report presents the results of Whitestone's soils exploration efforts and presents recommendations for design of the proposed structural foundations, floor slab, pavements, utilities, and related earthwork associated with the proposed Wawa Food Market and fueling station development.

Whitestone's geotechnical division appreciates the opportunity to be of service to The Autowash Group. Please note that Whitestone has the capability to perform the additional geotechnical engineering services recommended herein. Please contact us at (215) 712-2700 with any questions regarding the enclosed report.

Sincerely,

WHITESTONE ASSOCIATES, INC.

James M. Morgan
Senior Project Manager

Laurence W. Keller, P.E.
Principal, Geotechnical Services

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Enclosures

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FIGURES

FIGURE 1 Boring Location Plan

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APPENDIX A Records of Subsurface Exploration

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SECTION 1.0

Summary of Findings and Recommendations

An exploration and evaluation of the subsurface conditions has been performed on the site of the proposed Wawa Food Market and fueling station development located within the southeastern quadrant of the intersection of the Lancaster Avenue and Aberdeen Avenue in Radnor Township (Wayne), Chester County, Pennsylvania. The site of the proposed construction is shown on the *Boring Location Plan* included as Figure 1.

At the time of the investigation, the western portion of the site was developed with a Sunoco gasoline station with associated pavements and utilities, including underground storage tanks (USTs). The eastern portion was developed with a BP gasoline station with associated pavements and utilities, including USTs.

Based on a review of available historical aerial imagery dating back to 1948, several former structures previously occupied the subject property. Additionally, several existing USTs are in-place adjacent to the proposed Wawa Food Market building, canopy area, and new USTs location.

Based on the elevations provided by a hand-held Trimble Geo-XT GPS instrument, the site has approximate existing elevations ranging between +364 feet in the western and southern portions of the site and +370 feet in the northern portions of the site, as referenced from mean sea level (msl) elevation.

Based on a May 11, 2017 *Site Plan* prepared by JK Environmental, the proposed site redevelopment includes demolition of the existing structures and utilities and the construction of a single-story Wawa Food Market building, a canopy over fuel dispenser stations, up to five USTs, and associated new pavements, trash enclosure, identification signs, and utilities. The proposed development may include stormwater management (SWM) facilities, but final type, location, and size have not been provided at the time of this report. Whitestone anticipates that the proposed site grading will require maximum earth cuts and fills on the order of two feet. No site retaining walls are anticipated.

The geotechnical investigation included performing a reconnaissance of the project site, drilling seven soil borings (and one associated offset), and collecting soil samples for laboratory analysis. The data from this exploration and analysis were analyzed by Whitestone in light of the project information provided by The Autowash Group (TAG).

A summary of Whitestone's findings is presented in the following table and detailed descriptions of the subsurface conditions encountered are presented in Section 4.0.

| Subsurface Profile | Description | Bottom of Stratum (fbgs) |
|--------------------------------|---|---------------------------------|
| <i>Surface Cover Materials</i> | Asphalt Pavement: 6.0 inches underlain by up to 6.0 inches of subbase material. | 1.0 |
| <i>Existing Fill Materials</i> | Encountered all of the borings. Consisting of clay, silt, and sand mixtures with trace amounts of concrete, brick, and metal fragments. | 3.0 to 8.0 |
| <i>Residual Soils</i> | Lean clay (USCS: CL), silt (USCS: ML), and sand (USCS: SM) with lesser amounts of gravel. | +24.7 |
| <i>Groundwater</i> | Static groundwater was encountered in majority of test borings at depths of 3.5 fbgs to 9.0 fbgs | +3.5 |

fbgs: feet below ground surface.

Recommendations developed upon consideration of these findings are summarized in the table below and presented in greater detail in the indicated sections of the report.

| Geotechnical Consideration | Recommendation | Report Section |
|--|--|-----------------------|
| <i>Demolition of Existing Structures</i> | Demolition of the existing structures should include complete removal of slabs, foundation walls, and footings. The resultant excavations should be backfilled in a controlled manner using approved structural backfill materials. | 5.2 |
| <i>Demolition of Existing Utilities</i> | The in-place USTs associated with existing site development are located in close proximity to the proposed Wawa building, canopy, and new UST field. All existing USTs should be removed and backfilled with structural fill in accordance with this report. | 5.2 |
| <i>Groundwater Control</i> | Construction phase dewatering is anticipated for canopy foundations, USTs, and utility construction. Temporary dewatering is expected to include the use of sump pits and pumps installed within excavations. Submerged fill consisting of open-graded, crushed, three-quarter inch clean stone will be required within excavations that extend below groundwater level. | 5.4 |
| <i>Supplemental Investigation</i> | A significant portion of the proposed development was occupied by existing structures at the time of the investigation and was inaccessible to the drilling equipment. As such, additional exploration should be performed at a later date following demolition of the existing structures in order to confirm foundation design recommendations herein. In addition, construction phase evaluation of the existing fill materials should be performed by the owner's geotechnical engineer. | 5.12 |
| <i>Foundation System</i> | Shallow spread and continuous footings bearing on approved and recompacted existing fill materials, natural soils, and imported structural fill. Based on the extensive former site development, buried remnant slabs and foundations may be encountered. Isolated areas of overexcavation and replacement are anticipated. | 5.5 |
| <i>Floor Slab & Pavements</i> | A majority of the on-site soils will be suitable for support of the proposed floor slab and pavements following compaction and proofroll inspections. Isolated areas of overexcavation and replacement are anticipated. | 5.6 |
| <i>On-Site Soil Reuse</i> | A majority of the site soils above groundwater lever are expected to be suitable for reuse as structural fill and/or backfill provided that moisture levels are maintained within two percent of optimum moisture content. | 5.3 |

SECTION 2.0

Introduction

2.1 AUTHORIZATION

Peter Karakelian, P.E. of TAG issued authorization to Whitestone to perform a geotechnical investigation on this site relevant to the construction of the proposed Wawa Food Market and fueling station located at the southeastern quadrant of the intersection of Lancaster Avenue (U.S. Route 30) and Aberdeen Avenue in Radnor Township (Wayne), Chester County, Pennsylvania. The geotechnical investigation was performed in general accordance with Whitestone's June 2, 2017 revised proposal to TAG.

2.2 PURPOSE

The purpose of this subsurface exploration and analysis was to:

- ▶ ascertain the various soil profile components at test locations;
- ▶ estimate the engineering characteristics of the proposed foundation bearing and subgrade materials;
- ▶ provide geotechnical criteria for use by the design engineers in preparing the foundation, slab, and pavement design;
- ▶ provide recommendations for required earthwork and subgrade preparation;
- ▶ record groundwater levels (if encountered) at the time of the investigation and discuss the potential impact on the proposed construction; and
- ▶ recommend additional investigation and/or analysis (if warranted).

2.3 SCOPE

The scope of the exploration and analysis included the subsurface exploration, field testing and sampling, laboratory analysis, and an engineering analysis and evaluation of the foundation materials. This *Report of Geotechnical Investigation* is limited to addressing the site conditions related to the physical support of the proposed construction. Any references to suspicious odors, materials, or conditions are provided strictly for the client's information. A *Limited Phase II Environmental Site Assessment* report has been prepared by Whitestone's environmental division and submitted under separate cover.

2.3.1 Field Exploration

Field exploration of the project site was conducted by means of seven soil borings and one associated offset, identified as SB-01 through SB-07. The soil borings were advanced with a ATV-mounted Acker XLS drill rig equipped with hollow-stem augers. The locations of the soil borings are shown on the *Boring Location Plan* included as Figure 1. *Records of Subsurface Exploration* are provided in Appendix A. The test boring locations and termination depths are presented in the table below:

| SOIL BORING & TERMINATION DEPTH TABLE | | |
|---------------------------------------|--------------------|---------------------------|
| Proposed Construction | Boring Location(s) | Termination Depth (fbgs*) |
| Wawa Food Market Building | SB-04 and SB-05 | 20.0 |
| Fuel Canopy/Dispenser Islands | SB-01 and SB-03 | 13.0 to 20.0 |
| UST Field | SB-02/SB-02A | 3.5 to 24.7 |
| Proposed Trash Enclosure/Pavements | SB-06 and SB-07 | 11.0 |

* fbgs: feet below ground surface

The boring locations were based on the project information available at the time of the investigation provided by TAG, including the May 11, 2017 *Site Plan* prepared by JK Environmental. In addition, the investigation was performed in general accordance with scope of work outlined in the December 13, 2002 (implementation date February 20, 2006) *Geotechnical Report Standards* prepared by Wawa, Inc.

The soil borings were conducted in the presence of a Whitestone engineer who performed field tests, recorded visual classifications, and collected samples of the various strata encountered. The test areas were located in the field using normal taping procedures and estimated right angles. These locations are presumed to be accurate within a few feet.

Soil borings and Standard Penetration Tests (SPTs) were conducted in general accordance with ASTM International (ASTM) designation D 1586. The SPT resistance value (N) can be used as an indicator of the consistency of fine-grained soils and the relative density of coarse-grained soils. The N-value for various soil types can be correlated with the engineering behavior of earthworks and foundations.

Groundwater level observations, where encountered, were recorded during and immediately after the completion of field operations prior to backfilling the borings. Groundwater elevations derived from sources other than seasonally observed groundwater monitor wells may not be representative of true groundwater levels.

2.3.2 Laboratory Testing Program

In addition to the field investigation, a laboratory testing program was conducted to determine additional, pertinent engineering characteristics of representative samples of on-site soils. The laboratory testing program was performed in general accordance with applicable ASTM standard test methods and included physical testing of proposed building foundation bearing and pavement subgrade stratum.

Physical/Textural Analyses: Representative samples of selected strata encountered were subjected to a laboratory testing program that included Atterberg limits determinations (ASTM D-4318), moisture content determinations (ASTM D-2216) and washed gradation analyses (ASTM D-422) in order to perform supplementary engineering soil classifications in general accordance with ASTM D-2487. The soil strata tested were classified by the Unified Soil Classification System (USCS) and results of the laboratory testing are summarized in the following table. Quantitative test results are provided in Appendix B.

| PHYSICAL/TEXTURAL ANALYSES SUMMARY | | | | | | | |
|------------------------------------|--------|--------------|-------------------------|----------------------|--------------|---------------|---------------------|
| Boring No. | Sample | Depth (fbgs) | % Passing No. 200 Sieve | Moisture Content (%) | Liquid Limit | Plastic Index | USCS Classification |
| SB-02A | S-4 | 6.0 to 8.0 | 14.0 | 13.1 | Non-Plastic | | SM |
| SB-04 | S-2 | 3.0 to 5.0 | 8.8 | 24.0 | 40 | 20 | CL |

fbgs: feet below ground surface

The engineering classifications are useful when considered in conjunction with the additional site data to estimate properties of the soil types encountered and to predict the soil's behavior under construction and service loads.

SECTION 3.0

Site Description

3.1 LOCATION AND DESCRIPTION

The subject site comprises approximately 1.3 acres and is located within the southeastern quadrant of the intersection of Lancaster Avenue (U.S. Route 30) and Aberdeen Avenue in Radnor Township (Wayne), Chester County, Pennsylvania. The site is bordered by Lancaster Avenue to the north, followed by a gasoline station and retail development; retail and office building developments to the east; residential development to the site; Aberdeen Avenue to the west, followed by various retail and office building developments.

3.2 EXISTING CONDITIONS

Surface Cover/Development: At the time of the investigation, the site was developed. The western portion of the site was developed with a Sunoco gasoline station with associated pavements and utilities, including USTs. The eastern portion was developed with a BP gasoline station with associated pavements and utilities, including USTs.

Previous Site Development: Based on a review of available historical aerial imagery dating back to 1948, the subject property appeared developed with residential properties, with the surrounding roads in place. Sometime between 1948 and 1950, the residential structures and trees were removed and the western portion of the site was paved. Sometime between 1950 and 1958, the eastern portion of the site appeared to be a automotive service station. The site remained relatively unchanged until sometime between 1967 and 1971, when the western portion of the site was redeveloped to the existing Sunoco gasoline station layout. Sometime between 1971 and 1992, the eastern portion of the site was redeveloped to the existing BP gasoline station layout. No significant changes to the property were apparent between 1992 and present day.

Topography & Site Coordinates: A survey plan with existing topographical information was not available at the time of this report; however Whitestone utilized a handheld Trimble Geo-XT with sub-meter accuracy to approximate the coordinates and existing surface elevations of the test boring locations. Based on the elevations provided by the Trimble Geo-XT, the site has approximate existing elevations ranging between +364 feet in the western and southern portions of the site and +370 feet in the northern portions of the site.

The coordinates and surface elevations of the test boring locations recorded at the time of the investigation are presented in Appendix D.

Utilities: The existing structures are serviced by natural gas, water, stormwater, electric, and telecommunications. In addition, underground utilities traversed the perimeter of the site at the time of the investigation, including natural gas, sanitary sewer, water, stormwater, electric and telecommunications. The utility information contained in this report is presented for general discussion only and is not intended for construction purposes.

Site Drainage: Surface runoff generally consists of sheet flow across the existing ground surface and generally appears to flow from the north to the south. Stormwater collection facilities traverse the perimeter of the site as part as the existing roadways.

3.3 SITE BEDROCK GEOLOGY

The *Geologic Map of Pennsylvania* prepared by the Commonwealth of Pennsylvania Department of Environmental Resources Bureau of *Topographic and Geologic Survey*, dated 1980, indicates that subject site is located within the Upland Section of the Piedmont Physiographic Province of Pennsylvania. Specifically, the site is underlain by the Precambrian-aged Mafic Gneiss Formation. This formation consists of dark, medium-grained gneiss and includes rock of probable sedimentary origin and the parent bedrock weathers to silty sand and silt with upper layers of lean clay. The subsurface conditions encountered generally are consistent with the mapped geology.

3.4 PROPOSED CONSTRUCTION

Based on the aforementioned *Site Plan*, the proposed site redevelopment includes demolition of the existing structures, pavements and associated utilities and construction of a single-story Wawa Food Market building, a canopy over fuel dispenser stations, USTs, and associated new pavements, trash enclosure, identification signs, and utilities. The proposed development may include SWM facilities. No proposed grading plans were available at the time of this report, however, Whitestone anticipates maximum cuts and fills on the order of two feet. No site retaining walls are anticipated.

Whitestone anticipates that the proposed structures will consist of a combination of load-bearing masonry walls with steel joist and column framing and concrete slab-on-grade. Final maximum design loads have not been determined at this time; however, based on past experience with similar Wawa projects, maximum design loads are assumed to be less than the following:

- ▶ column load - 65 kips;
- ▶ wall load - 2.0 kips per linear foot;
- ▶ floor slab load - 100 pounds per square foot; and
- ▶ canopy overturning moment - 50 foot-kips.

The scope of Whitestone's investigation and the professional advice contained in this report were generated based on the project details and loading noted herein. Any revisions or additions to the design details enumerated in this report should be brought to the attention of Whitestone for additional evaluation as warranted.

SECTION 4.0 Subsurface Conditions

Details of the subsurface materials encountered are presented on the *Records of Subsurface Exploration* presented in Appendix A of this report. The subsurface soil conditions encountered in the soil borings consisted of the following generalized strata in order of increasing depth.

4.1 SUBSURFACE CONDITIONS

Surficial Cover Materials: The soil borings were performed within the existing pavement areas associated with the existing gasoline stations. These test locations encountered approximately six inches of asphalt underlain by approximately six inches of granular subbase materials.

Existing Fill Materials: Underlying the surficial cover materials, existing fill materials were encountered in all of the boring locations. The existing fill materials consisted generally of lean clay, silt, and sand mixtures with trace amounts of brick, asphalt, concrete, metal, and gravel. Several of the locations revealed loose or very soft soil conditions, especially in location SB-07, where approximately two feet of material could be penetrated by the weight of the sampling hammer. The existing fill materials extended to depths ranging from approximately 3.0 fbgs to 8.0 fbgs. Boring SB-02 was terminated within the existing fill materials and offset due to a utility concern.

Residual Soils: Beneath the existing fill materials, the test locations encountered residual soils composed of lean clay (USCS: CL) with variable amounts of sand; silt (USCS: ML) with variable amounts of gravel and sand; and sand with varying amounts of silt (USCS: SM). The tests were terminated within the residual soils at depths ranging from 11.0 fbgs to 24.7 fbgs. SPT N-values within coarse-grained portions of this stratum ranged between four bpf and 63 bpf, generally indicating loose to very dense relative densities and averaging approximately 12 bpf. Pocket penetrometer tests performed on the residual cohesive soils indicated unconfined compressive strengths (q_u) ranging between approximately 0.5 tons per square foot (tsf), and 1.5 tsf, generally indicating medium stiff to stiff soil consistencies.

Groundwater: Static groundwater was encountered during this investigation in majority of the boring locations at depths ranging from 3.5 fbgs to 9.0 fbgs, corresponding to approximate elevations ranging between +359 feet and +361 feet. In addition, perched/trapped water was encountered throughout the site within the existing fill materials and at the confluence of the fill materials and the cohesive materials. Static and perched/trapped water conditions generally will fluctuate seasonally and following periods of precipitation.

SECTION 5.0

Conclusions and Recommendations

5.1 GENERAL

Whitestone recommends supporting the proposed structures on conventional shallow foundations bearing within approved and compacted existing fill materials, residual soils, and/or controlled structural fill soils provided they are properly inspected, placed and compacted in accordance with Sections 5.2, 5.3, and 5.12 of this report. Existing fill materials should be overexcavated where encountered at or below proposed foundation bearing elevations if deemed unsuitable during inspection by the owner's geotechnical engineer.

Whitestone anticipates that the proposed floor slab and pavements may be supported on approved and compacted existing fill materials, underlying residual soils, and/or controlled structural fill materials subject to supplemental evaluation and subgrade preparation as described herein with limited areas of overexcavation and replacement, and/or mechanical stabilization anticipated due to the inherent variability of existing fill materials.

Due to the structures associated with the existing gasoline stations, significant portions of the proposed development were not accessible to drilling equipment at the time of Whitestone's exploration. Whitestone preliminarily anticipates that the subsurface conditions within the unexplored portions of the proposed building footprint will be suitable for support of shallow foundations and floor slabs, Whitestone recommends confirming the anticipated suitable subsurface conditions within the proposed Wawa Food Market building footprint by means of test pit excavations following demolition of the existing structures or during early phases of construction.

Whitestone anticipates that a majority of the natural site soils and approved existing fill material above groundwater level will be suitable for reuse as structural fill/backfill provided that soil moisture contents are controlled within two percent of optimum moisture level. Additionally, portions of the site soils are especially moisture sensitive and must be properly protected, compacted, proofrolled, and evaluated during construction as described herein. Immediate reuse of the site soils should not be expected, especially if construction occurs following inclement weather.

5.2 SITE PREPARATION AND EARTHWORK

Surface Cover Stripping and Demolition: Prior to stripping operations, all utilities should be identified and secured. Any surficial vegetation and pavements should be stripped at least 10 feet beyond the limits of the proposed building, canopy, UST field, and associated pavement areas. Any remnant structures

encountered including foundation walls, footings, slabs, and utilities should be removed entirely from below proposed foundations and slabs including their zones of influence (as determined by the Geotechnical Engineer) and excavated to at least two feet below proposed construction subgrade levels elsewhere.

Existing UST Removal: Existing USTs associated with current site development are located in close proximity of the proposed building, canopy, and UST field. All existing USTs should be removed and backfilled in a controlled manner with structural fill in accordance with Section 5.3 of this report.

Demolition of Existing Building and Canopy Structures: The existing single-story structures are situated within or near the proposed canopy structure and trash enclosure. Demolition of the existing buildings should include complete removal of the floor slab, foundation walls, and footings. The existing canopy structures are located within areas of the proposed canopy structure and the proposed food market building. Demolition of the existing canopies should include complete removal of the footings. The resultant excavation should be backfilled in a controlled manner using approved structural backfill materials in accordance with Section 5.3.

Existing Fill Materials Overexcavation and Replacement: During the investigation, the existing fill generally consisted of silt, clay, and sand with trace amounts of brick, concrete, and metal, however, SPT-N values within portions of these materials indicate these materials were likely placed in an uncontrolled manner. As such, Whitestone anticipates that isolated areas of overexcavation and replacement will be necessary in accordance with the recommendations presented in the following sections.

Surface Preparation/Proofrolling: Prior to placing any fill, backfill or subbase materials to raise or restore grades to the desired building or pavement subgrade elevations, the exposed soils should be compacted to a firm and unyielding surface with a minimum of two passes in two perpendicular directions of a minimum 10-ton, vibratory smooth drum roller. The surface should be proofrolled with a loaded tandem axle truck in the presence of the geotechnical engineer to help identify soft or loose pockets that may require removal and replacement or further investigation. Any fill or backfill should be placed and compacted in accordance with Section 5.3.

Weather Performance Criteria: Every effort must be made to maintain drainage of surface water runoff away from construction areas by grading and limiting the exposure of excavations and prepared subgrades to rainfall. Accordingly, excavation and fill placement procedures should be performed during favorable weather conditions. Overexcavation of saturated soils and replacement with controlled structural fill per Section 5.3 of this report may be required prior to resuming work on disturbed subgrade soils.

On-Site Soil Protection and Maintenance: The site soils are will degrade if exposed to inclement weather, freeze-thaw cycles, or repeated construction traffic. However, if properly protected and maintained as recommended herein, the site soils will provide adequate support for the proposed construction. The site contractors should employ appropriate means and methods to protect the subgrade including, but not limited to the following:

- ▶ leaving existing pavements in-place as long as practical to help minimize subgrade exposure to inclement weather;
- ▶ sealing exposed subgrade soils on a daily basis with a vibratory smooth drum roller;
- ▶ regrading the site as needed to maintain positive drainage away from open earthwork construction areas and to prevent standing water;
- ▶ removing wet surficial soils immediately; and
- ▶ limiting exposure to construction traffic and precipitation especially following inclement weather and subgrade thawing.

Pavement Subgrade Stabilization and Inspection: Pavement subgrade soils which are exposed to inclement weather and heavy construction traffic will degrade and require either extensive drying time or overexcavation and replacement in order to provide a suitable subgrade for pavements. Overexcavation of unstable soils (existing fill materials or natural soils) within pavement areas typically should be limited to approximately 1.5 feet below planned subgrade unless directed otherwise by the owner's geotechnical engineer, provided that a reinforcing geogrid approved by the owner's geotechnical engineer is used. Alternatively, unstable materials may be completely overexcavated and either aerated and recompacted or replaced with imported structural fill per Section 5.3. However, this option is likely least economical.

Geogrids typically are economical when proposed undercut depths exceed approximately 16 inches. The geogrid (Tensar TriAx TX130S, or similar) should be placed directly on the exposed subgrade and backfill should consist of a well-graded gravel and sand blend. The services of the geotechnical engineer should be retained to inspect soil conditions during construction and to provide specific recommendations for stabilizing subgrades. Additionally, a geotechnical engineer should be retained to verify the suitability of prepared foundation, floor slab and pavement subgrades for support of design loads.

5.3 STRUCTURAL FILL AND BACKFILL

Imported Fill Material: Any imported material placed as structural fill or backfill to raise elevations or restore design grades should consist of clean, relatively well-graded sand or gravel with a maximum particle size of two inches and five percent to 15 percent of material finer than a #200 sieve. Silts, clays, and silty or clayey sands and gravels with higher percentage of fines and with a liquid limit less than 40 and a plasticity index less than 20 may be considered subject to the owner's approval, provided that the

required moisture content and compaction controls are met during favorable weather conditions. The material should be free of clay lumps, organics, and deleterious material. Imported structural fill material should be approved by a qualified geotechnical engineer prior to delivery to the site.

On-Site Materials: Based on the conditions disclosed by the soil borings, Whitestone anticipates that a majority of the existing fill materials and natural soils above the groundwater level will be suitable for reuse as structural fill/backfill material provided that soil moisture contents are controlled within two percent of optimum moisture level. Additionally, the site soils must be properly compacted and evaluated during the construction phase as described in Section 5.3 and 5.12.

Materials that are below groundwater level or become exceedingly wet will likely require discing and aerating. Alternatively, imported fill materials may be used to attain the desired grades and expedite earthwork operations during wet weather periods. The contractor should cover stockpiled soils, seal subgrades, and provide proper surface drainage prior to forecasted wet weather.

Submerged Fill: If necessary during the construction of the canopy and the UST field, up to two feet of an open-graded, crushed, three-quarter inch stone may be placed in the wet to provide a working mat, expedite dewatering efforts and enable subsequent placement of structural fill or backfill in the dry. Prior to placing submerged fill materials, free water and disturbed materials should be removed to the extent recommended by the geotechnical engineer. A fines barrier geotextile, such as Mirafi 140N or equivalent, should be placed at the base and sides of the overexcavation to separate the stone from underlying and adjacent soils. The fabric also should be placed on top of the stone prior to subsequent fill placement if fill soils with a substantial amount of fines are to be used to restore grade. Submerged fill may be required during excavation activities for the UST field and canopy.

Demolition Material: Demolition material, free of environmental concerns, may be used as fill material provided the material is properly segregated and processed as recommended herein. Concrete and masonry materials should be crushed to a well graded blend with a maximum size of 1.5 inches in diameter. Stripped asphalt and deleterious building materials such as wood, insulation, metal, shingles etc. should not be used as structural fill material. Milled or recycled asphalt pavement (RAP) may be re-used as granular base for proposed pavements provided that the RAP particle size meets Pennsylvania Department of Transportation (PENNDOT) standard specifications for granular base and no more than 50% of the pavement granular base contains RAP.

Compaction and Placement Requirements: On-site soils and imported materials used as fill or backfill should be placed in maximum nine-inch loose lifts and compacted using a 10-ton smooth drum vibratory drum during mass grading activities or a small walk-behind roller or hand-held vibratory compactor within excavations. All structural fill and backfill, including 10 feet outside new exterior walls, should be compacted to at least 95 percent of the maximum dry density within two percent of the optimum moisture

content as determined by ASTM D 1557 (Modified Proctor). Fill and backfill placed within non-structural areas may be compacted to 92 percent of the maximum dry density within three percent of optimum moisture content as determined by ASTM D 1557 (Modified Proctor).

Structural Fill Testing: A sample of the imported fill material or any on-site material proposed for reuse as structural fill or backfill should be submitted to the geotechnical engineer for analysis and approval at least one week prior to its use. The placement of all fill and backfill should be monitored by a qualified engineering technician to ensure that the specified material and lift thicknesses are properly installed. A sufficient number of in-place density tests should be performed to ensure that the specified compaction is achieved throughout the height of the fill or backfill.

5.4 GROUNDWATER CONTROL

Based on static groundwater levels encountered during the investigation, Whitestone anticipates that groundwater will be deeper than anticipated Wawa Food Market building foundations and shallow utility excavations.

However, Whitestone anticipates that dewatering of static groundwater will be required for installation of the USTs, canopy structure, and deeper utility excavations. The total amount of groundwater to be removed will depend on the size of the excavation, the depth of shoring used to cut-off flow and the length of time that the excavation remains open.

Because portions of the subsurface soils will soften when exposed to water, every effort must be made to maintain drainage of surface water runoff away from construction areas by grading and limiting the exposure of excavations to rainfall. Overexcavation of saturated soils and replacement with controlled structural fill and/or one foot to two feet of open graded gravel (such as 3/4 inch clean crushed stone) may be required prior to resuming work on disturbed subgrade soils.

5.5 FOUNDATIONS

Shallow Foundation Design Criteria: Whitestone recommends supporting the proposed building and canopy structures on conventional shallow spread and continuous footings designed to bear within approved existing fill material, natural soils, and/or structural fill materials provided these materials are properly evaluated, placed, and compacted in accordance with Sections 5.3 and 5.12 of this report. Foundations bearing within these materials may be designed using a maximum allowable net bearing pressure of 2,000 pounds per square foot.

All footing bottoms should be improved by in-trench compaction in the presence of the geotechnical engineer. Regardless of loading conditions, proposed foundations should be sized no less than minimum dimensions of 24 inches for continuous wall footings and 36 inches for isolated column footings.

Footings should be designed so that the maximum toe pressure due to the combined effect of vertical loads and overturning moment does not exceed the recommended maximum allowable net bearing pressure. In addition, positive contact pressure should be maintained throughout the base of the footings such that no uplift or tension exists between the base of the footings and the supporting soil. Uplift loads should be resisted by the weight of the concrete. Side friction should be neglected when proportioning the footings so that lateral resistance should be provided by friction resistance at the base of the footings. An allowable coefficient of friction against sliding of 0.30 is recommended for use in the design of the foundations bearing within the on-site soils or imported structural backfill.

Inspection Criteria: Whitestone recommends that the suitability of the bearing soils along the footing bottoms be verified by a geotechnical engineer prior to placing concrete for the footings. Special attention should be given to areas underlain by existing fill materials. In the event that isolated areas of unsuitable materials are encountered in footing excavations, overexcavation and replacement of the materials or deeper foundation embedment may be necessary to provide a suitable footing subgrade. Any overexcavation to be restored with structural fill will need to extend at least one foot laterally beyond footing edges for each vertical foot of overexcavation. Lateral overexcavation may be eliminated if grade is restored with lean concrete. The bottoms of overexcavated areas should be compacted with vibratory smooth drum rollers, walk-behind compactors, vibrating plates or plate tampers (“jumping jacks”) to compact locally disturbed materials and densify any underlying loose zones. Any standing water within the footing excavation should be removed with a mechanical pump prior to concrete placement.

Settlement: Whitestone estimates post construction settlements of new foundations will be on the order of less than one inch if the recommendations outlined in this report are properly implemented. Differential settlement between individual footings should be less than one-half inch.

Frost Coverage: Footings subject to frost action should be placed at least 36 inches below adjacent exterior grades or the depth required by local building codes to provide protection from frost penetration. Interior footings not subject to frost action may be placed at a minimum depth of 18 inches below the slab subgrade.

5.6 FLOOR SLAB

Whitestone anticipates that approved site materials and new fill materials placed to raise grades (if necessary) will provide suitable support for the floor slab. The exposed subgrade should be inspected and compacted in accordance with Sections 5.3 and 5.12 of this report. Any areas that become softened or

disturbed as a result of wetting and/or repeated exposure to construction traffic should be removed and replaced with compacted structural fill. The properly prepared site soils and structural fill/backfill materials are expected to yield a minimum subgrade modulus (k) of 150 psi/in.

A minimum four inch layer of three-quarter inch crushed stone (AASHTO No. 57 stone or similar) should be installed below the floor slab to provide a uniform subgrade and capillary break. A moisture vapor barrier should be placed beneath the floor slab where recommended by the flooring manufacturer.

5.7 PAVEMENT DESIGN CRITERIA

General: Whitestone anticipates that the majority of the site soils and/or compacted structural fill/backfill placed to raise or restore design elevations will be suitable for support of the proposed pavements provided these materials are properly evaluated, compacted, and proofrolled in accordance with this report during favorable weather conditions. Subgrade stabilization with a triaxial geogrid, approved by the owner’s geotechnical engineer, may be used to minimize depths of overexcavation (if necessary) as discussed further in Section 5.3.

Design Criteria: A California Bearing Ratio (CBR) value of 4.0 has been assigned to the properly prepared subgrade soils for pavement design purposes. This value was correlated with pertinent soil support values and assumed traffic loads to prepare flexible and rigid pavement designs per the AASHTO *Guide for the Design of Pavement Structures*.

Design traffic loads were estimated based on Whitestone’s past experience with similar projects and correlated with 18-kip equivalent single axle loads (ESAL) for a 15-year life. Estimated maximum pavement loads of 25,000 ESALs and 60,000 ESALs were used for the standard duty and heavy duty pavement areas, respectively. These values assume the pavements primarily will accommodate both automobile and limited heavier truck traffic, with the heavier truck traffic designated to the main drive lanes. Actual loading experienced is anticipated to be less than this value.

Pavement Sections: The recommended flexible pavement sections are presented in the table below:

| FLEXIBLE PAVEMENT SECTIONS DESIGN | | | |
|-----------------------------------|--|----------------------------------|-------------------------------|
| Layer | Material | Standard Duty Thickness (Inches) | Heavy Duty Thickness (Inches) |
| Asphalt Surface | PENNDOT Super Pave 9.5 mm PG 64-22 Surface Course | 1.5 | 2.0 |
| Asphalt Base | PENNDOT Super Pave 19.0 mm PG 64-22 Base Course | 3.0 | 3.0 |
| Granular Subbase | PENNDOT 2A Stone | 6.0 | 6.0 |

A rigid concrete pavement should be used to provide suitable support at areas of high traffic or severe turns (such as loading areas, driveway aprons, and garbage dumpster aprons). The recommended rigid pavement is presented below in tabular format:

| RIGID PAVEMENT SECTIONS DESIGN | | | |
|---------------------------------------|---------------------------------|---|--------------------------------------|
| Layer | Material | Standard Duty Thickness (Inches) | Heavy Duty Thickness (Inches) |
| Surface | 4000 psi air-entrained concrete | 6.0 | 7.0 |
| Base | PENNDOT 2A Stone | 6.0 | 8.0 |

Additional Design Considerations: The pavement section thickness designs presented in this report are based on the design parameters detailed herein and are contingent on proper construction, inspection, and maintenance. Additional pavement thickness may be required by local code. The designs are contingent on achieving the minimum soil support value in the field. To accomplish this requirement, all subgrade soil and supporting fill or backfill must be properly evaluated, placed, and prepared as detailed in Sections 5.2, 5.3, and 5.12 of this report. Proper drainage must be provided for the pavement structure including appropriate grading and surface water control, as well as measures to drain water from the subgrade.

The performance of the pavement also will depend on the quality of materials and workmanship. Whitestone recommends that PENNDOT standards for materials, workmanship, and maintenance be applied to this site. Project specifications should include verifying that the installed asphaltic concrete material composition is within tolerance for the specified materials and that the percentage of air voids of the installed pavement is within specified ranges for the respective materials. All rigid concrete pavements should be suitably air-entrained, jointed, and reinforced.

5.8 RETAINING WALL/LATERAL EARTH PRESSURES

No retaining walls are proposed at the time of this report. However, Whitestone anticipates that a temporary excavation support will be required during installation of the proposed USTs. Whitestone should be notified if any other retaining structures or design considerations requiring lateral earth pressure estimations are proposed.

Retaining structures free to rotate generally can be designed to resist active earth pressures. Retaining structures restrained from movement and with corners need to be designed to resist at-rest earth pressures. The following soil parameters apply to the site soils encountered in a well-drained, level backfill condition and may be used for design of temporary retaining structures:

| LATERAL EARTH PRESSURE PARAMETERS | |
|--|------------|
| Parameters | Site Soils |
| Moist Density (γ_{moist}) | 140 pcf |
| Internal Friction Angle (ϕ) | 26° |
| Active Earth Pressure Coefficient (K_a) | 0.39 |
| Passive Earth Pressure Coefficient (K_p) | 2.56 |
| At-Rest Earth Pressure Coefficient (K_o) | 0.56 |

Lateral earth pressure will depend on the slope angle of construction phase grades and subgrades. The effect of other surcharges also will need to be included in earth pressure calculations, possibly including the loads imposed by adjacent traffic. Whitestone would be pleased to assist with the calculation of lateral earth pressures based on the soil parameters presented herein, if necessary.

5.9 SEISMIC AND LIQUEFACTION CONSIDERATIONS

The subsurface conditions are most consistent with a Site Class D as defined by the *International Building Code (IBC) 2009*. Based on the seismic zone and soil profile, liquefaction considerations are not expected to have a substantial impact on design. The following spectral accelerations are recommended:

| SEISMIC SITE PARAMETERS | | | |
|-------------------------|--------|-------|-------|
| S_s | S_1 | F_a | F_v |
| 0.278g | 0.061g | 1.578 | 2.400 |

5.10 EXCAVATIONS

Temporary Excavations: The existing fill materials and natural soils encountered during this investigation typically are, at a minimum, consistent with Type C Soil Conditions as defined by 29 CFR Part 1926 (OSHA) which require a maximum unbraced excavation angle of 1.5:1 (horizontal:vertical). Actual conditions encountered during construction should be evaluated by a competent person (as defined by OSHA) to ensure that safe excavation methods and/or shoring and bracing requirements are implemented. Particular attention to the stability of the UST excavation should be considered.

Due to the anticipated depth for the proposed UST excavation, the use of a temporary retaining structure most likely will be necessary. Such structures should be properly designed by the contractor's licensed engineer and should consider potential effects to adjacent roadways, the possibility of encountered obstructions in the existing site soils, and economy.

The specific design of temporary retaining structures is beyond the scope of this report. Whitestone would be pleased to provide additional consultation regarding the design of temporary retaining structures, if requested.

5.11 UST EMBEDMENT

The proposed USTs may be embedded within very dense granular soils and below the anticipated groundwater elevation, which will result in a partially submerged condition for proposed USTs. To prevent hydrostatic uplift of the tanks due to perched water within the tank pit, fastening of the tanks to anchors such as tie-downs and/or “dead men” to the bottom of the excavation should be provided to counteract the effects of buoyancy. Additionally, all USTs should be properly embedded beneath a properly designed concrete mat.

5.12 SUPPLEMENTAL POST INVESTIGATION SERVICES

Supplemental Evaluation of Existing Fill Materials and Inaccessible Areas: The conditions disclosed by the investigation indicated that a majority of the existing fill materials encountered will be suitable for reuse as structural backfill/fill and for supporting proposed foundations, slab, and pavement construction if evaluated and prepared as described herein. However, there is a potential risk of variability in existing fill materials, which may not be disclosed by soils borings performed throughout the site. In addition, based on available historic aerials, the site has been through several different redevelopments and significant portions of the proposed structures were inaccessible at the time of the investigation due to existing structures. As such, Whitestone recommends confirming further the condition of the existing fill and inaccessible areas by means of supplemental test pit excavations or subgrade proofroll in the early stages of construction to enable an assessment for the depths, areal extent, presence of voids, uncontrolled conditions, or deleterious materials. If unsuitable conditions are encountered, alternative recommendations, such as additional overexcavation and replacement, or subgrade stabilization methods may be required.

Construction Inspection and Monitoring: The owner’s geotechnical engineer should perform inspection, testing, and consultation during construction as described in previous sections of this report. Monitoring and testing should also be performed to verify that the existing surface cover materials are removed as recommended herein and, suitable materials, used for controlled fill, are properly placed and compacted over suitable subgrade soils. Any overexcavation of existing fill materials encountered within the proposed building footprint that are unsuitable for foundation and floor slab support should be witnessed and documented by the owner’s geotechnical engineer. The proper placement of structural backfill within the building should also be documented by the owner’s geotechnical engineer.

SECTION 6.0

General Comments

Supplemental recommendations may be required upon finalization of construction plans or if significant changes are made in the characteristics or location of the proposed structure. Soil bearing conditions should be checked at the appropriate time for consistency with those conditions encountered during Whitestone's geotechnical investigation.

The recommendations presented herein should be utilized by a qualified engineer in preparing the project plans and specifications. The engineer should consider these recommendations as minimum physical standards which may be superseded by local and regional building codes and structural considerations. These recommendations are prepared for the sole use of The Autowash Group for the specific project detailed and should not be used by any third party. These recommendations are relevant to the design phase and should not be substituted for construction specifications.

The possibility exists that conditions between borings may differ from those at specific boring locations, and conditions may not be as anticipated by the designers or contractors. In addition, the construction process may alter soil and rock conditions. Therefore, experienced geotechnical personnel should observe and document the construction procedures used and the conditions encountered.

Whitestone assumes that a qualified contractor will be employed to perform the construction work, and that the contractor will be required to exercise care to ensure all excavations are performed in accordance with applicable regulations and good practice. Particular attention should be paid to avoiding damaging or undermining adjacent properties and maintaining slope stability.

Whitestone recommends that the services of the geotechnical engineer be engaged to test and evaluate the soils in the footing excavations prior to concreting in order to determine that the soils will support the bearing capacities. Monitoring and testing also should be performed to verify that suitable materials are used for controlled fills and that they are properly placed and compacted over suitable subgrade soils.

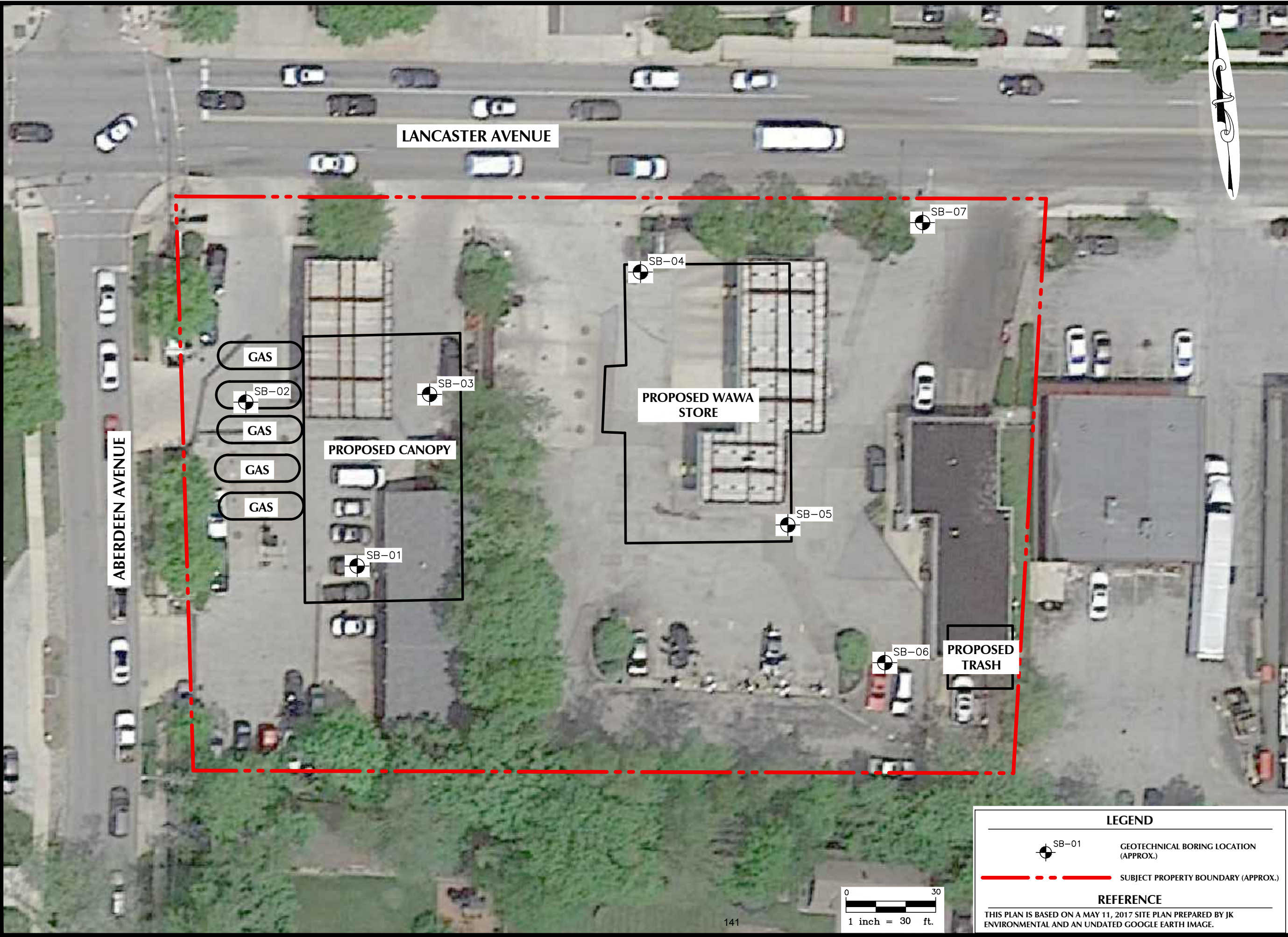
The exploration and analysis of the foundation conditions reported herein are considered sufficient in detail and scope to form a reasonable basis for the foundation design. The recommendations submitted for the proposed construction are based on the available soil information and the design details furnished by The Autowash Group. Deviations from the noted subsurface conditions encountered during construction should be brought to the attention of the geotechnical engineer.

The geotechnical engineer warrants that the findings, recommendations, specifications, or professional advice contained herein have been promulgated after being prepared in accordance with generally accepted professional engineering practice in the fields of foundation engineering, soil mechanics, and engineering geology. No other warranties are implied or expressed.



FIGURE 1
Boring Location Plan

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WHITESTONE ASSOCIATES, INC.
 Environmental & Geotechnical Engineers & Consultants

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DRAWING TITLE:
BORING LOCATION PLAN

CLIENT:
THE AUTOWASH GROUP

PROJECT:
PROPOSED WAWA FOOD MARKET & FUEL STATION
LANCASTER AVENUE & ABERDEEN AVENUE
RADNOR TOWNSHIP (WAYNE), CHESTER COUNTY, PA

| | |
|------------------------------------|---------------------------|
| PROJECT #: GP1714612.000 | |
| DESIGNED BY: GR | PROJ. MGR.: JMM |
| DATE: 7/10/17 | FIGURE: 2 |
| SCALE: 1" = 30' | |

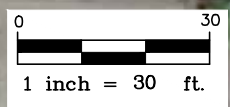
LEGEND

SB-01 GEOTECHNICAL BORING LOCATION (APPROX.)

--- SUBJECT PROPERTY BOUNDARY (APPROX.)

REFERENCE

THIS PLAN IS BASED ON A MAY 11, 2017 SITE PLAN PREPARED BY JK ENVIRONMENTAL AND AN UNDATED GOOGLE EARTH IMAGE.





APPENDIX A

Records of Subsurface Exploration

RECORD OF SUBSURFACE EXPLORATION

| | | | |
|--|---------------------------------|---|---------------------------------|
| Project: Proposed Wawa Food Market & Fuel Station | | WAI Project No.: GP1714612.000 | |
| Location: Lancaster Avenue & Aberdeen Avenue; Wayne (Radnor Township), Chester County, PA | | Client: The Autowash Group, Inc. | |
| Surface Elevation: ± 365.6 feet | Date Started: 7/5/2017 | Water Depth Elevation (feet bgs) (feet) | |
| Termination Depth: 20.0 feet bgs | Date Completed: 7/5/2017 | Cave-In Depth Elevation (feet bgs) (feet) | |
| Proposed Location: Fuel Canopy | Logged By: ML | During: 6.5 359.1 | At Completion: --- --- |
| Drill / Test Method: HSA / SPT | Contractor: AWD | At Completion: 6.5 359.1 | |
| | Equipment: Acker XLS | 24 Hours: --- --- | |

| SAMPLE INFORMATION | | | | | | DEPTH (feet) | STRATA | DESCRIPTION OF MATERIALS (Classification) | REMARKS |
|--------------------|-----|------|-------------------------|---------------|-----|-----------------|----------|--|--|
| Depth (feet) | No | Type | Blows Per 6" | Rec. (in.) | N | | | | |
| | | | | | | 0.0 | PAVEMENT | 6" Asphalt, 6" Gravel Subbase | Soft Dig Excavation to 3.0 fbg |
| 0 - 3 | S-1 | ↓ | Grab from Hand Auger | -- | --- | 1.0 | FILL | Gray and Light Brown Silty Sand, Moist (FILL) | PID = 0.0 ppm |
| 3 - 5 | S-2 | X | 3 - 2 - 5 - 6 | 24 | 7 | 5.0 | RESIDUAL | Gray and Brown Sandy Lean Clay, Moist, Medium Stiff (CL) | Qu = 0.75 tsf (Shear) PID = 0.0 ppm |
| 5 - 7 | S-3 | X | 9 - 8 - 9 - 9 | 24 | 17 | 6.5 | | As Above, Moist to Wet, Stiff to Very Stiff (CL) | Qu = 0.75 (Shear) PID = 0.0 ppm |
| 7 - 9 | S-4 | X | 2 - 2 - 2 - 3 | 22 | 4 | | | Gray Silty Sand, Wet, Loose (SM) | PID = 0.0 ppm |
| 9 - 11 | S-5 | X | 3 - 3 - 4 - 4 | 22 | 7 | 10.0 | | Gray and Light Brown Sandy Silt, Trace Gravel, Moist, Medium Stiff (ML) | Qu = 0.75 (Shear) PID = 0.0 ppm |
| 13 - 15 | S-6 | X | 1 - 2 - 3 - 4 | 22 | 5 | 15.0 | | Light Brown and Dark Brown Silty Sand, Moist, Loose (SM) | PID = 0.0 ppm |
| 18 - 20 | S-7 | X | 3 - 6 - 16 - 23 | 21 | 22 | 20.0 | | As Above, Brown, Wet, Medium Dense (SM) | PID = 0.0 ppm |
| | | | | | | | | Boring Log SB-01 Terminated at a Depth of 20.0 Feet Below Ground Surface | |

RECORD OF SUBSURFACE EXPLORATION

| | | | |
|--|---------------------------------|---|---|
| Project: Proposed Wawa Food Market & Fuel Station | | WAI Project No.: GP1714612.000 | |
| Location: Lancaster Avenue & Aberdeen Avenue; Wayne (Radnor Township), Chester County, PA | | Client: The Autowash Group, Inc. | |
| Surface Elevation: ± 364.3 feet | Date Started: 7/5/2017 | Water Depth Elevation (feet bgs) (feet) | Cave-In Depth Elevation (feet bgs) (feet) |
| Termination Depth: 3.5 feet bgs | Date Completed: 7/5/2017 | During: NE --- ▼ | At Completion: --- --- ▼ |
| Proposed Location: UST Field | Logged By: ML | At Completion: NE --- ▼ | At Completion: --- --- ▼ |
| Drill / Test Method: HSA / SPT | Contractor: AWD | 24 Hours: --- --- ▼ | 24 Hours: --- --- ▼ |
| | Equipment: Acker XLS | | |

| SAMPLE INFORMATION | | | | | | DEPTH (feet) | STRATA | DESCRIPTION OF MATERIALS (Classification) | REMARKS |
|--------------------|-----|------|----------------------|---------------|-------|-----------------|----------|--|---|
| Depth (feet) | No | Type | Blows Per 6" | Rec. (in.) | N | | | | |
| | | | | | | 0.0 | | | |
| 0 - 3 | S-1 | ↓ | Grab from Hand Auger | -- | --- | 1.0 | PAVEMENT | 6" Asphalt, 6" Gravel Subbase | Soft Dig Excavation to 3.0 fbgs |
| | | | | | | | FILL | Gray Silty Sand and Gravel, Moist (FILL) | |
| 3 - 3.5 | S-2 | X | 50/5" | 4 | 50/4" | 3.5 | | As Above, Moist (FILL) | |
| | | | | | | 5.0 | | | Boring Log SB-2 Terminated at a Depth of 3.5 Feet Below Ground Surface Due to Utility Concern, Offset Approx. 6 Feet North to SB-2A |
| | | | | | | 10.0 | | | |
| | | | | | | 15.0 | | | |
| | | | | | | 20.0 | | | |
| | | | | | | 25.0 | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |

RECORD OF SUBSURFACE EXPLORATION

| | | | |
|--|---------------------------------|---|---------------------------------|
| Project: Proposed Wawa Food Market & Fuel Station | | WAI Project No.: GP1714612.000 | |
| Location: Lancaster Avenue & Aberdeen Avenue; Wayne (Radnor Township), Chester County, PA | | Client: The Autowash Group, Inc. | |
| Surface Elevation: ± 364.3 feet | Date Started: 7/5/2017 | Water Depth Elevation (feet bgs) (feet) | |
| Termination Depth: 24.7 feet bgs | Date Completed: 7/5/2017 | Cave-In Depth Elevation (feet bgs) (feet) | |
| Proposed Location: UST Field | Logged By: ML | During: 4.0 360.3 | At Completion: --- --- |
| Drill / Test Method: HSA / SPT | Contractor: AWD | At Completion: 4.0 360.3 | |
| | Equipment: Acker XLS | 24 Hours: --- --- | 24 Hours: --- --- |

| SAMPLE INFORMATION | | | | | | DEPTH (feet) | STRATA | DESCRIPTION OF MATERIALS (Classification) | REMARKS |
|--------------------|-----|------|----------------------|---------------|-----|-----------------|----------|---|-------------------------------------|
| Depth (feet) | No | Type | Blows Per 6" | Rec. (in.) | N | | | | |
| | | | | | | 0.0 | PAVEMENT | 6" Asphalt, 6" Gravel Subbase | Offset 6' North from SB-2 |
| 0 - 4 | --- | | Grab from Hand Auger | -- | --- | 1.0 | FILL | Gray Silty Sand and Gravel, Moist (FILL) | Soft Dig to 4.0 fbs PID = 12 ppm |
| | | | | | | 3.0 | | | PID = 346 ppm |
| | | | | | | 4.0 | | | |
| 4 - 6 | S-3 | X | 2 - 1 - 1 - 1 | 16 | 2 | 4.5 | | Brown Silty Sand, Moist (FILL) | PID = 277 ppm |
| | | | | | | 5.0 | | White Poorly-Graded Sand with Silt, Moist (FILL) | PID = 344 ppm |
| 6 - 8 | S-4 | X | 2 - 4 - 6 - 6 | 24 | 10 | 5.5 | | Gray Silty Sand, Moist (FILL) | PID = 655 ppm PID = 1046 ppm |
| | | | | | | 8.0 | | As Above, Wet (FILL) | PID = 1254 ppm |
| 8 - 10 | S-5 | X | 6 - 7 - 8 - 12 | 24 | 15 | | RESIDUAL | Gray Brown Silty Sand, Wet, Medium Dense (SM) | PID = 4 to 8 ppm |
| | | | | | | 10.0 | | | |
| | | | | | | 15.0 | | | |
| 13 - 15 | S-6 | X | 5 - 6 - 9 - 23 | 12 | 15 | | | As Above, Brown and White, Wet, Medium Dense (SM) | PID = 1 to 3 ppm |
| | | | | | | 20.0 | | | |
| 18 - 20 | S-7 | X | 10 - 13 - 15 - 25 | 18 | 28 | | | As Above, Wet, Medium Dense (SM) | PID = 0.0 ppm |
| | | | | | | 23.0 | | | |
| 23 - 24.7 | S-8 | X | 19 - 20 - 43 - 50/2' | 24 | 63 | | | As Above, Wet, Very Dense (SM) | PID = 0.0 ppm |
| | | | | | | 24.7 | | Boring Log SB-02A Terminated at a Depth of 24.7 Feet Below Ground Surface | |

RECORD OF SUBSURFACE EXPLORATION

| | | | |
|--|---------------------------------|---|-----------------------------------|
| Project: Proposed Wawa Food Market & Fuel Station | | WAI Project No.: GP1714612.000 | |
| Location: Lancaster Avenue & Aberdeen Avenue; Wayne (Radnor Township), Chester County, PA | | Client: The Autowash Group, Inc. | |
| Surface Elevation: ± 368.4 feet | Date Started: 7/5/2017 | Water Depth Elevation (feet bgs) (feet) | |
| Termination Depth: 13.0 feet bgs | Date Completed: 7/5/2017 | Cave-In Depth Elevation (feet bgs) (feet) | |
| Proposed Location: Fuel Canopy | Logged By: ML | During: NE --- ▼ | At Completion: --- --- ▼ |
| Drill / Test Method: HSA / SPT | Contractor: AWD | At Completion: NE --- ▼ | |
| | Equipment: Acker XLS | 24 Hours: --- --- ▼ | 24 Hours: --- --- ▼ |

| SAMPLE INFORMATION | | | | | | DEPTH | STRATA | DESCRIPTION OF MATERIALS (Classification) | REMARKS |
|--------------------|-----|------|----------------------|---------------|-----|--------|----------|--|---------------------------------------|
| Depth (feet) | No | Type | Blows Per 6" | Rec. (in.) | N | (feet) | | | |
| | | | | | | 0.0 | PAVEMENT | 6" Asphalt, 6" Gravel Subbase | Soft Dig to 3.0 fbs |
| 0 - 3 | S-1 | ↓ | Grab from Hand Auger | -- | --- | 1.0 | FILL | Gray and Brown Silt with Sand and Gravel, Moist (FILL) | PID = 0.0 ppm Qu = 0.5 tsf |
| 3 - 5 | S-2 | × | 2 - 3 - 3 - 2 | 12 | 6 | 5.0 | | As Above, with 15% Brick Fragments (FILL) | PID = 0.0 ppm Qu = 0.5 tsf |
| 5 - 7 | S-3 | × | 2 - 2 - 2 - 2 | 6 | 4 | | | Gray and Brown Silty Sand with Gravel, Moist (FILL) | PID = 0.0 ppm |
| 7 - 9 | S-4 | × | 1 - 2 - 2 - 2 | 24 | 4 | | RESIDUAL | Gray and Brown Sandy Silt, Moist, Medium Stiff (ML) | PID = 0.0 ppm Qu = 0.5 tsf (Shear) |
| 9 - 11 | S-5 | × | 2 - 2 - 2 - 2 | 22 | 4 | 10.0 | | As Above, Gray, Brown and Block, Moist, Medium Stiff (ML) | PID = 0.0 ppm Qu = 0.5 tsf (Shear) |
| 11 - 13 | S-6 | × | 4 - 8 - 10 - 12 | 24 | 18 | 13.0 | | Brown, Gray and White Silty Sand, Moist, Medium Dense (SM) | PID = 0.0 ppm |
| | | | | | | 15.0 | | Boring Log SB-03 Terminated at a Depth of 13.0 Feet Below Ground Surface | |
| | | | | | | 20.0 | | | |
| | | | | | | 25.0 | | | |

RECORD OF SUBSURFACE EXPLORATION

| | | | |
|--|---------------------------------|---|---|
| Project: Proposed Wawa Food Market & Fuel Station | | WAI Project No.: GP1714612.000 | |
| Location: Lancaster Avenue & Aberdeen Avenue; Wayne (Radnor Township), Chester County, PA | | Client: The Autowash Group, Inc. | |
| Surface Elevation: ± 369.9 feet | Date Started: 7/5/2017 | Water Depth Elevation (feet bgs) (feet) | Cave-In Depth Elevation (feet bgs) (feet) |
| Termination Depth: 20.0 feet bgs | Date Completed: 7/5/2017 | During: 9.0 360.9 | At Completion: 9.0 360.9 |
| Proposed Location: Food Market Building | Logged By: ML | 24 Hours: --- --- | At Completion: --- --- |
| Drill / Test Method: HSA / SPT | Contractor: AWD | 24 Hours: --- --- | 24 Hours: --- --- |
| | Equipment: Acker XLS | | |

| SAMPLE INFORMATION | | | | | | DEPTH (feet) | STRATA | DESCRIPTION OF MATERIALS (Classification) | REMARKS |
|--------------------|-----|------|-------------------------|---------------|-----|-----------------|----------|--|---------------------------------------|
| Depth (feet) | No | Type | Blows Per 6" | Rec. (in.) | N | | | | |
| | | | | | | 0.0 | PAVEMENT | 6" Asphalt, 6" Gravel Subbase | Soft Dig to 3.0 fbs |
| 0 - 3 | S-1 | ↓ | Grab from Hand Auger | -- | --- | 1.0 | FILL | Gray and Brown Lean Clay, Moist (FILL) | PID = 0.0 ppm Qu = 1.5 tsf |
| 3 - 5 | S-2 | X | 1 - 1 - 1 - 2 | 24 | 2 | 5.0 | | As Above, Trace Black Wire Fragments, Moist (FILL) | PID = 0.0 ppm Qu = 1.5 tsf |
| 5 - 7 | S-3 | X | 3 - 4 - 4 - 7 | 24 | 8 | 8.0 | | Gray and Brown Sandy Silt, Moist, Medium Stiff (ML) | PID = 0.0 ppm Qu = 0.5 tsf (Shear) |
| 7 - 9 | S-4 | X | 5 - 5 - 5 - 5 | 20 | 10 | 10.0 | | As Above, with 30% Quartz Sand, Moist, Medium Stiff (ML) | PID = 0.0 ppm Qu = 0.5 tsf (Shear) |
| 9 - 11 | S-5 | X | 1 - 1 - 2 - 2 | 18 | 3 | 15.0 | | As Above, Orange Brown, Wet, Soft to Medium Stiff (ML) | PID = 0.0 ppm Qu = 0.5 tsf (Shear) |
| 11 - 13 | S-6 | X | W O - 1 - 3 - 3 H | 24 | 4 | 20.0 | | As Above, Wet, Soft to Medium Stiff (ML) | PID = 0.0 ppm Qu = 0.5 tsf (Shear) |
| 13 - 15 | S-7 | X | 2 - 4 - 5 - 6 | 24 | 9 | | | As Above, Wet, Medium Stiff to Stiff (ML) | PID = 0.0 ppm Qu = 0.5 tsf (Shear) |
| 18 - 20 | S-8 | X | 5 - 5 - 8 - 8 | 11 | 13 | | | As Above, Wet, Stiff (ML) | PID = 0.0 ppm Qu = 0.5 tsf (Shear) |
| | | | | | | | | Boring Log SB-04 Terminated at a Depth of 20.0 Feet Below Ground Surface | |

RECORD OF SUBSURFACE EXPLORATION

| | | | |
|--|---------------------------------|---|---|
| Project: Proposed Wawa Food Market & Fuel Station | | WAI Project No.: GP1714612.000 | |
| Location: Lancaster Avenue & Aberdeen Avenue; Wayne (Radnor Township), Chester County, PA | | Client: The Autowash Group, Inc. | |
| Surface Elevation: ± 364.1 feet | Date Started: 7/5/2017 | Water Depth Elevation (feet bgs) (feet) | Cave-In Depth Elevation (feet bgs) (feet) |
| Termination Depth: 20.0 feet bgs | Date Completed: 7/5/2017 | During: 3.5 360.6 | At Completion: 3.5 360.6 |
| Proposed Location: Food Market Building | Logged By: ML | 24 Hours: --- --- | At Completion: --- --- |
| Drill / Test Method: HSA / SPT | Contractor: AWD | 24 Hours: --- --- | At Completion: --- --- |
| | Equipment: Acker XLS | | |

| SAMPLE INFORMATION | | | | | | DEPTH (feet) | STRATA | DESCRIPTION OF MATERIALS (Classification) | REMARKS |
|--------------------|-----|------|----------------------|---------------|-----|-----------------|----------|--|-------------------------------|
| Depth (feet) | No | Type | Blows Per 6" | Rec. (in.) | N | | | | |
| | | | | | | 0.0 | PAVEMENT | 6" Asphalt, 6" Gravel Subbase | Soft Dig to 3.0 fbs |
| 0 - 3 | S-1 | ↓ | Grab from Hand Auger | -- | --- | 1.0 | FILL | Gray and Brown Silty Sand with Gravel, Moist (FILL) | PID = 0.0 ppm |
| 3 - 5 | S-2 | X | 3 - 3 - 4 - 4 | 12 | 7 | 5.0 | FILL | Brown Sandy Silt, Trace Gravel, Moist (FILL) | PID = 0.0 ppm |
| 5 - 7 | S-3 | X | 3 - 3 - 2 - 4 | 14 | 5 | 7.0 | RESIDUAL | Gray Silty Sand with 10% Gravel, Wet (ML) | PID = 0.0 ppm |
| 7 - 9 | S-4 | X | 6 - 3 - 4 - 3 | 24 | 7 | 10.0 | RESIDUAL | Gray and Brown Sandy Silt, Wet, Medium Stiff (ML) | PID = 0.0 ppm Qu = 1.5 tsf |
| 9 - 11 | S-5 | X | 2 - 3 - 2 - 3 | 24 | 5 | 14.0 | RESIDUAL | As Above, Wet, Medium Stiff (ML) | PID = 0.0 ppm Qu = 1.5 tsf |
| 13 - 15 | S-6 | X | 2 - 2 - 3 - 5 | 24 | 5 | 15.0 | RESIDUAL | Orange Brown Silty Sand, Wet, Loose (SM) | PID = 0.0 ppm |
| 18 - 20 | S-7 | X | 5 - 3 - 8 - 11 | 24 | 11 | 20.0 | RESIDUAL | As Above, Wet, Medium Dense (SM) | PID = 0.0 ppm |
| | | | | | | 25.0 | | Boring Log SB-05 Terminated at a Depth of 20.0 Feet Below Ground Surface | |

RECORD OF SUBSURFACE EXPLORATION

| | | | |
|--|---------------------------------|---|---------------------------------|
| Project: Proposed Wawa Food Market & Fuel Station | | WAI Project No.: GP1714612.000 | |
| Location: Lancaster Avenue & Aberdeen Avenue; Wayne (Radnor Township), Chester County, PA | | Client: The Autowash Group, Inc. | |
| Surface Elevation: ± 367.1 feet | Date Started: 7/5/2017 | Water Depth Elevation (feet bgs) (feet) | |
| Termination Depth: 11.0 feet bgs | Date Completed: 7/5/2017 | Cave-In Depth Elevation (feet bgs) (feet) | |
| Proposed Location: Trash Enclosure / Pavement | Logged By: ML | During: 8.0 359.1 | At Completion: --- --- |
| Drill / Test Method: HSA / SPT | Contractor: AWD | At Completion: 8.0 359.1 | |
| | Equipment: Acker XLS | 24 Hours: --- --- | |

| SAMPLE INFORMATION | | | | | | DEPTH (feet) | STRATA | DESCRIPTION OF MATERIALS (Classification) | REMARKS |
|--|-----|------|-------------------------|---------------|-----|-----------------|----------|--|---------------------|
| Depth (feet) | No | Type | Blows Per 6" | Rec. (in.) | N | | | | |
| | | | | | | 0.0 | PAVEMENT | 6" Asphalt, 6" Gravel Subbase | Soft Dig to 3.0 fbs |
| 0 - 3 | S-1 | ↓ | Grab from Hand Auger | -- | --- | 1.0 | FILL | Brown and Gray Silty Sand, Moist (FILL) | PID = 0.0 ppm |
| 3 - 5 | S-2 | X | 2 - 1 - 1 - 1 | 15 | 2 | 3.0 | RESIDUAL | Brown and Gray Sandy Silt, Moist, Soft (ML) | PID = 0.0 ppm |
| 5 - 7 | S-3 | X | 5 - 6 - 5 - 4 | 16 | 11 | 5.0 | | As Above, Some Gravel, Moist, Stiff (ML) | PID = 0.0 ppm |
| 7 - 9 | S-4 | X | 5 - 4 - 4 - 3 | 16 | 8 | 7.0 | | Orange Silty Sand, Wet, Loose (SM) | PID = 0.0 ppm |
| 9 - 11 | S-5 | X | 3 - 3 - 3 - 5 | NR | 6 | 10.0 | | No Recovery Due to Gravel In Spoon Tip, Assumed As Above, Loose (SM) | PID = 0.0 ppm |
| | | | | | | 15.0 | | | |
| | | | | | | 20.0 | | | |
| | | | | | | 25.0 | | | |
| Boring Log SB-06 Terminated at a Depth of 11.0 Feet Below Ground Surface | | | | | | | | | |

RECORD OF SUBSURFACE EXPLORATION

| | | | |
|--|---------------------------------|---|---|
| Project: Proposed Wawa Food Market & Fuel Station | | WAI Project No.: GP1714612.000 | |
| Location: Lancaster Avenue & Aberdeen Avenue; Wayne (Radnor Township), Chester County, PA | | Client: The Autowash Group, Inc. | |
| Surface Elevation: ± 369.0 feet | Date Started: 7/5/2017 | Water Depth Elevation (feet bgs) (feet) | Cave-In Depth Elevation (feet bgs) (feet) |
| Termination Depth: 11.0 feet bgs | Date Completed: 7/5/2017 | During: 9.0 360.0 ▼ | At Completion: --- --- ▼ |
| Proposed Location: Pavement | Logged By: ML | At Completion: 9.0 360.0 ▼ | At Completion: --- --- ▼ |
| Drill / Test Method: HSA / SPT | Contractor: AWD | 24 Hours: --- --- ▼ | 24 Hours: --- --- ▼ |
| | Equipment: Acker XLS | | |

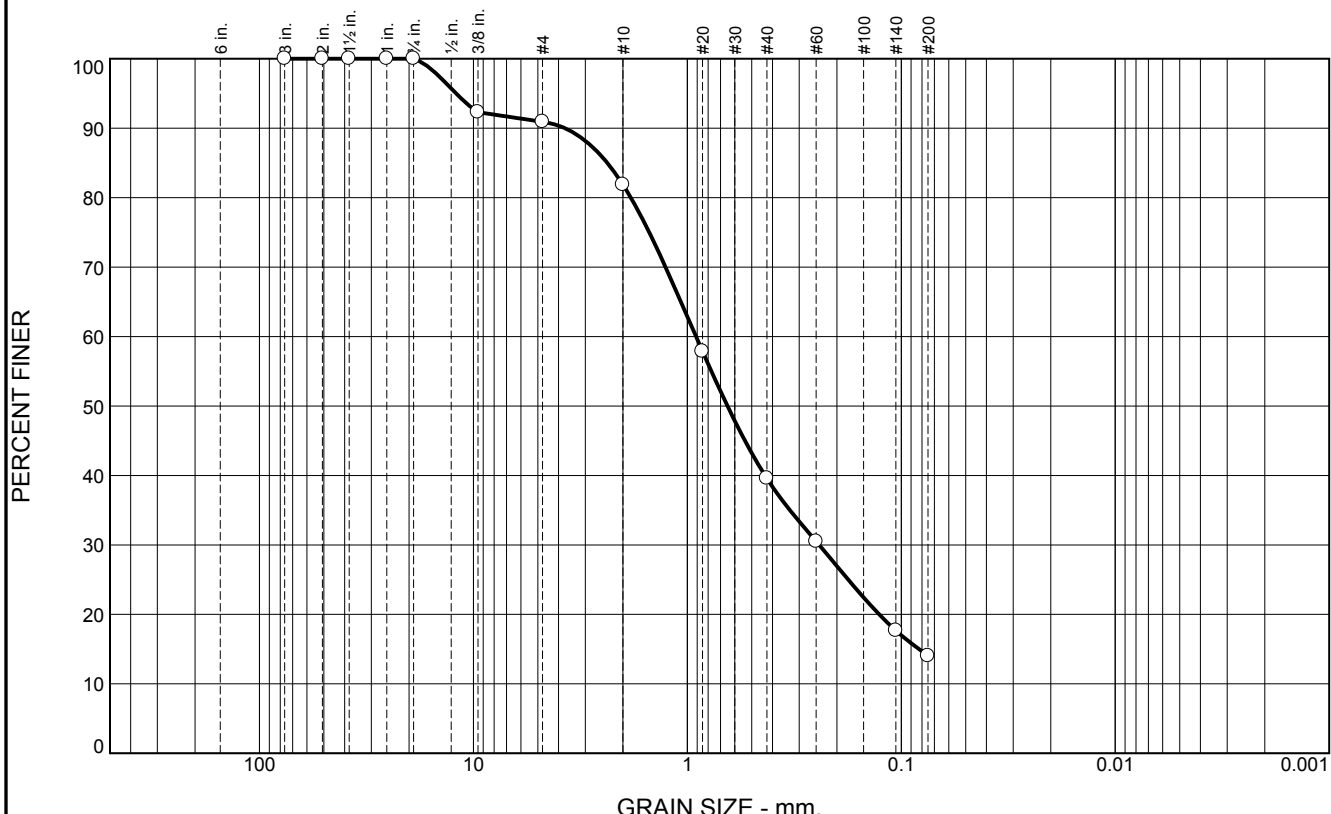
| SAMPLE INFORMATION | | | | | | DEPTH (feet) | STRATA | DESCRIPTION OF MATERIALS (Classification) | REMARKS |
|--|-----|------|----------------------|---------------|-----|-----------------|----------|---|---------------------|
| Depth (feet) | No | Type | Blows Per 6" | Rec. (in.) | N | | | | |
| | | | | | | 0.0 | PAVEMENT | 6" Asphalt, 6" Gravel Subbase | Soft Dig to 3.0 fbs |
| 0 - 3 | S-1 | ↓ | Grab from Hand Auger | -- | --- | 1.0 | FILL | Brown and Gray Silty Sand and Gravel, Moist (FILL) | PID = 0.0 ppm |
| 3 - 5 | S-2 | ⊗ | WOH / 24" | 21 | WOH | 5.0 | FILL | Gray and Brown Silty Clay, Moist (FILL) | PID = 0.0 ppm |
| 5 - 7 | S-3 | ⊗ | 1 - 3 - 2 - 3 | 20 | 5 | 6.6 | RESIDUAL | Gray and Brown Silty Clay with 10% Gravel, Moist, Medium Stiff (CL) | PID = 0.0 ppm |
| 7 - 9 | S-4 | ⊗ | 1 - 2 - 2 - 2 | 16 | 4 | 9.0 | RESIDUAL | Orange Brown Sandy Silt, Moist, Medium Stiff (ML) | PID = 0.0 ppm |
| 9 - 11 | S-5 | ⊗ | 2 - 2 - 2 - 3 | 22 | 4 | 11.0 | RESIDUAL | As Above, Wet, Medium Stiff (ML) | PID = 0.0 ppm |
| | | | | | | 15.0 | | | |
| | | | | | | 20.0 | | | |
| | | | | | | 25.0 | | | |
| Boring Log SB-07 Terminated at a Depth of 11.0 Feet Below Ground Surface | | | | | | | | | |



APPENDIX B

Laboratory Test Results

Particle Size Distribution Report



| % +3" | % Gravel | | % Sand | | | % Fines | |
|-------|----------|------|--------|--------|------|---------|------|
| | Coarse | Fine | Coarse | Medium | Fine | Silt | Clay |
| 0.0 | 0.0 | 9.1 | 9.0 | 42.3 | 25.6 | 14.0 | |

| SIEVE SIZE | PERCENT FINER | SPEC.* PERCENT | PASS? (X=NO) |
|------------|---------------|----------------|--------------|
| 3 | 100.0 | | |
| 2 | 100.0 | | |
| 1.5 | 100.0 | | |
| 1 | 100.0 | | |
| .75 | 100.0 | | |
| .375 | 92.3 | | |
| #4 | 90.9 | | |
| #10 | 81.9 | | |
| #20 | 57.9 | | |
| #40 | 39.6 | | |
| #60 | 30.5 | | |
| #140 | 17.7 | | |
| #200 | 14.0 | | |

Material Description

Silty Sand

Atterberg Limits
 PL= NP LL= NP PI= NP

Coefficients
 D₉₀= 3.7343 D₈₅= 2.3664 D₆₀= 0.9112
 D₅₀= 0.6492 D₃₀= 0.2421 D₁₅= 0.0827
 D₁₀= C_u= C_c=

Classification
 USCS= SM AASHTO= A-1-b

Remarks
 W_n = 13.1 %

* (no specification provided)

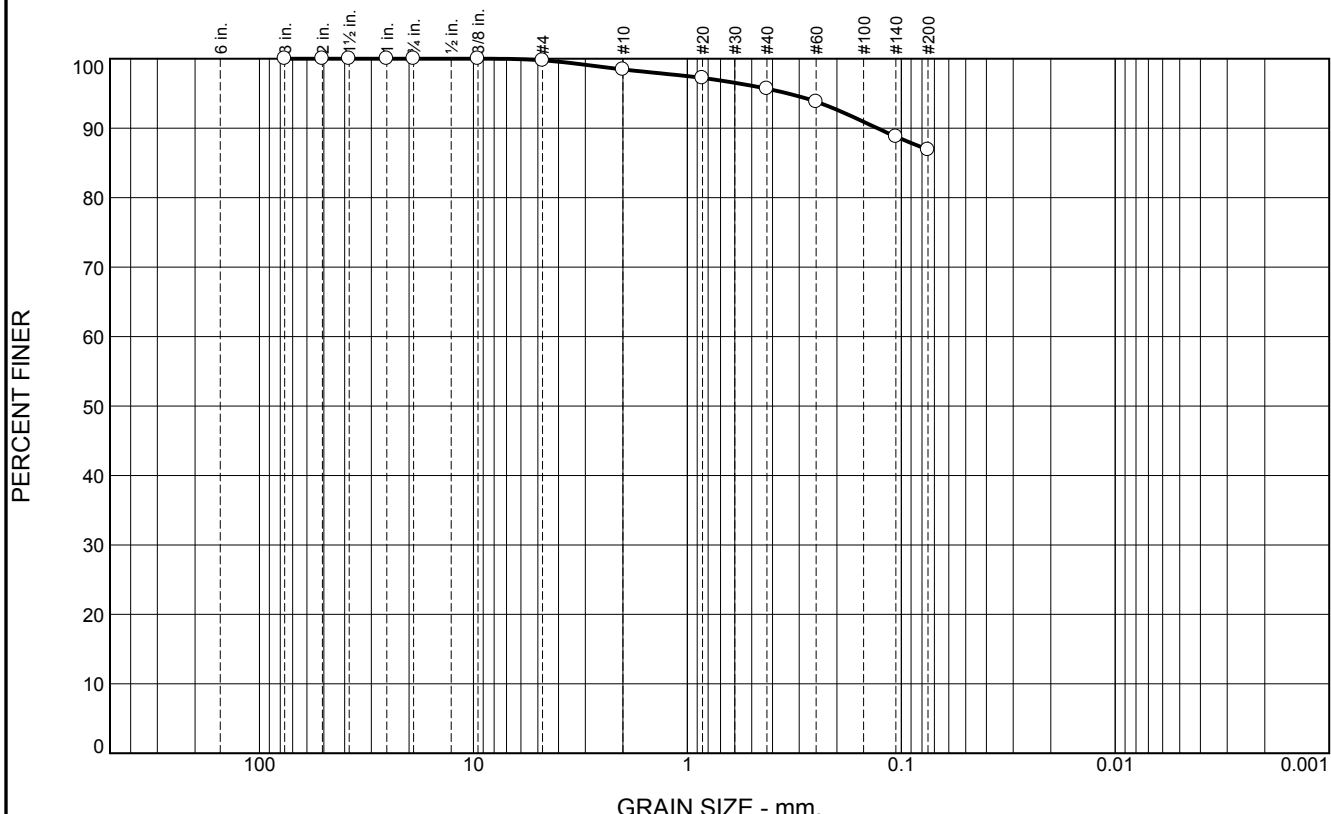
Source of Sample: SB-2 Depth: 6.0' - 8.0'
 Sample Number: S-4

Date: 07/19/2017

**WHITESTONE
 ASSOCIATES, INC.
 Warren, New Jersey**

Client: The Autowash Group
Project: Proposed Wawa Food Market and Fueling Station
 Lancaster Ave & Aberdeen Ave, Radnor Twp, Chester Co, PA
Project No: GP1714612.000 **Figure**

Particle Size Distribution Report



| % +3" | % Gravel | | % Sand | | | % Fines | |
|-------|----------|------|--------|--------|------|---------|------|
| | Coarse | Fine | Coarse | Medium | Fine | Silt | Clay |
| 0.0 | 0.0 | 0.2 | 1.3 | 2.8 | 8.8 | 86.9 | |

| SIEVE SIZE | PERCENT FINER | SPEC.* PERCENT | PASS? (X=NO) |
|------------|---------------|----------------|--------------|
| 3 | 100.0 | | |
| 2 | 100.0 | | |
| 1.5 | 100.0 | | |
| 1 | 100.0 | | |
| .75 | 100.0 | | |
| .375 | 100.0 | | |
| #4 | 99.8 | | |
| #10 | 98.5 | | |
| #20 | 97.2 | | |
| #40 | 95.7 | | |
| #60 | 93.8 | | |
| #140 | 88.8 | | |
| #200 | 86.9 | | |

Material Description

Lean Clay

Atterberg Limits
 PL= 20 LL= 40 PI= 20

Coefficients
 D₉₀= 0.1296 D₈₅= D₆₀=
 D₅₀= D₃₀= D₁₅=
 D₁₀= C_u= C_c=

Classification
 USCS= CL AASHTO= A-6(18)

Remarks
 W_n = 24.0 %


* (no specification provided)

Source of Sample: SB-4 Depth: 3.0' - 5.0'
 Sample Number: S-2

Date: 07/19/2017

**WHITESTONE
 ASSOCIATES, INC.
 Warren, New Jersey**

Client: The Autowash Group
Project: Proposed Wawa Food Market and Fueling Station
 Lancaster Ave & Aberdeen Ave, Radnor Twp, Chester Co, PA
Project No: GP1714612.000 **Figure**



APPENDIX C
Supplemental Information
(USCS, Terms and Symbols)

UNIFIED SOIL CLASSIFICATION SYSTEM

SOIL CLASSIFICATION CHART

| MAJOR DIVISIONS | | | LETTER SYMBOL | TYPICAL DESCRIPTIONS | |
|----------------------|--|--|--|--|---|
| COARSE GRAINED SOILS | GRAVEL AND GRAVELLY SOILS | CLEAN GRAVELS (LITTLE OR NO FINES) | GW | WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES | |
| | MORE THAN 50% OF COARSE FRACTION <u>RETAINED</u> ON NO. 4 SIEVE | GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES) | GP | POORLY-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES | |
| | | SAND AND SANDY SOILS | GC | SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES | |
| | MORE THAN 50% OF MATERIAL IS <u>LARGER</u> THAN NO. 200 SIEVE SIZE | SAND AND SANDY SOILS | CLEAN SAND (LITTLE OR NO FINES) | SW | WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES |
| | | | SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES) | SP | POORLY-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES |
| | | SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES) | SM | SILTY SANDS, SAND-SILT MIXTURES | |
| FINE GRAINED SOILS | SILTS AND CLAYS | LIQUID LIMITS <u>LESS</u> THAN 50 | ML | INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY | |
| | | LIQUID LIMITS <u>GREATER</u> THAN 50 | CL | INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS | |
| | SILTS AND CLAYS | LIQUID LIMITS <u>GREATER</u> THAN 50 | OL | ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY | |
| | | LIQUID LIMITS <u>GREATER</u> THAN 50 | MH | INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS | |
| | | LIQUID LIMITS <u>GREATER</u> THAN 50 | CH | INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS | |
| | | LIQUID LIMITS <u>GREATER</u> THAN 50 | OH | ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS | |
| HIGHLY ORGANIC SOILS | | | PT | PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS | |

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS FOR SAMPLES WITH 5% TO 12% FINES

GRADATION*

% FINER BY WEIGHT

TRACE..... 1% TO 10%
 LITTLE..... 10% TO 20%
 SOME..... 20% TO 35%
 AND..... 35% TO 50%

COMPACTNESS*

Sand and/or Gravel

RELATIVE DENSITY

LOOSE..... 0% TO 40%
 MEDIUM DENSE.... 40% TO 70%
 DENSE..... 70% TO 90%
 VERY DENSE..... 90% TO 100%

CONSISTENCY*

Clay and/or Silt

RANGE OF SHEARING STRENGTH IN POUNDS PER SQUARE FOOT

VERY SOFT..... LESS THAN 250
 SOFT..... 250 TO 500
 MEDIUM..... 500 TO 1000
 STIFF..... 1000 TO 2000
 VERY STIFF..... 2000 TO 4000
 HARD..... GREATER THAN 4000

* VALUES ARE FROM LABORATORY OR FIELD TEST DATA, WHERE APPLICABLE. WHEN NO TESTING WAS PERFORMED, VALUES ARE ESTIMATED.

GEOTECHNICAL TERMS AND SYMBOLS

SAMPLE IDENTIFICATION

The Unified Soil Classification System is used to identify the soil unless otherwise noted.

SOIL PROPERTY SYMBOLS

- N: Standard Penetration Value: Blows per ft. of a 140 lb. hammer falling 30" on a 2" O.D. split-spoon.
- Qu: Unconfined compressive strength, TSF.
- Qp: Penetrometer value, unconfined compressive strength, TSF.
- Mc: Moisture content, %.
- LL: Liquid limit, %.
- PI: Plasticity index, %.
- δd: Natural dry density, PCF.
- ▼: Apparent groundwater level at time noted after completion of boring.

DRILLING AND SAMPLING SYMBOLS

- NE: Not Encountered (Groundwater was not encountered).
- SS: Split-Spoon - 1 3/8" I.D., 2" O.D., except where noted.
- ST: Shelby Tube - 3" O.D., except where noted.
- AU: Auger Sample.
- OB: Diamond Bit.
- CB: Carbide Bit
- WS: Washed Sample.

RELATIVE DENSITY AND CONSISTENCY CLASSIFICATION

| <u>Term (Non-Cohesive Soils)</u> | <u>Standard Penetration Resistance</u> |
|----------------------------------|--|
| Very Loose | 0-4 |
| Loose | 4-10 |
| Medium Dense | 10-30 |
| Dense | 30-50 |
| Very Dense | Over 50 |

| <u>Term (Cohesive Soils)</u> | <u>Qu (TSF)</u> |
|------------------------------|-----------------|
| Very Soft | 0 - 0.25 |
| Soft | 0.25 - 0.50 |
| Firm (Medium) | 0.50 - 1.00 |
| Stiff | 1.00 - 2.00 |
| Very Stiff | 2.00 - 4.00 |
| Hard | 4.00+ |

PARTICLE SIZE

| | | | | | |
|----------|-------------|-------------|---------------|------|-----------------|
| Boulders | 8 in.+ | Coarse Sand | 5mm-0.6mm | Silt | 0.074mm-0.005mm |
| Cobbles | 8 in.-3 in. | Medium Sand | 0.6mm-0.2mm | Clay | -0.005mm |
| Gravel | 3 in.-5mm | Fine Sand | 0.2mm-0.074mm | | |

M:\Geotechnical Forms and References\Geotech Inv. Forms\New Logo Templates\USCSTRMSSYM PA.docx



APPENDIX D

Table Summary of Soil Boring Location Coordinates

| TABLE SUMMARY OF SOIL BORING LOCATION COORDINATES | | | |
|--|-------------------|-------------------|--|
| Soil Boring Number | Latitude | Longitude | Elevation (feet above msl)* |
| SB-01 | 40° 02' 35.779" N | 75° 22' 55.732" W | 365.59 |
| SB-02 | 40° 02' 36.415" N | 75° 22' 52.302" W | 364.32 |
| SB-03 | 40° 02' 36.303" N | 75° 22' 51.474" W | 368.41 |
| SB-04 | 40° 02' 36.707" N | 75° 22' 50.410" W | 369.85 |
| SB-05 | 40° 02' 35.838" N | 75° 22' 49.952" W | 364.08 |
| SB-06 | 40° 02' 35.339" N | 75° 22' 49.538" W | 367.11 |
| SB-07 | 40° 02' 36.665" N | 75° 22' 49.259" W | 368.95 |

* msl: mean sea level



P.O. Box 509
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610-387-6930

**MONITORING WELL LOCATIONS
ABERDEEN SUNOCO & WAYNE BP
306 E. LANCASTER AVENUE
WAYNE, PENNSYLVANIA**

Sources: nearmap

Notes:

Figure: 1
Drawn: MB
Checked: BD
2/27/2018

TABLE 1
ABERDEEN SUNOCO
PADEP FACILITY ID #23-41203
302 E. LANCASTER AVENUE
RADNOR TOWNSHIP, DELAWARE COUNTY

| Groundwater Level Measurements | | | | | | |
|--------------------------------|------------|--|-------------------------|--------------------------|-------------------------|-------------------------------|
| Monitoring Well | Date | Top of Casing Elevation (ftmsl) ¹ | Depth to Product (feet) | Product Thickness (feet) | Depth to Water (ftbtoc) | Groundwater Elevation (ftmsl) |
| Former MW-3 | 2/25/2014 | 365.70 | NP | 0.00 | 5.74 | 359.96 |
| | 3/25/2014 | | --- | --- | --- | --- |
| | 5/19/2014 | | NP | 0.00 | 6.25 | 359.45 |
| | 8/6/2014 | | NP | 0.00 | 6.82 | 358.88 |
| MW-6 | 2/25/2014 | 364.60 | NP | 0.00 | 4.15 | 360.45 |
| | 3/25/2014 | | NP | 0.00 | 4.56 | 360.04 |
| | 5/19/2014 | | NP | 0.00 | 4.29 | 360.31 |
| | 8/6/2014 | | NP | 0.00 | 4.65 | 359.95 |
| | 11/6/2014 | | NP | 0.00 | 4.83 | 359.77 |
| | 2/19/2015 | | NP | 0.00 | 5.00 | 359.60 |
| | 5/8/2015 | | NP | 0.00 | 4.82 | 359.78 |
| | 5/20/2015 | | NP | 0.00 | 4.95 | 359.65 |
| | 8/6/2015 | | NP | 0.00 | 5.02 | 359.58 |
| | 11/5/2015 | | NP | 0.00 | 5.38 | 359.22 |
| | 2/24/2016 | | NP | 0.00 | 4.34 | 360.26 |
| | 5/25/2016 | | NP | 0.00 | 4.70 | 359.90 |
| | 8/8/2016 | | NP | 0.00 | 5.03 | 359.57 |
| | 11/7/2016 | | NP | 0.00 | 5.63 | 358.97 |
| | 2/6/2017 | | NP | 0.00 | 5.50 | 359.10 |
| | 5/4/2017 | | NP | 0.00 | 5.15 | 359.45 |
| | 8/7/2017 | | NP | 0.00 | 5.13 | 359.47 |
| | 11/20/2017 | | NP | 0.00 | 5.50 | 359.10 |
| 2/8/2018 | NP | 0.00 | 4.97 | 359.63 | | |
| 5/2/2018 | NP | 0.00 | 4.67 | 359.93 | | |
| MW-7 | 2/25/2014 | 362.29 | NP | 0.00 | 2.72 | 359.57 |
| | 3/25/2014 | | NP | 0.00 | --- | --- |
| | 5/19/2014 | | NP | 0.00 | 3.19 | 359.10 |
| | 8/6/2014 | | NP | 0.00 | 3.68 | 358.61 |
| | 11/6/2014 | | NP | 0.00 | 3.70 | 358.59 |
| | 2/19/2015 | | NP | 0.00 | 3.82 | 358.47 |
| | 5/8/2015 | | NP | 0.00 | 3.75 | 358.54 |
| | 5/20/2015 | | NP | 0.00 | 3.89 | 358.40 |
| | 8/6/2015 | | NP | 0.00 | 3.89 | 358.40 |
| | 11/5/2015 | | NP | 0.00 | 4.11 | 358.18 |
| | 2/24/2016 | | NP | 0.00 | 3.28 | 359.01 |
| | 5/25/2016 | | NP | 0.00 | 3.28 | 359.01 |
| | 8/8/2016 | | NP | 0.00 | 3.86 | 358.43 |
| | 11/7/2016 | | NP | 0.00 | 4.05 | 358.24 |
| | 2/6/2017 | | NP | 0.00 | 3.97 | 358.32 |
| | 5/4/2017 | | NP | 0.00 | 3.93 | 358.36 |
| | 8/7/2017 | | NP | 0.00 | 3.85 | 358.44 |
| | 11/20/2017 | | NP | 0.00 | 3.83 | 358.46 |
| 2/8/2018 | NP | 0.00 | 3.26 | 359.03 | | |
| 5/2/2018 | NP | 0.00 | 3.52 | 358.77 | | |
| MW-8 | 2/25/2014 | 364.24 | NP | 0.00 | 3.17 | 361.07 |
| | 3/25/2014 | | NP | 0.00 | 3.73 | 360.51 |
| | 5/19/2014 | | NP | 0.00 | 3.49 | 360.75 |
| | 8/6/2014 | | NP | 0.00 | 4.07 | 360.17 |
| | 11/6/2014 | | NP | 0.00 | 4.11 | 360.13 |
| | 2/19/2015 | | NP | 0.00 | 4.16 | 360.08 |
| | 5/8/2015 | | NP | 0.00 | 4.13 | 360.11 |
| | 5/20/2015 | | NP | 0.00 | 4.27 | 359.97 |
| | 8/6/2015 | | NP | 0.00 | 4.38 | 359.86 |
| | 11/5/2015 | | NP | 0.00 | 4.49 | 359.75 |
| | 2/24/2016 | | NP | 0.00 | 3.59 | 360.65 |
| | 5/25/2016 | | NP | 0.00 | 3.97 | 360.27 |
| | 8/8/2016 | | NP | 0.00 | 4.34 | 359.90 |
| | 11/7/2016 | | NP | 0.00 | 4.72 | 359.52 |
| | 2/6/2017 | | NP | 0.00 | 4.50 | 359.74 |
| | 5/4/2017 | | NP | 0.00 | 4.27 | 359.97 |
| | 8/7/2017 | | NP | 0.00 | 4.41 | 359.83 |
| | 11/20/2017 | | NP | 0.00 | 4.42 | 359.82 |
| 2/8/2018 | NP | 0.00 | 3.78 | 360.46 | | |
| 5/2/2018 | NP | 0.00 | 3.85 | 360.39 | | |

TABLE 1
ABERDEEN SUNOCO
PADEP FACILITY ID #23-41203
302 E. LANCASTER AVENUE
RADNOR TOWNSHIP, DELAWARE COUNTY

Groundwater Level Measurements

| Monitoring Well | Date | Top of Casing Elevation (ftmsl) ¹ | Depth to Product (feet) | Product Thickness (feet) | Depth to Water (ftbtoc) | Groundwater Elevation (ftmsl) |
|-----------------|------------|--|-------------------------|--------------------------|-------------------------|-------------------------------|
| MW-9 | 2/25/2014 | 364.36 | NP | 0.00 | 5.96 | 358.40 |
| | 3/25/2014 | | NP | 0.00 | 4.32 | 360.04 |
| | 5/19/2014 | | NP | 0.00 | 6.19 | 358.17 |
| | 8/6/2014 | | NP | 0.00 | 6.52 | 357.84 |
| | 11/6/2014 | | NP | 0.00 | 6.62 | 357.74 |
| | 2/19/2015 | | NP | 0.00 | 6.80 | 357.56 |
| | 5/8/2015 | | NP | 0.00 | 6.60 | 357.76 |
| | 5/20/2015 | | NP | 0.00 | 6.77 | 357.59 |
| | 8/6/2015 | | NP | 0.00 | 6.74 | 357.62 |
| | 11/5/2015 | | NP | 0.00 | 6.94 | 357.42 |
| | 2/24/2016 | | NP | 0.00 | 6.14 | 358.22 |
| | 5/25/2016 | | NP | 0.00 | 6.45 | 357.91 |
| | 8/8/2016 | | NP | 0.00 | 6.71 | 357.65 |
| | 11/7/2016 | | NP | 0.00 | 7.11 | 357.25 |
| | 2/6/2017 | | NP | 0.00 | 6.95 | 357.41 |
| | 5/4/2017 | | NP | 0.00 | 6.73 | 357.63 |
| | 8/7/2017 | | NP | 0.00 | 6.75 | 357.61 |
| | 11/20/2017 | | NP | 0.00 | 6.88 | 357.48 |
| 2/8/2018 | NP | 0.00 | 6.49 | 357.87 | | |
| 5/2/2018 | NP | 0.00 | 6.44 | 357.92 | | |
| MW-10 | 2/25/2014 | 362.91 | 3.58 | 0.27 | 3.85 | 359.27 |
| | 3/25/2014 | | Film | Film | 4.61 | 358.30 |
| | 5/19/2014 | | Film | 0.01 | 4.01 | 358.90 |
| | 8/6/2014 | | Film | 0.01 | 4.45 | 358.46 |
| | 11/6/2014 | | Film | Film | 4.11 | 358.80 |
| | 2/19/2015 | | Film | Film | 4.80 | 358.11 |
| | 5/8/2015 | | NP | 0.00 | 4.55 | 358.36 |
| | 5/20/2015 | | NP | 0.00 | 4.65 | 358.26 |
| | 8/6/2015 | | NP | 0.00 | 4.72 | 358.19 |
| | 11/5/2015 | | NP | 0.00 | 4.91 | 358.00 |
| | 2/24/2016 | | NP | 0.00 | 3.91 | 359.00 |
| | 5/25/2016 | | NP | 0.00 | 4.30 | 358.61 |
| | 8/8/2016 | | NP | 0.00 | 4.58 | 358.33 |
| | 11/7/2016 | | NP | 0.00 | 5.02 | 357.89 |
| | 2/6/2017 | | NP | 0.00 | 4.87 | 358.04 |
| | 5/4/2017 | | NP | 0.00 | 4.61 | 358.30 |
| | 8/7/2017 | | NP | 0.00 | 4.59 | 358.32 |
| | 11/20/2017 | | NP | 0.00 | 4.70 | 358.21 |
| 2/8/2018 | NP | 0.00 | 4.17 | 358.74 | | |
| 5/2/2018 | NP | 0.00 | 4.13 | 358.78 | | |
| MW-11 | 2/25/2014 | 361.72 | NP | 0.00 | 3.12 | 358.60 |
| | 3/25/2014 | | NP | 0.00 | 3.17 | 358.55 |
| | 5/19/2014 | | NP | 0.00 | 3.02 | 358.70 |
| | 8/6/2014 | | NP | 0.00 | 3.40 | 358.32 |
| | 11/6/2014 | | NP | 0.00 | 3.45 | 358.27 |
| | 2/19/2015 | | NP | 0.00 | 3.57 | 358.15 |
| | 5/8/2015 | | NP | 0.00 | 3.49 | 358.23 |
| | 5/20/2015 | | NP | 0.00 | 3.57 | 358.15 |
| | 8/6/2015 | | NP | 0.00 | 3.68 | 358.04 |
| | 11/5/2015 | | NP | 0.00 | 3.82 | 357.90 |
| | 2/24/2016 | | NP | 0.00 | 2.91 | 358.81 |
| | 5/25/2016 | | NP | 0.00 | 3.44 | 358.28 |
| | 8/8/2016 | | NP | 0.00 | 3.66 | 358.06 |
| | 11/7/2016 | | NP | 0.00 | 4.06 | 357.66 |
| | 2/6/2017 | | NP | 0.00 | 4.03 | 357.69 |
| | 5/4/2017 | | NP | 0.00 | 3.87 | 357.85 |
| | 8/7/2017 | | NP | 0.00 | 3.90 | 357.82 |
| | 11/20/2017 | | NP | 0.00 | 3.79 | 357.93 |
| 2/8/2018 | NP | 0.00 | 3.18 | 358.54 | | |
| 5/2/2018 | NP | 0.00 | 3.37 | 358.35 | | |

TABLE 1
ABERDEEN SUNOCO
PADEP FACILITY ID #23-41203
302 E. LANCASTER AVENUE
RADNOR TOWNSHIP, DELAWARE COUNTY

Groundwater Level Measurements

| Monitoring Well | Date | Top of Casing Elevation (ftmsl) ¹ | Depth to Product (feet) | Product Thickness (feet) | Depth to Water (ftbtoc) | Groundwater Elevation (ftmsl) |
|-----------------|------------|--|-------------------------|--------------------------|-------------------------|-------------------------------|
| MW-12 | 2/25/2014 | 360.26 | NP | 0.00 | 1.33 | 358.93 |
| | 3/25/2014 | | NP | 0.00 | 1.94 | 358.32 |
| | 5/19/2014 | | NP | 0.00 | 1.72 | 358.54 |
| | 8/6/2014 | | NP | 0.00 | 2.16 | 358.10 |
| | 11/6/2014 | | NP | 0.00 | 1.20 | 359.06 |
| | 2/19/2015 | | NP | 0.00 | 2.35 | 357.91 |
| | 5/8/2015 | | NP | 0.00 | 2.26 | 358.00 |
| | 5/20/2015 | | NP | 0.00 | 2.37 | 357.89 |
| | 8/6/2015 | | NP | 0.00 | 2.43 | 357.83 |
| | 11/5/2015 | | NP | 0.00 | 2.42 | 357.84 |
| | 2/24/2016 | | NP | 0.00 | 1.76 | 358.50 |
| | 5/25/2016 | | NP | 0.00 | 2.04 | 358.22 |
| | 8/8/2016 | | NP | 0.00 | 2.44 | 357.82 |
| | 11/7/2016 | | NP | 0.00 | 2.75 | 357.51 |
| | 2/6/2017 | | NP | 0.00 | 2.61 | 357.65 |
| | 5/4/2017 | | NP | 0.00 | 2.39 | 357.87 |
| | 8/7/2017 | | NP | 0.00 | 2.58 | 357.68 |
| | 11/20/2017 | | NP | 0.00 | 2.50 | 357.76 |
| 2/8/2018 | NP | 0.00 | 1.96 | 358.30 | | |
| 5/2/2018 | NP | 0.00 | 2.12 | 358.14 | | |
| MW-13 | 2/25/2014 | 361.71 | NP | 0.00 | 2.57 | 359.14 |
| | 3/25/2014 | | NP | 0.00 | 3.23 | 358.48 |
| | 5/19/2014 | | NP | 0.00 | 3.05 | 358.66 |
| | 8/6/2014 | | NP | 0.00 | 3.53 | 358.18 |
| | 11/6/2014 | | NP | 0.00 | 3.52 | 358.19 |
| | 2/19/2015 | | NP | 0.00 | 3.68 | 358.03 |
| | 5/8/2015 | | NP | 0.00 | 3.62 | 358.09 |
| | 5/20/2015 | | NP | 0.00 | 3.78 | 357.93 |
| | 8/6/2015 | | NP | 0.00 | 3.82 | 357.89 |
| | 11/5/2015 | | NP | 0.00 | 3.94 | 357.77 |
| | 2/24/2016 | | NP | 0.00 | 3.10 | 358.61 |
| | 5/25/2016 | | NP | 0.00 | 3.44 | 358.27 |
| | 8/8/2016 | | NP | 0.00 | 3.82 | 357.89 |
| | 11/7/2016 | | NP | 0.00 | 4.20 | 357.51 |
| | 2/6/2017 | | NP | 0.00 | 3.69 | 358.02 |
| | 5/4/2017 | | NP | 0.00 | 3.81 | 357.90 |
| | 8/7/2017 | | NP | 0.00 | 3.89 | 357.82 |
| | 11/20/2017 | | NP | 0.00 | 3.84 | 357.87 |
| 2/8/2018 | NP | 0.00 | 3.23 | 358.48 | | |
| 5/2/2018 | NP | 0.00 | 3.39 | 358.32 | | |
| MW-14 | 2/25/2014 | 362.72 | --- | --- | --- | --- |
| | 3/25/2014 | | NP | 0.00 | 3.74 | 358.98 |
| | 5/19/2014 | | NP | 0.00 | 3.65 | 359.07 |
| | 8/6/2014 | | NP | 0.00 | 4.03 | 358.69 |
| | 11/6/2014 | | NP | 0.00 | 4.05 | 358.67 |
| | 2/19/2015 | | NP | 0.00 | 4.27 | 358.45 |
| | 5/8/2015 | | NP | 0.00 | 4.18 | 358.54 |
| | 5/20/2015 | | NP | 0.00 | 4.33 | 358.39 |
| | 8/6/2015 | | NP | 0.00 | 4.42 | 358.30 |
| | 11/5/2015 | | NP | 0.00 | 4.60 | 358.12 |
| | 2/24/2016 | | NP | 0.00 | 3.68 | 359.04 |
| | 5/25/2016 | | NP | 0.00 | 4.05 | 358.67 |
| | 8/8/2016 | | NP | 0.00 | 4.38 | 358.34 |
| | 11/7/2016 | | NP | 0.00 | 4.86 | 357.86 |
| | 2/6/2017 | | NP | 0.00 | 4.61 | 358.11 |
| | 5/4/2017 | | NP | 0.00 | 4.40 | 358.32 |
| | 8/7/2017 | | NP | 0.00 | 4.44 | 358.28 |
| | 11/20/2017 | | NP | 0.00 | 4.51 | 358.21 |
| 2/8/2018 | NP | 0.00 | 3.85 | 358.87 | | |
| 5/2/2018 | NP | 0.00 | 3.88 | 358.84 | | |

TABLE 1
ABERDEEN SUNOCO
PADEP FACILITY ID #23-41203
302 E. LANCASTER AVENUE
RADNOR TOWNSHIP, DELAWARE COUNTY

Groundwater Level Measurements

| Monitoring Well | Date | Top of Casing Elevation (ftmsl) ¹ | Depth to Product (feet) | Product Thickness (feet) | Depth to Water (ftbtoc) | Groundwater Elevation (ftmsl) |
|-----------------|------------|--|-------------------------|--------------------------|-------------------------|-------------------------------|
| MW-15 | 2/25/2014 | 360.87 | --- | --- | --- | --- |
| | 3/25/2014 | | NP | 0.00 | 3.70 | 357.17 |
| | 5/19/2014 | | NP | 0.00 | 3.69 | 357.18 |
| | 8/6/2014 | | NP | 0.00 | 3.88 | 356.99 |
| | 11/6/2014 | | NP | 0.00 | 3.85 | 357.02 |
| | 2/19/2015 | | NP | 0.00 | 3.95 | 356.92 |
| | 5/8/2015 | | NP | 0.00 | 3.92 | 356.95 |
| | 5/20/2015 | | NP | 0.00 | 4.06 | 356.81 |
| | 8/6/2015 | | NP | 0.00 | 4.07 | 356.80 |
| | 11/5/2015 | | NP | 0.00 | 4.16 | 356.71 |
| | 2/24/2016 | | NP | 0.00 | 3.52 | 357.35 |
| | 5/25/2016 | | NP | 0.00 | 3.85 | 357.02 |
| | 8/8/2016 | | NP | 0.00 | 4.03 | 356.84 |
| | 11/7/2016 | | NP | 0.00 | 4.31 | 356.56 |
| | 2/6/2017 | | NP | 0.00 | 4.14 | 356.73 |
| | 5/4/2017 | | NP | 0.00 | 4.04 | 356.83 |
| | 8/7/2017 | | NP | 0.00 | 3.98 | 356.89 |
| 11/20/2017 | NP | 0.00 | 3.86 | 357.01 | | |
| 2/8/2018 | NP | 0.00 | 3.44 | 357.43 | | |
| 5/2/2018 | NP | 0.00 | 3.50 | 357.37 | | |
| MW-16 | 5/8/2015 | 362.86 | NP | 0.00 | 4.60 | 358.26 |
| | 5/20/2015 | | NP | 0.00 | 4.78 | 358.08 |
| | 8/6/2015 | | NP | 0.00 | 4.86 | 358.00 |
| | 8/7/2015 | | NP | 0.00 | 4.89 | 357.97 |
| | 11/5/2015 | | NP | 0.00 | 5.06 | 357.80 |
| | 2/24/2016 | | NP | 0.00 | 4.30 | 358.56 |
| | 5/25/2016 | | NP | 0.00 | 4.49 | 358.37 |
| | 8/8/2016 | | NP | 0.00 | 4.82 | 358.04 |
| | 11/7/2016 | | NP | 0.00 | 5.25 | 357.61 |
| | 2/6/2017 | | NP | 0.00 | 5.06 | 357.80 |
| | 5/4/2017 | | NP | 0.00 | 4.82 | 358.04 |
| | 8/7/2017 | | NP | 0.00 | 4.84 | 358.02 |
| | 11/20/2017 | | NP | 0.00 | 4.96 | 357.90 |
| 2/8/2018 | NP | 0.00 | 4.37 | 358.49 | | |
| 5/2/2018 | NP | 0.00 | 4.33 | 358.53 | | |
| MW-17 | 5/8/2015 | 363.38 | NP | 0.00 | 4.39 | 358.99 |
| | 5/20/2015 | | NP | 0.00 | 4.53 | 358.85 |
| | 8/6/2015 | | NP | 0.00 | 4.63 | 358.75 |
| | 8/7/2015 | | NP | 0.00 | 4.64 | 358.74 |
| | 11/5/2015 | | NP | 0.00 | 4.79 | 358.59 |
| | 2/24/2016 | | NP | 0.00 | 3.81 | 359.57 |
| | 5/25/2016 | | NP | 0.00 | 4.27 | 359.11 |
| | 8/8/2016 | | NP | 0.00 | 4.59 | 358.79 |
| | 11/7/2016 | | NP | 0.00 | 5.02 | 358.36 |
| | 2/6/2017 | | NP | 0.00 | 4.79 | 358.59 |
| | 5/4/2017 | | NP | 0.00 | 4.58 | 358.80 |
| | 8/7/2017 | | NP | 0.00 | 4.63 | 358.75 |
| | 11/20/2017 | | NP | 0.00 | 4.68 | 358.70 |
| | 2/8/2018 | | NP | 0.00 | 4.01 | 359.37 |
| 5/2/2018 | NP | 0.00 | 4.23 | 359.15 | | |

Notes:

ftmsl = feet above mean sea level

ftbtoc = feet below top of casing

NP = No product

film = product detected by interface probe less than 0.01 feet thick.

¹ = Top of casing elevations surveyed by Chester Valley Engineers in March 2014.

Corrected groundwater elevation = Top of casing elevation - depth to water

TABLE 1
BP WAYNE
306 E. LANCASTER AVENUE
RADNOR TOWNSHIP, DELAWARE COUNTY
FACILITY ID #23-29806

| Groundwater Level Measurements | | | | | | |
|---------------------------------------|-------------|---|--------------------------------|---------------------------------|-------------------------------|--|
| Monitor Well | Date | Top of Casing Elevation (feet)¹ | Depth to Product (feet) | Product Thickness (feet) | Depth to Water (ftboc) | Corrected Groundwater Elevation (ftMSL) |
| MW-1 | 2/6/2017 | 365.60 | NP | 0.00 | 6.34 | 359.26 |
| | 5/4/2017 | | NP | 0.00 | 5.83 | 359.77 |
| | 8/7/2017 | | NP | 0.00 | 5.83 | 359.77 |
| | 11/20/2017 | | NP | 0.00 | 6.23 | 359.37 |
| | 2/5/2018 | | NP | 0.00 | 5.84 | 359.76 |
| | 5/1/2018 | | NP | 0.00 | 5.30 | 360.30 |
| MW-2 | 2/6/2017 | 365.28 | NP | 0.00 | 7.16 | 358.12 |
| | 5/4/2017 | | NP | 0.00 | 6.85 | 358.43 |
| | 8/7/2017 | | NP | 0.00 | 7.08 | 358.20 |
| | 11/20/2017 | | NP | 0.00 | 7.02 | 358.26 |
| | 2/5/2018 | | NP | 0.00 | 6.60 | 358.68 |
| | 5/1/2018 | | NP | 0.00 | 6.33 | 358.95 |
| MW-3 | 2/6/2017 | 366.36 | NP | 0.00 | 8.13 | 358.23 |
| | 5/4/2017 | | NP | 0.00 | 7.83 | 358.53 |
| | 8/7/2017 | | NP | 0.00 | 7.98 | 358.38 |
| | 11/20/2017 | | NP | 0.00 | 8.09 | 358.27 |
| | 2/5/2018 | | NP | 0.00 | 7.05 | 359.31 |
| | 5/1/2018 | | NP | 0.00 | 7.19 | 359.17 |
| MW-4 | 2/6/2017 | 365.31 | NP | 0.00 | 7.49 | 357.82 |
| | 5/4/2017 | | NP | 0.00 | 7.19 | 358.12 |
| | 8/7/2017 | | NP | 0.00 | 7.31 | 358.00 |
| | 11/20/2017 | | NP | 0.00 | 7.31 | 358.00 |
| | 2/5/2018 | | NP | 0.00 | 6.89 | 358.42 |
| | 5/1/2018 | | NP | 0.00 | 6.70 | 358.61 |
| MW-5 | 5/4/2017 | 365.61 | NP | 0.00 | 6.56 | 359.05 |
| | 8/7/2017 | | NP | 0.00 | 6.65 | 358.96 |
| | 11/20/2017 | | NP | 0.00 | 6.82 | 358.79 |
| | 2/5/2018 | | NP | 0.00 | 6.38 | 359.23 |
| | 5/1/2018 | | NP | 0.00 | 5.99 | 359.62 |
| MW-6 | 5/4/2017 | 364.98 | NP | 0.00 | 6.47 | 358.51 |
| | 8/7/2017 | | NP | 0.00 | 6.56 | 358.42 |
| | 11/20/2017 | | NP | 0.00 | 6.64 | 358.34 |
| | 2/5/2018 | | NP | 0.00 | 6.25 | 358.73 |
| | 5/1/2018 | | NP | 0.00 | 5.95 | 359.03 |

Notes:

¹ Top of casing elevation measured by E&LP, Inc. in February 2017

ftboc = feet below top of casing

ftMSL = feet above Mean Sea Level

NP = No product

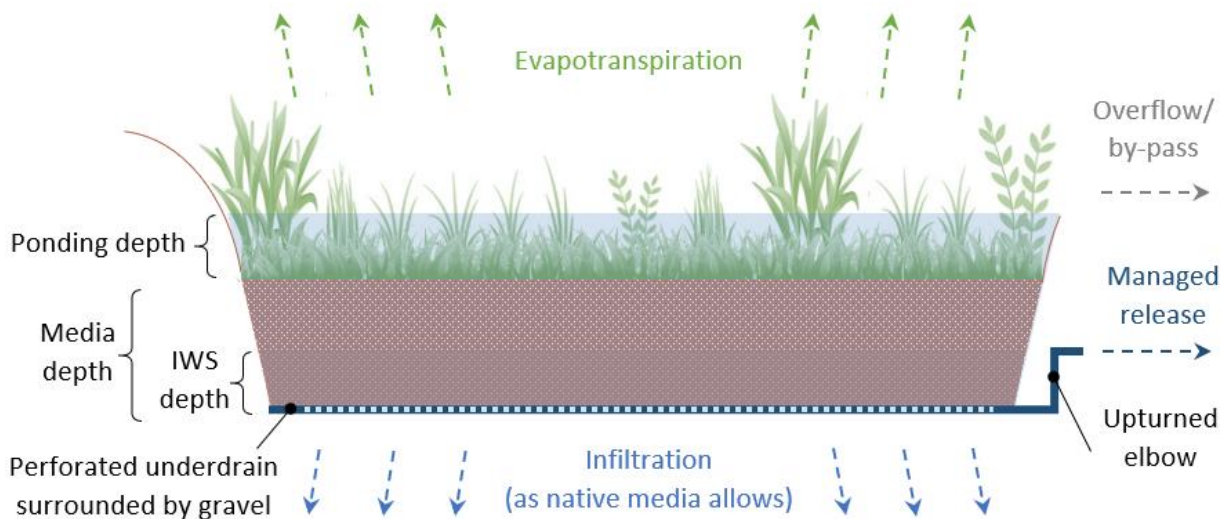
Managed Release Concept

December 13, 2018

Description

Managed Release Concept (MRC) is a post-construction stormwater management (PCSM) strategy that involves the collection, storage, and filtration of captured runoff through a best management practice (BMP) that is preferably vegetated and includes a release of a portion of the captured runoff through an underdrain within the BMP, or from a pool protected from solar radiation. If the MRC BMP is not vegetated, then pretreatment is required to meet water quality requirements. The MRC is intended to be used for project areas or subareas where infiltration is not feasible to meet regulatory requirements under § 102.8(g)(2). Figure 1 illustrates the components of a typical MRC BMP.

Figure 1: Managed Release Concept with Internal Water Storage (IWS) and Uprturned Elbow for a Vegetated BMP



MRC requires storage (which includes the media void space) that temporarily impounds the captured runoff from storm events up to and including the 2-year/24-hour storm. The runoff is temporarily impounded for use by vegetation, is filtered through a soil media or another acceptable pre-treatment device, is infiltrated through in-situ soils to the highest degree feasible for a project site, and is released through an underdrain and control structure at a rate similar to the lateral unsaturated flow movement to the receiving waters from undeveloped areas. An internal water storage is included in the design for further water quality and evapotranspiration (ET) benefits.

The MRC strategy may be used to satisfy Chapter 102 volume management requirements under 25 Pa. Code § 102.8(g)(2), regarding the net change in the pre- vs. post-development runoff volume from storm events up to and including the 2-year/24-hour storm ($\Delta 2$ volume). For projects that include infiltrating and non-infiltrating subareas and meet the applicability requirements, the MRC BMP can be combined with other volume reducing BMPs.

In accordance with 25 Pa. Code § 102.8(e), the person preparing the PCSM Plan shall be trained and experienced in PCSM design methods and techniques applicable to the size and scope of the project being designed. Due to the complexity of the design of an MRC BMP and the associated analyses, the Department of Environmental Protection (DEP) requires that a licensed professional engineer perform the design and analyses identified in this document.

Applicability

MRC may be authorized as a PCSM BMP where certain criteria are met, as follows:

1. A professional engineer, licensed in the Commonwealth of Pennsylvania, must perform the analyses, calculations, and evaluations associated with MRC BMPs.
2. The applicant has completed a thorough pre-development site characterization and assessment of soil and geology of the project site (not just the proposed location of the BMP), and the applicant's licensed professional engineer has determined that it is not feasible to remove the $\Delta 2$ volume through infiltration and ET alone due to soil and/or geologic conditions or other environmental constraints on the project site. DEP intends for the use of MRC to be limited to sites where infiltration is extremely limited, not feasible (i.e., groundwater and/or regularly occurring seasonally high-water tables within one foot of the bottom of the BMP's soil media), or undesirable (e.g., sinkhole-prone areas or contaminated soils).
3. The installation and implementation of structural and non-structural BMPs on the project site, to the extent practicable, is not sufficient to reduce the $\Delta 2$ volume.
4. BMPs providing infiltration and ET are maximized on the overall project site.
5. The licensed professional engineer has investigated downstream conditions and identifies in the PCSM Plan that the off-site discharge flow path to the confluence with the receiving surface water will not experience accelerated erosion or damage.

Where all of these criteria are met, and assuming use of MRC does not conflict with local ordinances, DEP or a delegated conservation district (CCD) may authorize the use of MRC for BMPs proposed on a project site.

The use of MRC does not preclude the applicant from minimizing any increase in stormwater runoff volume to the extent practicable, per 25 Pa. Code § 102.8(b)(3), and, when applicable, does not alleviate the requirement to demonstrate that non-discharge alternatives do not exist for the project, per 25 Pa. Code § 102.8(h)(1).

MRC can be utilized with various BMPs. The licensed professional engineer would need to determine suitability and may adapt various elements to achieve the project goals. MRC can be used for both new construction and retrofit projects. Other uses of MRC may be proposed by the licensed professional engineer for DEP review and approval.

DEP Review

When CCDs receive a Notice of Intent (NOI) for PAG-02 General Permit coverage that includes a PCSM Plan with MRC BMP(s), CCDs will forward the PCSM Plan to the appropriate DEP regional office for technical review when one or more of the following conditions exist, unless otherwise waived by DEP:

1. The total drainage area to any MRC BMP is at least 5 acres or the total impervious area to any MRC BMP is at least 3 acres.
2. The applicant proposes an overall increase in impervious area (including gravel, stone, etc.) of at least 10 acres.
3. The MRC BMP will be designed to discharge to waters classified as impaired due to siltation/sediment or flow alterations, regardless if the water is under an approved Total Maximum Daily Load (TMDL).

Eligibility for PAG-02 coverage will not be affected by DEP's technical review. DEP may also delegate the technical review to CCDs with PCSM delegation.

In addition, if deviations from the design standards set forth in this document are proposed, the submission of an individual permit application is necessary, unless waived by DEP.

If none of these conditions apply, the delegated CCD may complete the review of the MRC BMP and PCSM Plan.

Completing the NOI/Application and Worksheets Where an MRC BMP Is Proposed

An applicant proposing the use of an MRC BMP should include a complete MRC Design Summary sheet with the NOI/application. One MRC Design Summary sheet should be completed and submitted for each BMP that will utilize MRC. The MRC Design Summary sheet is available through DEP’s website as a [PDF](#) and [Word](#) document.

The total volume managed in an MRC BMP is a combination of the volume permanently removed via infiltration and ET and the volume managed and released through the underdrain for storms up to and including the 2-year/24-hour storm event. The total managed volume can be entered onto Worksheet 5 and into Section D.3 of the NOI/application as follows:

- Worksheet 5 can be completed by identifying the volume removed by the MRC BMP (i.e., the volume that is removed by infiltration and ET) and the volume managed by the MRC BMP (i.e., the volume that discharges through the underdrain) as two separate entries under the “Other” line. The underlying BMP will also have to be identified on Worksheet 5. For example:

| Proposed BMPs from PA Stormwater Best Management Practices Manual Chapter 6 | | Area (ft ²) | Volume Reduction Permanently Removed (ft ³) |
|---|---------------------------------------|-------------------------|---|
| Other | Rain Garden with MRC (volume removed) | 3,049 | 5,124 |
| Other | Rain Garden with MRC (volume managed) | 3,049 | 2,648 |

- Section D.3 of the NOI/application can be completed by including the total volume removed and managed by the MRC into Box 7. For example:

| | Pre-construction | Post Construction | Net Change |
|--|------------------|-------------------|------------|
| Design storm frequency <u>2-YR/24-HR</u> | | | |
| Rainfall amount <u>3.19</u> inches | | | |
| Impervious area (acres) | 1 0 | 2 0.75 | 3 0.75 |
| Volume of stormwater runoff <input type="checkbox"/> acre-feet or <input checked="" type="checkbox"/> cubic feet (check appropriate box) | 4 5,384 | 5 12,209 | 6 6,825 |
| Volume of stormwater runoff <input type="checkbox"/> acre-feet or <input checked="" type="checkbox"/> cubic feet (check appropriate box) | | 7 7,772 | 8 -947 |

See the Design Example at the end of this document for information on how these values can be determined.

For the purpose of completing Worksheet 10, MRC is considered a primary BMP for nitrate removal.

MRC Design Standards

Implementation of the following design standards will satisfy the requirements in 25 Pa. Code §§ 102.8(g)(2) and 102.8(g)(3) for managing the net change in runoff volume, rate and water quality for the stormwater managed by MRC BMPs. MRC BMPs and these standards constitute an alternative BMP and design standard under Pa. Code § 102.11(b).

When similar non-regulated impervious areas (existing impervious area not included in the proposed earth disturbance) drain to the MRC, the volume managed can be increased to offset volume from adjacent earth disturbance not captured by the MRC that drains to the same surface water in close proximity to the MRC. In these instances, the MRC design should be adjusted to account for equivalent capture, release rate, and peak flow

attenuation from the combined areas. The maximum volume managed by an MRC cannot exceed the volume generated by the 2-year/24-hour storm for the area draining to the MRC BMP.

Deviations from the MRC Design Standards may be proposed by the licensed professional engineer through an individual permit application.

1. **Runoff Capture** – A minimum of the first one inch of runoff of all new impervious surfaces that the MRC is intended to treat should be captured and managed by the MRC BMP, filtered through vegetated media or treated and filtered to the extent practicable through the in-situ soils or other acceptable treatment systems, and released as indicated in MRC Standard 2, except where MRC contributing drainage areas with less than 50% impervious surface, in which a minimum of ½-inch of runoff from the disturbed area drainage to the MRC BMP should be captured and managed. The MRC may be designed for offsetting when contributing non-regulated impervious surfaces are present in the contributing drainage area.
2. **Release Rate** – The stormwater release rate from the BMP should not exceed 0.01 cfs (rounded to the nearest hundredth) per acre of the regulated impervious area (e.g., 1.576 ac. is 0.01576 cfs, rounded to 0.02 cfs). Hydrologic routing modeling is necessary to demonstrate compliance with the standard for release rate. This release rate is calculated based on the contributing drainage area managed by the MRC.

NOTE – This release rate is approximately the expected rate of interflow after a 2-year/24-hour storm event for a Pennsylvania non-karst watershed based on the NRCS curvilinear unit hydrograph. Releasing at this rate will produce a condition where baseflow contributions will be similar to that of an undeveloped area during and after storm events. As the level of outflow would be similar to what would be expected during and after the storm, it would not be expected to impact the storm event's effects on flooding and erosion. This rate should also be used for karst watersheds unless it can be demonstrated that interflow on a particular project site differs from this standard.

3. **Internal Water Storage (IWS)** – A volume for IWS should be provided that is at least one foot deep below the lowest structural outlet (i.e. the outlet for the underdrain) in the MRC BMP to encourage ET, infiltration and denitrification. To encourage ET, the overall soil media depth of a facility including the IWS can be no deeper than four (4) feet, and up to 50% of the IWS volume can be included (only for vegetated MRC BMPs) as available storage during hydrologic routings to demonstrate compliance with the standard for the Release Rate (No. 2 above) and Peak Flow Attenuation (No. 4 below). For soil media, a void space of 30% can be used to describe the soil volume storage and recovery. If an alternate void space is used, specific data demonstrating the void space should be submitted.

Use of Liners – The MRC BMP should not have an impervious liner installed unless environmental or geological conditions necessitate use of a liner, or if an existing structure would be damaged as a result of not lining the facility.

NOTE – The presence of a project site in an area of known karst conditions does not, in itself, serve as evidence of the applicability of MRC to a project site or to the use of a liner to avoid infiltration. DEP and delegated CCDs reserve the right to request a detailed subsurface investigation where considered warranted to evaluate the likelihood of sinkhole formation as a result of post-construction stormwater management.

4. **Peak Flow Attenuation** – The peak flow from the post-construction 2-year/24-hour storm should be managed back to the pre-construction 1-year/24-hour storm peak flow, unless an approved and current Act 167 Plan or another requirement (such as limited capacity of a downstream channel), is more restrictive. In the event the MRC drainage area is part of a larger overall site with non-MRC BMPs, only the MRC drainage peak flows must be managed back to the 1-year/24-hour level and overflows can be combined with flows from the non-MRC BMPs.

In situations where the pre-construction drainage area to the MRC BMP varies significantly compared to the post-construction drainage area, the post-construction drainage area boundary to the MRC BMP (using existing land uses) can be used to calculate the target pre-construction 1-year rate, as long all areas in question are in close proximity to the MRC BMP and drain to the same surface water. In cases where the BMP is managing

additional volume to offset adjacent areas that could not be captured in the MRC BMP, the target pre-construction 1-year release rate should be calculated based on the combined flow rates from the BMP drainage area and adjacent area.

NOTE – This standard is used to ensure that MRC does not contribute to channel-eroding flows in receiving surface waters.

Flows Greater Than 2-Year/24-Hour Storm – The recommended design for MRC BMPs is to bypass storm events larger than the 2-year/24-hour storm to a traditional detention BMP; however, DEP understands that site and cost limitations may not allow for this bypass. When it is demonstrated by the licensed professional engineer that larger storm events cannot be bypassed, the MRC BMP surface component should be designed to manage the post construction 10-, 50- and 100-year/24-hour storm event peak flows to their corresponding pre-construction rates and the MRC BMP should have an increased (i.e., more frequent) inspection and maintenance schedule that includes inspection and repair after extreme events (10-, 50- and 100-year/24-hour storm events).

5. **Stormwater BMP Manual** – Follow the design considerations for BMPs as presented in the *Pennsylvania Stormwater Best Management Practices Manual* (Stormwater BMP Manual) (363-0300-002). MRC may be incorporated into the design of other BMPs by a licensed professional engineer.
6. **MRC BMP Selection** – Standard MRC BMPs include the following system types:
 - a. **Vegetated MRC** – Vegetation must be provided for 75% of the surface of the MRC BMP. Native vegetation should be selected by the licensed professional engineer, in consultation with a professional that is knowledgeable in native plant ecology. Vegetation should be selected based on the plants' ability to grow within the anticipated conditions considering the depth and duration of stormwater stored in the MRC BMP.
 - b. **Non-vegetated MRC: Porous Pavement** – Porous pavements with a storage bed require a vacuum street sweeping maintenance regime adequate for the drainage area characteristics; the vacuum street sweeping equipment must provide adequate suction capacity to remove particles on surface to provide a sufficient water quality demonstration and to maintain flow pathways.
 - c. **Non-vegetated MRC: Underground Storage Chambers** – The use of the MRC BMP with non-vegetated, non-porous pavement stormwater practices must have pre-treatment, post-treatment, or a combination of both pre- and post-treatment measures incorporated into the design, to provide sufficient water quality. Underground storage chambers must be accessible for maintenance, and for this reason are not recommended to be rock beds. Pre- and post-treatment can be obtained through a treatment train concept of other BMPs listed in the Stormwater BMP Manual (as updated) such that the combination of BMPs meet 85% removal of TSS. Preferred pre- and post-treatment BMPs include: level spreader with vegetated filter strip, vegetated swale, other vegetated systems, and manufactured treatment devices. An applicant must demonstrate that the treatment train will provide 85% TSS removal by using Worksheets 11 – 13 or by providing an alternative water quality demonstration that is acceptable to DEP.
7. **Pre-Development Site Characterization and Assessment of Soil and Geology** – Adequate and appropriate soils and geologic testing and evaluation must be performed to demonstrate the infiltration capacity of the entire project site to the satisfaction of DEP. At a minimum, one infiltration test for every 40,000 square feet of disturbed acreage should be performed with a minimum of four tests, equally distributed across a site. The infiltration tests must be done in the most accommodating soil horizon for infiltration as demonstrated by a deep hole test within 100 feet of the infiltration test. All other sections of Appendix C Protocol 1, Site Evaluation and Soil Infiltration Testing and Appendix C Protocol 2, Infiltration Systems Guidelines per the Stormwater BMP Manual (as updated) should be followed to clearly demonstrate the in-situ infiltration capability on-site at applicable elevations and for a variety of locations. Soil probes and infiltration test locations should be identified on the PCSM Plan drawing(s). The use of soil borings as a substitute for test pits can be used as a planning tool but will not generally be accepted for final design of infiltration MRC BMPs.

NOTE – The above recommended number of infiltration tests per disturbed area is to be based upon the disturbed area that is not considered a restoration activity or road maintenance activity. For example, a

large sewer main installation project disturbs 30-ac. in total, with 29-ac. of disturbance for the sewer line installation (that will be covered by a restoration plan) and 1-ac. of disturbance for a pumping station that requires a PCSM plan. The recommended number of infiltration tests would be based on the 1-acre, not 30-acres.

NOTE – The minimum number of tests can be reduced, if it can be demonstrated that the subsurface conditions are uniform; however, this is considered a deviation from MRC Design Standards, generally requiring an individual permit.

NOTE – Infiltration tests resulting in saturated hydraulic conductivities of less than or equal to 0.2 inches per hour classify as extremely limited as they include the lower part of the range of HSG C soils and HSG D soils.

8. **Separation Distance** – At least one foot of separation distance should exist between the groundwater or the seasonally high-water table and the bottom footprint of the MRC BMP's soil media; however, a two-foot separation is preferred. There is no minimum separation required between bedrock or hardpan and the MRC BMP's soil media.
9. **Ponding Depth and Drawdown time** – The maximum ponding time (i.e., the time after end of storm event for stored surface water to lower to soil surface) should not exceed 72 hours for any storm event. In general, a maximum ponding depth (i.e., storage depth above BMP surface) of one to two feet at the peak of the 2-year/24-hour storm event should not be exceeded for the design of surface BMPs. In accordance with MRC Design Standard 4, the MRC might incorporate a multi-stage detention facility with the upper portions of the facility providing flow attenuation for storm events greater than a 2-year/24-hour storm, to meet 25 Pa. Code § 102.8(g)(3). In the absence of a multi-stage system, an engineered overflow structure or reinforced spillway / berm should be installed to provide safe conveyance for storm events greater than a 2-year/24-hour storm. Ponding depth for storms larger than the 2-year/24-hour storm should not exceed four feet, and drawdown to the MRC BMP surface should not exceed 72-hours for all design storms. For subsurface MRC systems, drawdown to the IWS storage level should not exceed 7 days.
10. **Soil Media** – The selection of soil media should be done by considering anticipated pollutants to be treated and the vegetation that will be used. On-site soils should be evaluated for desired characteristics and infiltration rates as listed below. The minimum depth of the soil media above the invert elevation of the underdrain pipe should be a minimum of 2 feet (24 inches) to provide pollutant removal. If in-situ soils are unsuitable for the purpose of providing IWS, an additional one to two feet of suitable soil media should be provided below the underdrain.

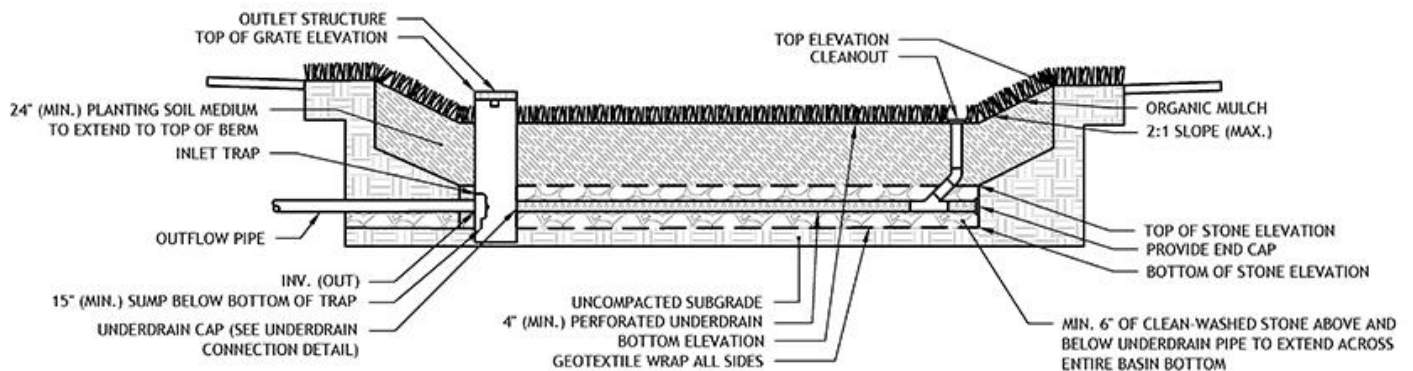
Soil Media Drainage – The designer will need to exercise caution when selecting a soil media, as there is a delicate balance between infiltration rate and residence time. As noted in Appendix C, Protocol 2 of the Stormwater BMP Manual, soil infiltration rate should be between 0.1 inches per hour and 10 inches per hour for infiltration into native soils. To maximize water quality treatment, the residence time within the soil media used in MRC BMPs should be selected to be close to the parameters established for infiltration into native soils. **The designer will need to select a soil media that provide the proper infiltration rate and ponding time to achieve water quality for the anticipated life cycle of the BMP.**

11. **Underdrain Design** – The licensed professional engineer can refer to PennDOT Publication 408 Section 610 for specifications of underdrains. However, underdrains should have a minimum infiltration rate of 10 gallons (1.34 cubic feet) per minute per linear foot of pipe. There may need to be multiple underdrains, or longer underdrains, to provide adequate design capacity for drainage. Section 6.4.7 of the Stormwater BMP Manual (Constructed Filter) has recommended design standards for lateral spacing of multiple underdrains.

IWS Outflow with Capped / Orifice Underdrain – It is highly recommended that an upturned elbow or an elevated weir be designed at the outlet of the underdrain (see Figure 1). The upturned elbow or elevated weir will create a zone within the soil media, referred to as the IWS. Research has shown that IWS can improve runoff volume reduction and water quality treatment. The upturned elbow or elevated weir can also help if site conditions present daylighting issues for the underdrain's discharge elevation. Underdrains should be capped within an outlet structure when used to allow access for maintenance. The cap should be drilled

for an appropriately sized orifice to manage release rates. Figure 2 below provides an example underdrain detail. Note that all cleanouts and turns within the underdrain should not exceed 45 degrees. For lined, non-vegetated MRCs the underdrain leading to the upturned elbow should be located at the bottom of the IWS.

Figure 2: Example Underdrain Detail (courtesy of Philadelphia Water Department's *Stormwater Management Guidance Design Manual*)



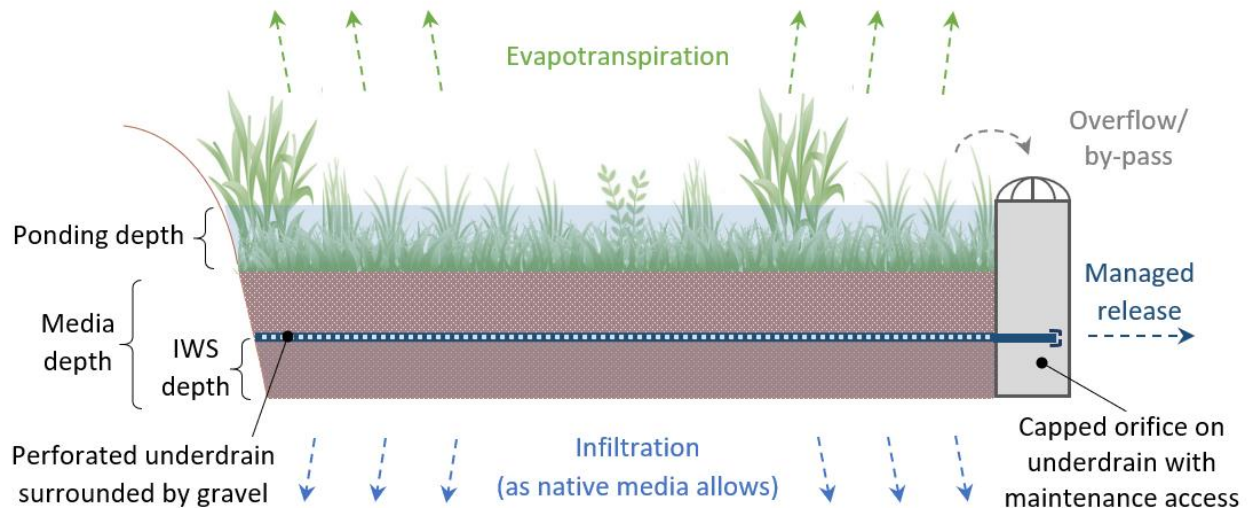
Underdrain Aggregate Envelope – A 6-inch stone envelope of AASHTO #57 should be placed around the underdrain. A geotextile (or pea gravel diaphragm) is needed around the aggregate envelope. Note that if the underdrain is placed on the bottom of the BMP, the stone should not be placed throughout the bottom of the BMP, but just in the envelope of the underdrain.

Cleanout for Underdrain – The underdrain(s) should be equipped with a clean-out for maintenance. The design of any clean-out should ensure that excess surface water does not enter the underdrain system. Consideration must be given for cleaning and inspecting underdrains and access to the upturned elbow or elevated weir.

Orifices – An appropriately sized orifice is necessary on the outlet of the underdrain to control flow to the required release rate (see Figure 3). The orifice should be clean, smooth and sanded so that no burrs or irregularities are present. The orifice should be on a plate or cap of sufficient thickness, and the edges of the orifice should be ground so that flow through the orifice is smooth. Orifices should be vertical. The orifice plate and other connections should be water-tight and accessible for maintenance. Control valves cannot be substituted for an orifice.

12. **Discharge Flow Path** – The MRC BMP should be directed to a suitably vegetated flow path, which can safely convey the releases without erosion or loss of stability. The discharge should be dispersed through the use of a level spreader. The licensed professional engineer can provide an analysis, with calculations, which identifies that a level spreader is not necessary, or that discharge to a channel will not cause increased erosion.
13. **Antidegradation Requirements** – Where the storm water from the project site discharges to a special protection surface water, an MRC BMP can be used to satisfy the Antidegradation Best Available Combination of Technologies (ABACT) regulatory requirements from Chapters 93 and 102 (assuming that non-discharge alternatives do not exist).

Figure 3: Managed Release Concept with Capped / Orifice Underdrain and Optional Control Valve Outflow with Maintenance Access for a Vegetated BMP



Water Quality

The use of a vegetated MRC BMP or porous pavement MRC BMP with adequate vacuum street sweeping maintenance regime, as per the MRC Design Standards, is a sufficient water quality demonstration and no additional water quality calculations are needed. If the proposed MRC is an underground storage chamber, then a water quality demonstration will need to be included such that the pre- or post-MRC BMP flows are shown to remove 85% of TSS (see MRC Design Standard 6.c above).

Construction Sequence

A licensed professional engineer should provide appropriate construction sequencing for the MRC BMP. Guidance should be based on the Stormwater BMP Manual to the greatest degree possible. Construction sequencing should be project-specific, but at a minimum include the following:

1. Install the MRC BMP during final phases of site construction to prevent sedimentation and/or damage from construction activity. After installation, prevent sediment-laden water from entering via overland, inlets and pipes.
2. Install and maintain proper E&S BMPs during construction.
3. If necessary, excavate the MRC BMP bottom to an un-compacted subgrade free from rocks and debris. Do NOT compact the subgrade.
4. Install outlet control structures and or reinforced spillway, pipe bedding, underdrain piping with aggregate envelope, cleanouts, etc.
5. Place soil media gently. Do not compact soil media. The placement of soil media should be done from outside the BMP footprint to avoid compaction by construction equipment. Equipment should never drive over placed soil media.
6. Seed and stabilize disturbed area. Vegetate with native plantings.
7. Maintain inlet protection and other E&S BMPs until the site is fully stabilized.

Operation and Maintenance Schedule

The licensed professional engineer should provide an appropriate long-term operation and maintenance schedule for the MRC BMP. Guidance should be based on the Stormwater BMP Manual to the greatest degree possible. The long-term operation and maintenance schedule should be project-specific. At a minimum, the long-term operation and maintenance schedule must meet 25 Pa. Code § 102.8(f)(10) and include the following:

1. Upgradient catch basins and inlets should be inspected and cleaned annually, or more often if historical maintenance records suggest a more frequent cleaning.
2. The vegetation (for the MRC BMP and contributing drainage area) should be maintained in good condition, and any bare spots revegetated.
3. Care should be taken to avoid excessive compaction by mowers. Mow only as appropriate for vegetative species.
4. Inspect at least two times per year after runoff events greater than 0.8 inch and make sure that runoff drains down within the design parameters (the licensed professional engineer should clearly identify what these parameters are).
5. At least two times per year, or more if historical maintenance indicate it is necessary, inspect for accumulation of sediment, damage to outlet control structures, erosion, signs of water contamination/spills, and instability. Leaf litter needs to be removed annually.
6. As needed, remove accumulated sediment as required to maintain infiltration through the MRCs soil media and to maintain water quality functionality. Restore original cross section. Properly dispose of sediment.
7. If porous pavement is included in the design, vacuum at least twice per year. Vacuum should have sufficient suction power and be designed for use with porous pavements.
8. All MRC BMP components should be maintained as indicated in the Stormwater BMP Manual.

As noted above, if the MRC BMP will manage peak flows in excess of the 2-year/24-hour storm event, an increased inspection and maintenance frequency will typically be necessary.

Design Example

Designers are encouraged to adapt the MRC to site-specific needs utilizing the design considerations listed above. The following example is provided to demonstrate hydrologic modeling for a vegetated MRC BMP from a pre-construction condition of completely pervious to a post-construction condition of completely impervious. The following example illustrates modeling of the contributing drainage area to the MRC BMP, modeling of MRC BMP specific processes, and interpretation of model results to show that the MRC BMP meets the design specifications for the MRC.

Modeling Contributing Drainage Area

The 1- and 2-year/24-hour storm events are modeled using NOAA-14 rainfall depths for Philadelphia, as the example site is located in the Philadelphia area, with a NOAA type C 24-hour rainfall distribution. The 1-inch runoff event is modeled using NJ DEP's water quality 2-hr distribution.

Runoff is modeled using the standard SCS unit hydrograph. The NRCS curve number for the post-construction contributing drainage area is modeled as a 98 to represent a completely impervious surface with a time of concentration of 5 minutes. Pre-construction condition is modeled with a CN of 74 to represent meadow in good condition over HSG C soil. The pre-construction condition is modeled with a time of concentration of 15 minutes.

Modeling MRC BMP Processes

Routing is performed through the basin using stage-discharge and stage-storage relationships. A schematic of pre- and post-construction conditions is shown in Figure 4. The managed release orifice is located 1 foot above the bottom of the soil media. The ponding depth during the 2-year/24-hour storm was limited for this example to 1.1 foot above the media. There is a total of 2.5 feet of media depth that includes an IWS depth of 1 foot created by an upturned elbow. A 4-inch diameter underdrain is encapsulated by gravel on all four sides, but it is not a continuous gravel layer. The MRC BMP footprint is 0.07 acre (3,049 square feet) with a contributing drainage area of 0.75 acre (32,670 square feet) of 100% impervious area. In this case, a rain garden was selected as the MRC BMP. The MRC BMP schematic and parameters are summarized in Figure 5 and Table 1, respectively.

Figure 4: Pre- and Post-Construction Modeling Conditions

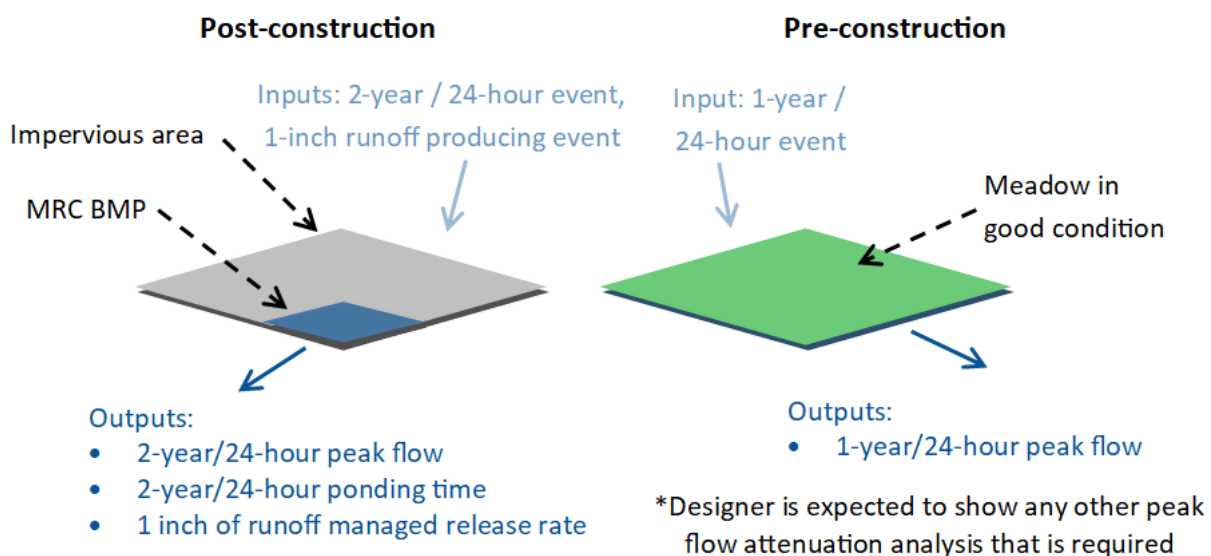


Figure 5: Design Example Schematic

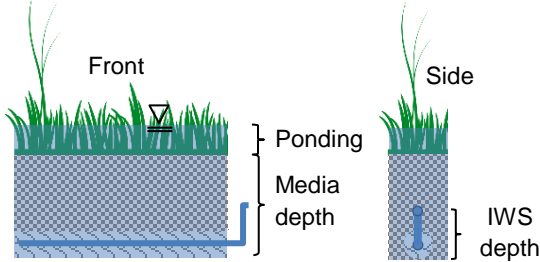


Table 1: Design Example Parameters

| Parameter | Value |
|--|-----------|
| BMP footprint area | 0.07 ac |
| Contributing area (all impervious) | 0.75 ac |
| Ponding depth | 1.1 ft |
| Media depth | 2.5 ft |
| IWS depth (included within soil media depth) | 1 ft |
| Infiltration rate | 0.1 in/hr |
| Void space | 30% |

A rain garden was selected to apply the MRC because the IWS in it will encourage ET and supply limited infiltration. A pre-development site characterization and assessment of soils and geology was conducted at the location of the MRC BMP; which identified a depth greater than 2 feet to groundwater and a design infiltration rate of 0.1 in/hr. For routing purposes, a 30% void space was used to model the soil media to mimic the amount of soil storage recovery through ET and infiltration. The starting water surface elevation of ½ of total IWS depth below the lowest orifice was used for routing.

Modeling Results

Modeling results are presented below as determined through the use of HydroCAD®. Figure 6 shows the maximum managed release outflow and water surface elevation from the 1-inch runoff event and was obtained by plotting outflow and water surface elevation over time. A maximum of 0.01 cfs is obtained through the managed release outflow.

Figure 6: Design Example Results for the 1-inch Runoff Event

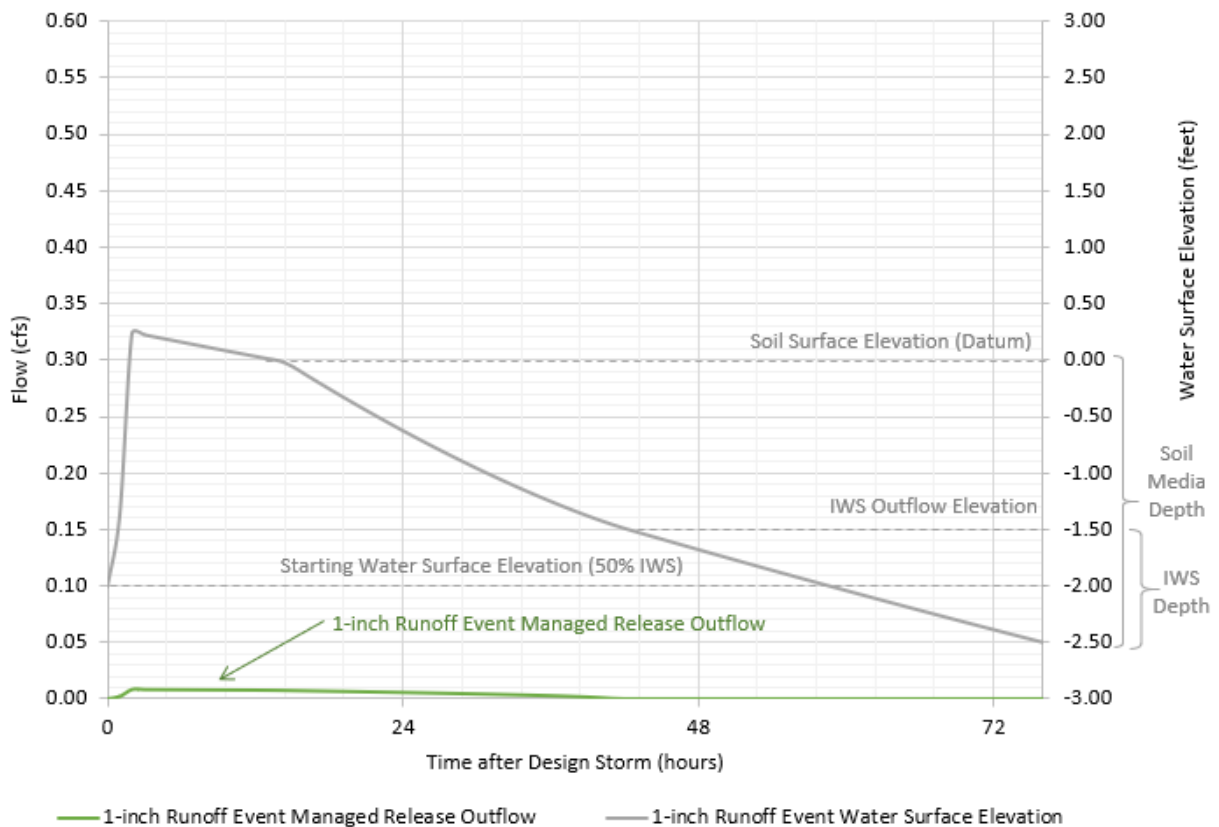
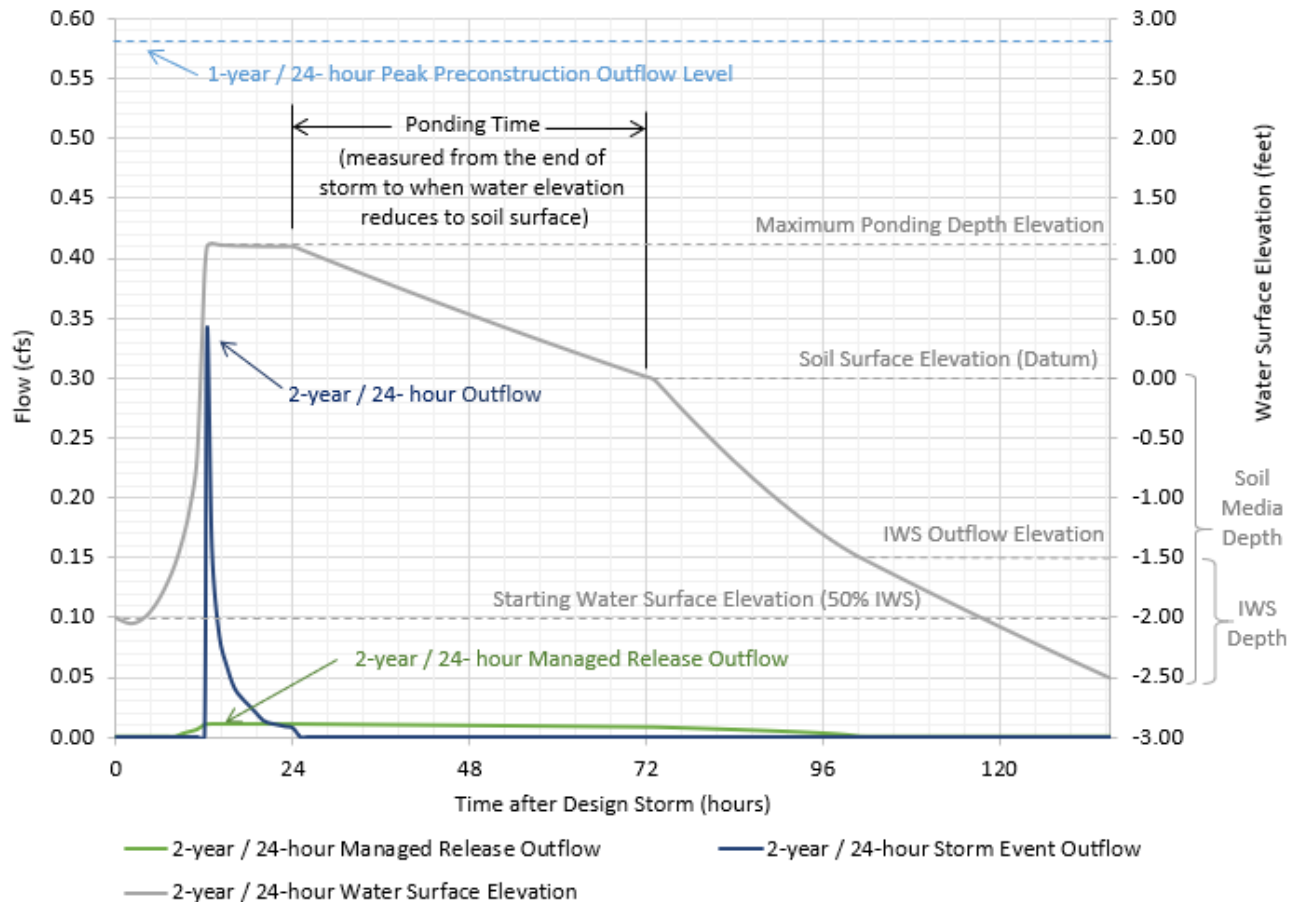


Figure 7 shows the maximum flow for the 2-year/24-hour storm, the managed release outflow for the 2-year/24-hour storm, and the ponding depth during and after the 2-year/24-hour storm. Pre-construction peak flow from the 1-year/24-hour storm event was determined to be 0.58 cfs.

Figure 7: Design Example Results for 2-year/24-hour Storm Event



Key parameters used to demonstrate compliance with the MRC Design Standards are presented in Table 2 for this example.

- The volume managed through the underdrain by release was determined by multiplying the managed release rate (cfs) by the duration of the managed release flow (seconds), and was determined to be 2,648 cubic feet (cf) or 0.97 inch over the contributing drainage area (0.75 acre). This value can also be determined by calculating the area under the 2-year/24-hour Managed Release Outflow curve in Figure 7. This particular example used the hydrograph (values in cubic feet per second outputted in hourly intervals) produced by the HydroCAD® model for the release managed through the underdrain. The rates were summed and multiplied by 3,600 to convert into cubic feet over the duration of managed release (about 93 hours).
- The volume reduced through infiltration was determined by multiplying the infiltration rate (in/hr) by the duration of infiltration and was determined to be 4,361 or 1.6 inch over the contributing drainage area. This particular example used the hydrograph (values in cubic feet per second outputted in hourly intervals) produced by the HydroCAD® model for the infiltration. The rates were summed and multiplied by 3,600 to convert into cubic feet over the duration of infiltration (about 171 hours).
- The volume reduced through ET is calculated with a void space of 10% over the full depth of the soil column of 2.5 feet, reducing 762 cf or 0.28 inch over the contributing drainage area.

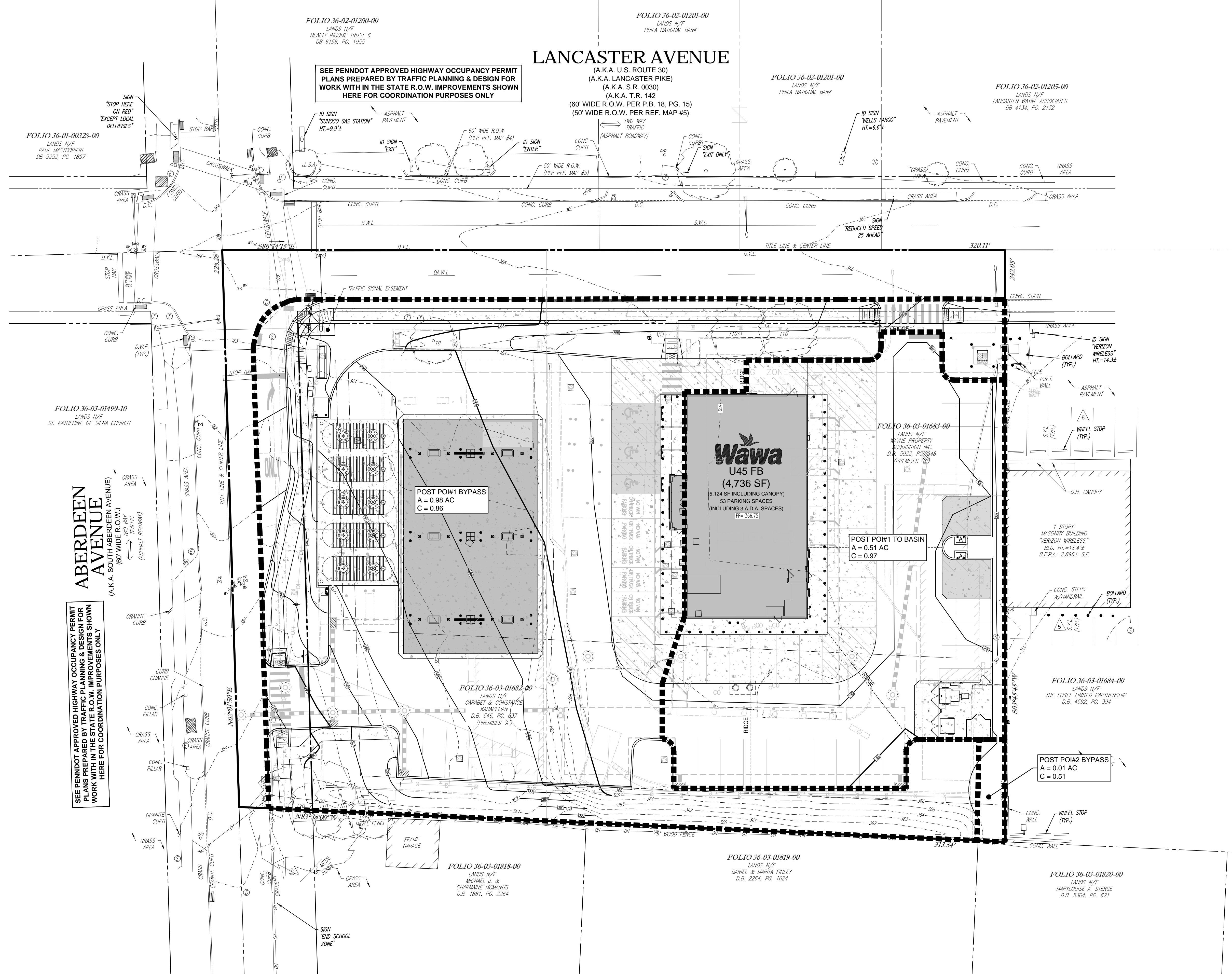
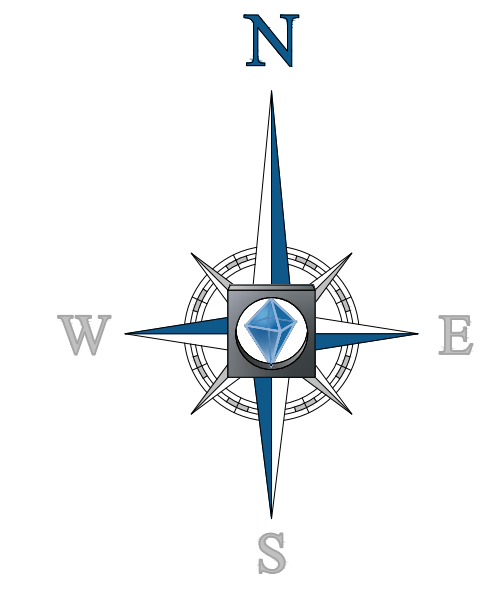
- The total 2-year/24-hour runoff volume permanently removed by the MRC BMP is the sum of the volume reduced by infiltration + the volume reduced through ET and was determined to be 5,124 cf or 1.88 inches over the contributing drainage area.
- The total 2-year/24-hour runoff volume managed by the MRC BMP is the sum of the volume managed through underdrain release + the volume reduced by infiltration + the volume reduced through ET and was determined to be 7,772 cf or 2.85 inches over the contributing drainage area.

Table 2: Design Example Summary for 2-year/24-hour Storm Event

| Parameter | Design Example Value | Design Standard |
|--|-----------------------------|---|
| Ponding Time @ 2-Year/24-Hour Storm (hrs) | 48 hrs | <i>72 hrs max</i> |
| MRC BMP Release Rate (cfs) | 0.01 cfs | <i>No greater than 0.01 cfs / acre of contributing impervious</i> |
| 2-Year/24-Hour Post-Development Peak Rate (cfs) | 0.34 cfs | <i>1-Year/24-Hour Pre-Development Peak Rate (or per approved Act 167 Plan) (0.58 cfs)</i> |
| Volume managed through underdrain and volume removed | 2.8 in | <i>1-in for new impervious surfaces, ½-in for disturbed areas with 50% or more pervious</i> |
| a. Total 2-Year/24-Hour Runoff Volume Managed by BMP (cf) | 7,772 | <i>Net Change (Δ 2 volume)</i> |
| b. Total 2-Year/24-Hour Runoff Volume Permanently Removed (cf) | 5,124 | |
| c. 2-Year/24-Hour Volume Managed Through Release (cf) | 2,648 | <i>Difference of a. and b.</i> |

Along with the hydrologic modeling demonstration of the MRC, peak flow attenuation analysis from the 10-, 50- & 100-year/24-hour storm events along with the Pre-Development Site Characterization and Assessment of Soil and Geology and the Discharge Flow Path analysis must be provided.

Drainage Area Maps



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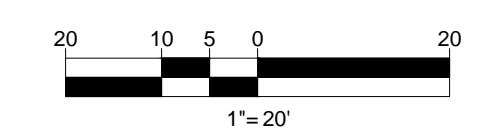
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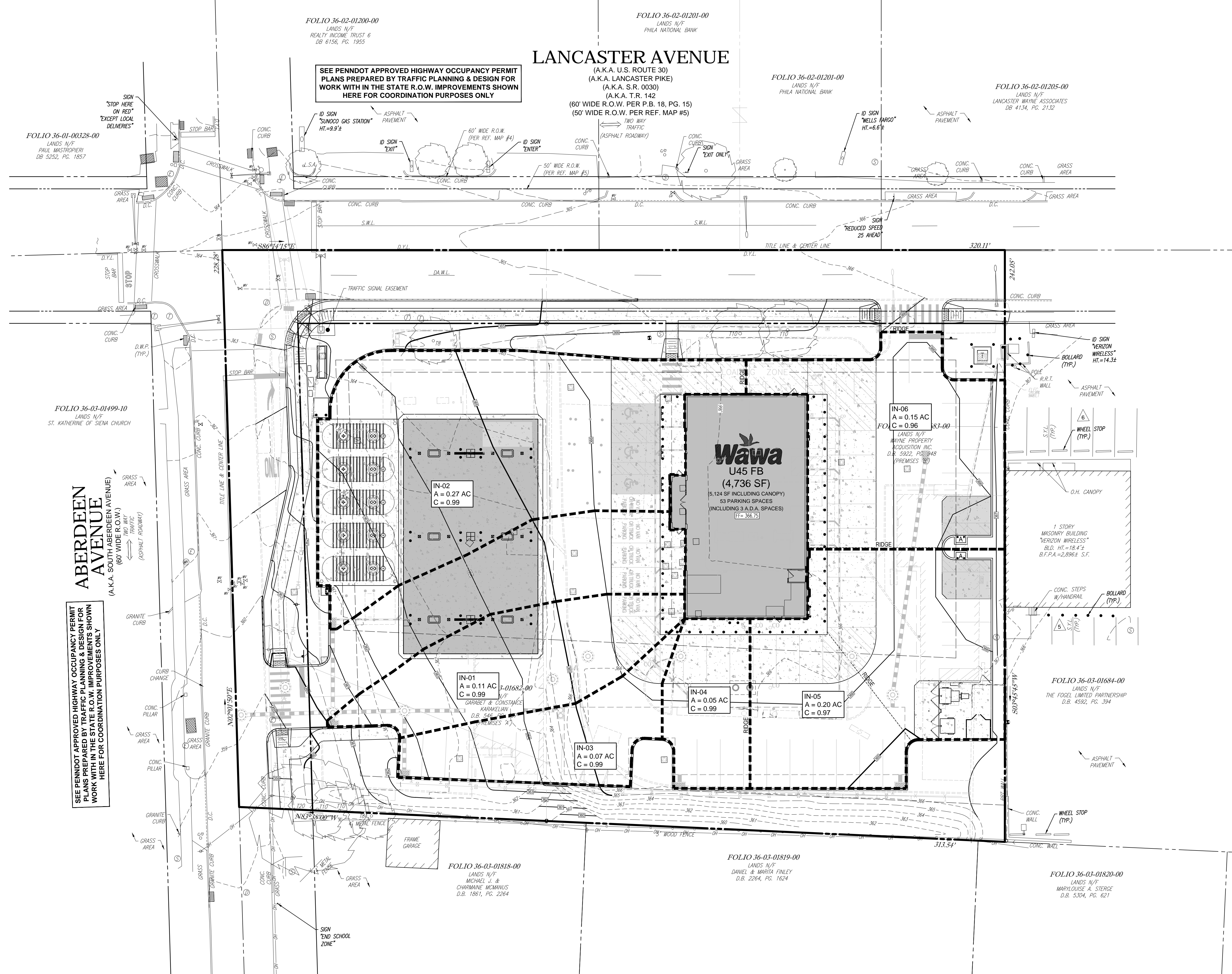
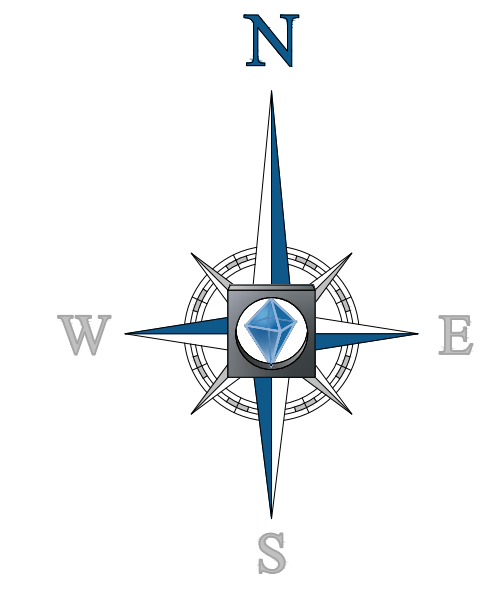
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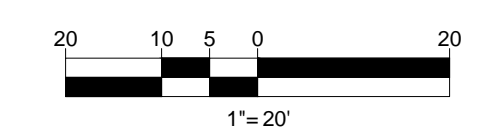
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