Stormwater Management Report
Woods Hole Oceanographic Institution
Quissett Campus Site Expansion

360 Woods Hole Road
Woods Hole, MA 02543

Submitted on behalf of:
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1.0 Introduction

This report describes the hydrologic and hydraulic analysis for the proposed site expansion to the Quissett Campus facility owned by the Woods Hole Oceanographic Institution located in Woods Hole, MA. Development at Quissett Campus includes several institutional and laboratory buildings with interconnecting pedestrian paths and vehicular driveways and parking lots. The facility's main access is through an entrance driveway off Woods Hole Road to the west of the property. Two alternate entrances from Oyster Pond Road to the east also provide full site access. Approximately 124 acres of land area is contained within the property. Stormwater runoff is managed on-site with a series of collection structures and disposal measures. This report accompanies a set of drawings that represent the proposed site improvements and stormwater treatment system, and a set of calculations that identify the stormwater runoff flows and capacity analysis of the receiving facilities. The following narrative briefly describes the intended site improvements, as it relates to stormwater management.

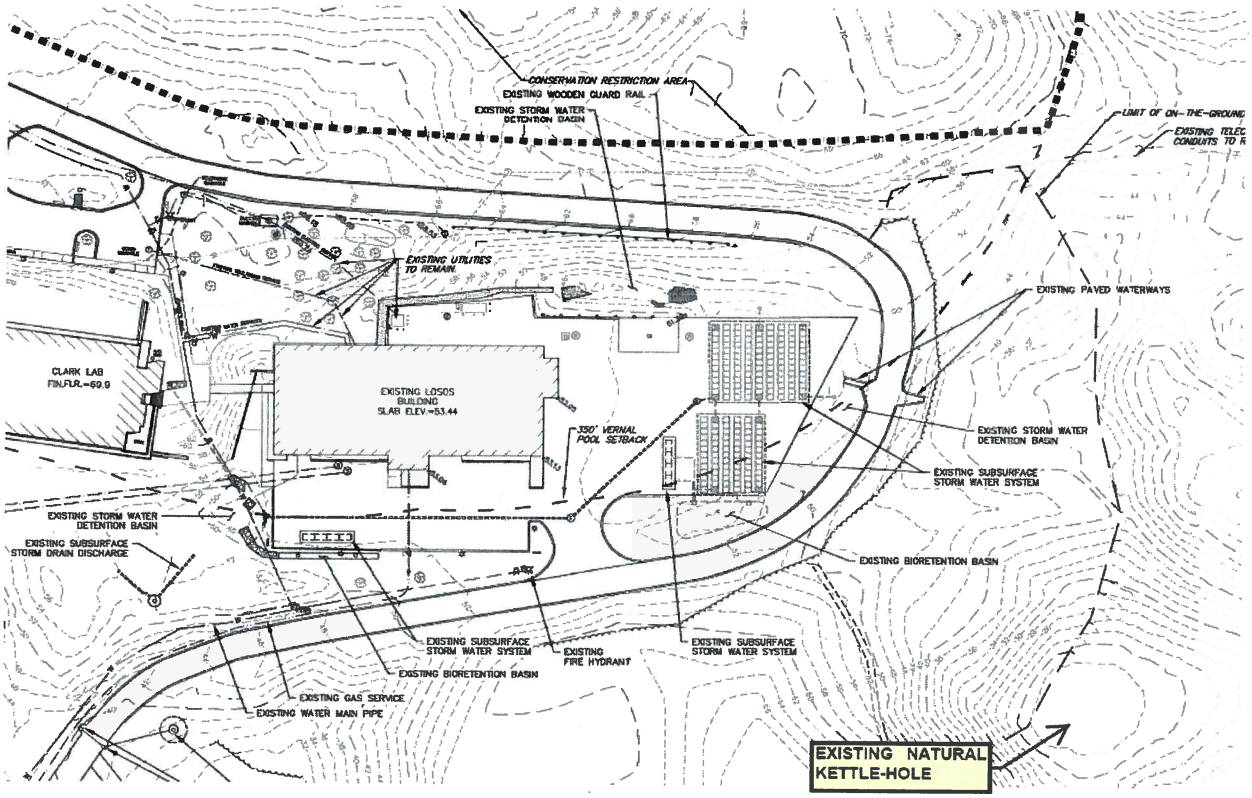
1.1 Existing Site

Approximately four acres of land is proposed to be impacted by the proposed site expansion. The work area include undeveloped woodland northeast of the existing LOSOS Laboratory loading/staging paved area and Ring Road East which is the main campus driveway along the north portion of the site. The entire four acres within the work area is currently woodland. The existing topography include several depression that currently receive stormwater from a portion of Ring Road East.

In terms of Stormwater analysis the four acres for the proposed work is within a larger contributing drainage area of approximately 9.8 acres which includes portion Ring Road East and undeveloped woodland. Existing woodland is dominated with pine and oak trees with dense underbrush. There are no wetland resources within the project area or within one hundred feet (100') of the proposed work area. There two vernal pools located approximately 350-feet west of the proposed work area. The property is not located within a DEP approved Zone II for a public water supply. As proposed, the re-development should pose no adverse effects to the nearby vernal pools or the environment.

Most of the contributing drainage area is undeveloped woodland of approximately 9.6 acres. The remaining developed 0.2 acre area consists of the outer portion of Ring Road and is managed with a paved spillway discharging into a natural depression. Two natural depressions which includes one substantial sized kettle-hole contain storm runoff preventing off-site discharges. One of the natural depressions is contributing to the vernal pool located north of the development. The existing large kettle-hole has a bottom grade elevation of approximately 18-feet and a rim elevation above 38-feet with a volume holding capacity in excess of 530,000 cubic feet (4 million gallons). Overflow storm runoff from other depressions and from portion of Ring Road East would reach the existing kettle-hole where the water will be absorbed into the groundwater system.

Site geology has been mapped as being part of a glacial till (ground moraine). In specific, the soils contained for the majority of the site area is mapped as Barnstable-Plymouth Complex (soil map unit 488C) with some soils mapped as Plymouth Barnstable complex (soil map unit 484D) to the east side. Soil tests performed on site revealed a random and varying soil profile. Encountered soils correspond to textural classes of friable to loose sandy loam and loamy sands. The soil tests confirm the presence of gravelly sands as the parent material below the upper soil horizons. These soils are designated hydrologic group Class A and a drainage class of well to excessively drained soils as it was confirmed by the observations during soil testing. From referenced information, saturated soil hydraulic conductivity typically ranges from 4 to 13 inches per hour, in/hr. (28 to 92 μm/sec) within the topsoil and ranging from 13 to 20 in/hr. (92 to 141 μm/sec) for the substratum parent soil material, depending on the predominant soil textural class. Permeameter tests performed on site at five different locations measured saturated hydraulic conductivity of 80.7, 71.4, 14.7, 79.7 and 16.4 in/hr. Groundwater was not encountered during soil testing but based on groundwater monitoring wells in the vicinity of the site the groundwater level is estimated at elevation 7-feet North American Vertical Datum (NAVD88). The proposed drainage analysis and design incorporates these findings.

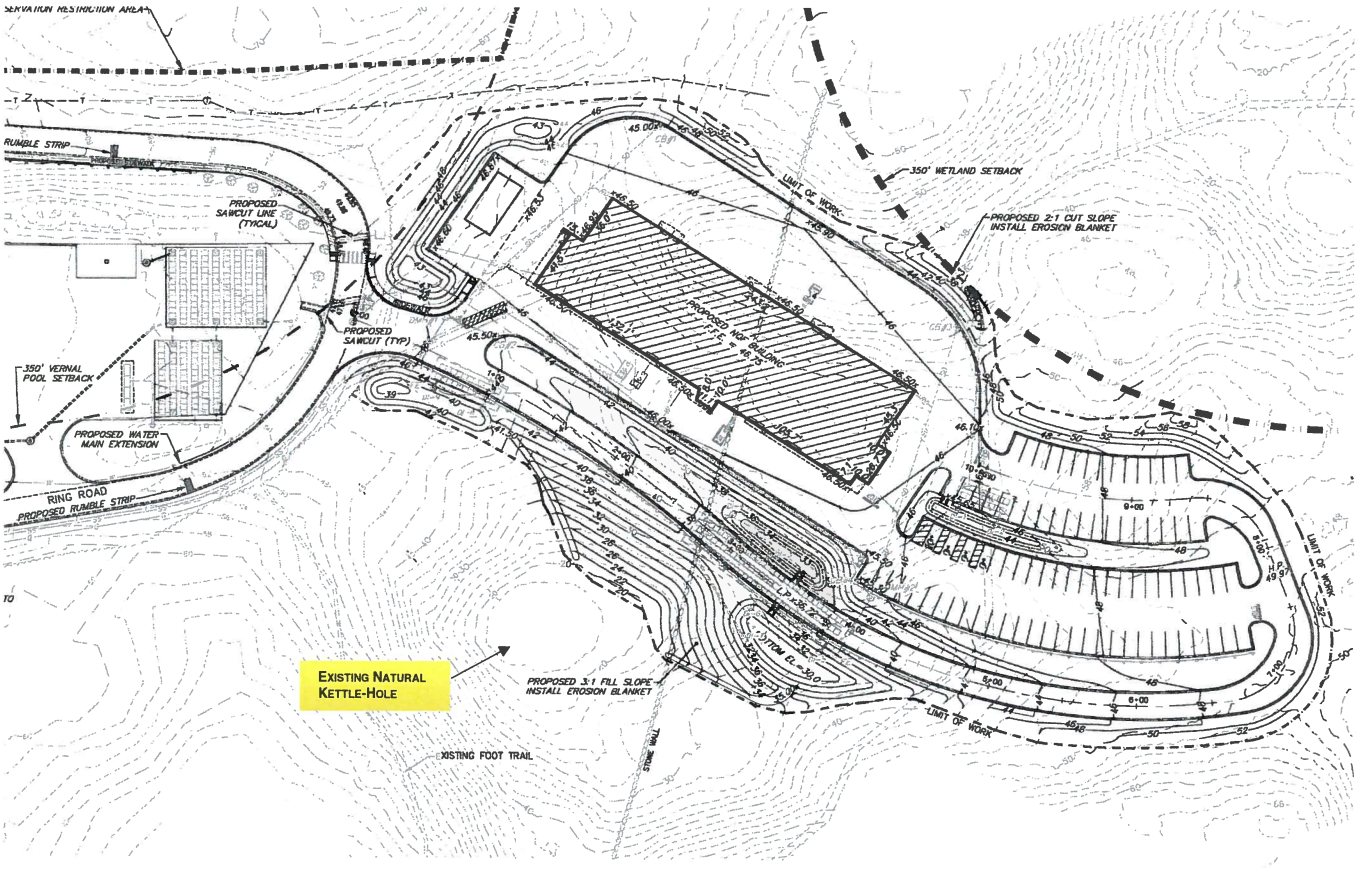


EXISTING DEVELOPMENT

1.2 Proposed Development

The Wood Hole Oceanographic Institution (WHOI) proposes to expand the campus by constructing a new building (NQF) of approximately 20,000 square feet in footprint area. The proposal includes a bituminous concrete pavement driveway and parking lots to accommodate the uses on the site. The proposed paved access driveway, parking lots and walkways cover an area of approximately 87,000 sq.ft. The project is designed to contain the stormwater runoff volume within the site without off-site discharges.

As previously mentioned the proposed site improvements is within a drainage contributing area of approximately 9.8 acres in size. Overall runoff patterns will remain the same given the topography of the site which contains a destination point in the form of a kettle hole. Several rain-gardens are proposed to manage the more frequent rain events of low intensity and to provide storm runoff quality treatment prior to final discharge. Also, several subsurface leaching systems are proposed to manage some runoff volume by allowing infiltration into the subsoil. Primary stormwater management for less frequent with greater intensity rain storms is provided by the volume holding capacity of the existing kettle hole. Daylight drains and an overflow spillway will discharge onto constructed stone splash pads and stone waterways to protect against soil erosion leading runoff into the kettle hole.



PROPOSED DEVELOPMENT

The proposed development will increase impervious surfaces within the contributing drainage area. Currently there is 8,310 square feet of impervious area discharging into woodland thru existing paved waterway on Ring Road. Approximately 107,000 square feet in impervious area is proposed. The surface runoff from this area is proposed to discharge into retention basins and subsurface leaching systems prior to final discharge into existing kettle hole. Drainage systems have been designed to control the 25-year 24-hour design storm event (see enclosed HydroCAD analysis). A portion of the existing kettle hole will be regraded along the south-eastern portion due to proposed development. After site improvements the volume holding capacity of the kettle hole will be reduced by 10% to approximately 480,000 cubic feet (3.6 million gallons).

The proposed stormwater runoff management provides peak runoff attenuation, total suspended solids (TSS) removal, and groundwater recharge. The pre-treatment system components in the form of rain-gardens, solid catch basins and subsurface leaching systems are properly sized to accommodate the first flush of stormwater runoff (refer to calculations below). The proposed stormwater systems shall be maintained and inspected in accordance to the Operation and Management Plan (O&M) provided for proper operation.

2.0 Stormwater Quality Analysis

Runoff water from the development, primarily impervious surfaces, carries pollutants that can be harmful to the environment without treatment. It is the initial stormwater flush that carries the majority of the pollutants as rainwater washes the surfaces. The proposed design of the drainage system for the adjacent LOSOS building implements rain-gardens and subsurface leaching systems as pre-treatment components and as means for groundwater recharge. The proposed NGQ drainage design will also implement the same techniques and practices. Rain gardens, subsurface leaching systems and basins for this development are designed to account for the treatment of the water quality volume from storm runoff ("first flush"). These components are not intended to completely control the storm runoff volume from less frequent and higher intensity storm events such as the 50 and 100-year design storms. The main stormwater management system is the existing kettle hole which after the proposed site improvements will have a holding volume capacity in excess of 480,000 cubic feet (3.6 million gallons) as mentioned above. Overflow and inlet structures will by-pass storm runoff volume from high intensity storms out of the pre-treatment components with daylight discharge towards the kettle hole.

Stormwater volume collected within the rain gardens and subsurface leaching systems will be infiltrated into the ground. Four rain gardens and one detention basin proposed for portions of paved areas have volume storage capacity of 2,929, 646, 4,399, 1,076 and 797 cubic feet. These holding capacities do not account for soil infiltration which means that there is physically a greater volume capacity within these systems. All the surface runoff from paved areas will be routed into rain gardens and subsurface leaching systems for pre-treatment. The quality volume for pre-treatment is being calculated as 1-inch of runoff over impervious areas. The use of computer modeling software (HydroCAD) assisted in the storage stage analysis and pooling water levels for the analysis below. The calculations below demonstrate that the proposed pre-

treatment systems provide a capacity that exceeds the first flush of runoff calculated as one-inch over impervious surfaces.

2.1 Stormwater Quality Volume (Vwq) calculations

Total Impervious Area within contributing drainage area.

Impervious areas (including existing, proposed pavement and roof areas) = 115,195 square feet

Target quality volume = 1 inch x (1 foot / 12 inches) x 115,195 s.f. = 9,600 cubic feet

2.2 Water Quality Volume (Vwq) calculations

2.2.1 Water quality volume for Bioretention Basin A

Impervious paved area, Ai = 34,763 sq. ft.

Vwq = 1-inch / 12 x Ai = 1 x (1/12) x 34,763 = *2,897 cubic feet (c.f.)*

Bottom elevation of depression = 39.0 feet, (subsurface inlet grate elev. = 41.50 feet)

Storage volume (HydroCAD) = 2,929 c.f. @ elevation 41.50 feet (30" water depth)

2.2.2 Water quality volume for Bioretention Basin B

Impervious paved area, Ai = 7,362 sq. ft.

Vwq = 1-inch / 12 x Ai = 1 x (1/12) x 7,362 = *614 c.f.*

Bottom elevation of depression = 33.0 feet, (subsurface inlet grate elev. = 34.30 feet)

Storage volume (HydroCAD) = 646 c.f. @ elevation 34.3 feet (16" water depth)

2.2.3 Water quality volume for Bioretention Basin C

Impervious paved area, Ai = 52,277 sq. ft.

Vwq = 1-inch / 12 x Ai = 1 x (1/12) x 52,277 = *4,356 c.f.*

Bottom elevation of depression = 30.0 feet, (subsurface inlet grate elev. = 33.00 feet)

Storage volume (HydroCAD) = 4,399 c.f. @ elevation 33.0 feet (36" water depth)

2.2.4 Water quality volume for Bioretention Basin D

Impervious paved area, Ai = 12,353 sq. ft.

Vwq = 1-inch / 12 x Ai = 1 x (1/12) x 12,353 = *1,029 c.f.*

Bottom elevation of depression = 44.0 feet, (subsurface inlet grate elev. = 45.30 feet)

Storage volume (HydroCAD) = 1,209 c.f. @ elevation 45.3 feet (16" water depth)

2.2.5 Water quality volume for Detension Basin E

Impervious paved area, Ai = 8,657 sq. ft.

Vwq = 1-inch / 12 x Ai = 1 x (1/12) x 8,657 = *721 c.f.*

Bottom elevation of depression = 43.0 feet

Storage volume (HydroCAD) = 797 c.f. @ elevation 43.8 feet (10" water depth)

Bottom area (rain gardens and forebay basin), Ab = 485+302+916+546+533=2,782 sq.ft.

Rawl's rate, loamy sand (Ks) = 2.41 in / hr

Drawdown time = Rv x 12/(Ab x Ks) = 9,600 x 12/(2,782 x 2.41) = 17.2 hours < 72 hrs. OK

Impervious Area within contributing drainage area with discharges into pre-treatment.

Paved Area with discharge into rain garden A

NQF Building and pavement areas = 34,763 square feet

Rain Garden "A" storage capacity to 30-inches depth = 2,929 cubic feet

Treatment depth equivalent of paved areas = 2,929 c.f. x 12 inch/foot / 34,763 s.f. = 1.01 inches

Paved Area with discharge into rain garden B

Inner half of proposed paved access driveway = 7,362 square feet

Rain Garden "B" storage capacity to 16-inches depth = 646 cubic feet

Treatment depth equivalent of paved areas = 646 c.f. x 12 inch/foot / 7,362 s.f. = 1.05 inches

Paved Area with discharge into rain garden C

NQF Building, pavement areas and outer half of proposed access driveway = 52,277 square feet

Rain Garden "C" storage capacity to 36-inches depth = 4,399 cubic feet

Treatment depth equivalent of paved areas = 4,399 c.f. x 12 inch/foot / 52,277 s.f. = 1.01 inches

Paved Area with discharge into rain garden D

Proposed rear paved parking lot = 12,353 square feet

Rain Garden "D" storage capacity to 14-inches depth = 1,076 cubic feet

Treatment depth equivalent of paved areas = 1,076 c.f. x 12 inch/foot / 12,353 s.f. = 1.04 inches

Paved Area with discharge into rain garden E

Inner half of existing Ring Road = 8,657 square feet

Rain Garden "E" storage capacity to 10-inches depth = 797 cubic feet

Treatment depth equivalent of paved areas = 797 c.f. x 12 inch/foot / 8,657 s.f. = 1.10 inches

Summary:

Target (recommended) quality volume = 9,600 cubic feet

Total quality volume provided = 2,929 + 646 + 4,399 + 1,076 + 797 = 9,847 cubic feet

2.3 TSS Removal Calculations

Although the proposed systems provide TSS removal, the final discharge from these drainage areas does not reach any wetland or body of water since it is fully recharged into the ground within the property limits. Therefore suspended solids are not going to impair surface waters. However, the systems include rain-gardens, deep sump solid catch basins and detention basins that provide 80% TSS removal (referencing Mass DEP Stormwater Management Handbook) prior to overflow discharges (for extreme storms) into the kettle hole or to the wooded land for the case of the norther parking lot.

3.0 Stormwater System Capacity Analysis

As described above storm runoff can carry pollutants from paved surfaces. The proposed pre-treatment systems in the form of rain gardens and detention basin will manage and initial volume equivalent to the recommended quality volume. However certain occasional rain storm events can produce runoff volume in excess of that calculated for the quality volume. For that reason the proposed stormwater system includes overflow structures and inlets with daylight discharge drains towards the existing kettle hole. The kettle hole is the final destination for runoff of large storm events similar to several other kettle holes within Quissett Campus that are being used as stormwater destination areas. So overflow runoff volume from the proposed rain gardens and subsurface leaching systems will be discharging into the kettle hole to manage high intensity storm events. The kettle hole volume holding capacity is large enough to manage the calculated volume of the 50-year and 100-year 24-hour design storm at a water depth of less than eighteen inches (24"). The following sections compare the Stormwater management system behavior due to runoff volume from high intensity design storm events with the designed system holding capacities.

3.1 System Quantity Volume Capacity

The use of computer software (AutoCAD and HydroCAD) was implemented to determine the volume holding capacity of the system. As illustrated in the table below, the rain gardens and subsurface leaching systems are large enough to manage the quality volume and the existing kettle-hole volume capacity is more than capable of containing the quantity volume. The kettle-hole capacity of 480,000 cubic feet can hold volume equivalent to over four-feet of runoff over the proposed 115,195 square feet impervious surfaces. The true capacity of the system is even greater given the fact that naturally the soils will leach water into the ground as part of the groundwater recharge process (the process of infiltration was only considered in the quality/quantity analysis for recharge in less than 72 hours).

3.2 High Intensity Design Storm Analysis

As stated above it is a requirement by the Town of Falmouth bylaws that Stormwater management systems be designed to control the 25-year frequency design storm. To achieve this condition the drainage system size is set to contain the volume of water produced by this high intensity design storm. The analysis is based on allowing the rainfall volume to infiltrate into the surrounding soils through its surface area based on the recommended Rawl's rate for saturated hydraulic conductivity for loamy sand soils of 2.41 inches/hour and sandy soils of 8.27 inches/hour. However there is the probability that the site may experience a higher intensity rainstorm event in which case daylight pipes and/or overflow spillways will discharge runoff volume from high intensity storms towards the existing kettle hole. Refer to enclosed calculations, Appendix SW-C.

4.0 Construction Period Controls

Proper control measures during the construction stages of this project are needed to prevent erosion and sedimentation problems. Open excavations, stockpiled material and equipment storage shall be properly managed to avoid conditions that may be detrimental to the project. Equipment and machinery mobilization throughout the construction period within the site should also be properly managed.

4.1 Erosion and Sedimentation Control Plan

The Erosion and Sedimentation Control Plan includes the following:

1. The Installer shall examine the work area and site conditions under which this work is to be performed prior to installation of sedimentation and erosion control.
2. Establishing and maintaining the limit of work and sedimentation controls throughout the duration of the work and prior to performing any clearing and excavation activities on the site.
3. The contractor shall construct the "Entrance Protection Pad" at entrances to and from paved roads. All construction site vehicles exiting the work site shall use the "Stone Tracking Pad" to avoid tracking sediment off-site. The contractor shall remove all sediments spilled, dropped, washed or tracked onto public ways.
4. The Contractor shall stabilize all graded and/or disturbed areas by installing loam and seed at the earliest time possible to prevent erosion and sedimentation.
5. The Contractor shall implement supplemental drainage and erosion control measures (such as temporary swales, stone checks, seeding or mulching) as may be necessary during the course of the construction based on changes of stormwater runoff patterns.
6. After every rainstorm during construction the Contractor shall examine the conditions of all the erosion and sedimentation controls and perform any required repairs or replacements.
7. The Contractor shall retain an additional 200 linear feet of silt fence on site in the event erosion occurs. If erosion occurs during construction the Contractor shall take steps to control the erosion and mitigate the damaged areas.

8. The Contractor shall remove all land clearing waste material (brush, stumps, wood, leaves, chips, etc.) during construction from site and properly transport it to an approved disposal site or chip and spread it on site as required. The Contractor shall not mix land clearing waste material with other construction activities waste material.
9. All excavated areas rendering a slope greater than 3 horizontal to 1 vertical (3:1) shall be stabilized with the installation of erosion control matting.
10. Topsoil stripped from areas to be graded shall be stockpiled at locations approved by the project engineer and shall not cause damage to the sedimentation and erosion controls.
11. All unsuitable and excessive material not intended for reuse or re-purpose within the site shall be stripped from areas impacted by construction and disposed of off-site.
12. Excavated material or imported material shall not be piled in areas where sediments may damage the existing stormwater system on the site.
13. The Contractor shall implement measures to control dust levels by means such as water truck spraying during construction until all disturbed areas are stabilized.
14. Stabilization for paved areas shall be achieved by installing the gravel base immediately after the rough grading and sub-base compaction is complete.
15. The Contractor shall avoid smearing the bottom levels or face walls of the excavation for subsurface leaching systems and bio-filtration systems. The contractor shall scarify any areas where smearing occurs to provide adequate filtration through the soils.
16. The Contractor shall avoid using dirty or silty crushed stone for the construction of the subsurface leaching systems. Instead the Contractor shall use double washed crushed stone for these components.
17. All protective measures (i.e.: silt sacs, hay bale dams, etc.) installed in the vicinity of the construction site to protect existing stormwater systems shall be removed once the disturbed areas are stabilized.

5.0 Operation and Maintenance Plan

A properly operating drainage system is the basis for long life of the driveways and parking areas and for the protection of wetland resources against pollutants carried by stormwater. If the drainage system fails to work, frequent pooling of stormwater would be expected to occur along the pavement surface leading to saturation of the gravel base and shortening the life expectancy of the pavement. The owner or owner's representative is responsible for the maintenance and operation of the drainage systems.

The owner shall maintain a copy of the Site Plan or other drawings depicting the locations of all of the stormwater system components. Only personnel authorized by the owner shall maintain and operate the drainage system.

5.1 Preventive Measures

The owner shall implement the following long-term pollution prevention measures:

1. The drainage system is intended for the interception of rainfall precipitation, snowmelt runoff and occasional landscape irrigation. No other discharges shall be allowed within the systems unless reviewed by the appropriate trade professional for conformance with the design parameters of the system.
2. Proper driveway, and parking pavement maintenance shall be performed without harming the drainage system. The owner shall properly manage snow and ice on the road. Snow or ice removal shall not obstruct the stormwater inlets and outlets
3. Lawns, gardens and landscape maintenance clippings and refuse shall be properly disposed of. Dumping of yard waste should not be allowed within the drainage systems.
4. The owner shall contact a contractor who specializes in spill clean-ups in the event of spills into any of the drainage system.

5.2 Inspections and Procedures

To provide for adequate maintenance of the drainage system, the following inspections and procedures will be required:

1. The proposed riprap/stone and paved waterways should be kept clean by removing any debris that may collect on the surface or any obstruction that may prevent the proper functioning and water flow of the system.
2. The proposed crushed stone splash pads should be kept clean by removing any debris that may collect on the surface.
3. Inspect catch basins after every major storm event (typically a storm of one inch of rainfall) and at least once a year. Inspection will include measuring the depth of silt and sediment collected in the sump of the structure, visually inspect the condition of the grease trap and outlet piping.
4. If the depth of silt and/or sediment inside the catch basin reaches half the distance from the bottom of the structure to the outlet, the structure should be cleaned of all debris.
5. If puddles form on the surface of the catch basin, inspect the outlet piping for the presence of clogging or obstruction. If clogging or an obstacle exists within the pipe, arrange for the piping to be cleaned.
6. Vegetated drain basins (rain gardens) should be inspected at least once a year and after every major storm (larger than one inch of rainfall) to observe accumulation of sediments. If a depth of sediments of over 4 inches is noticed the owner shall arrange for a contractor to properly remove the accumulated sediments.
7. Remove any debris accumulation within the vegetated drain basins (rain gardens). Spread new mulch on a yearly basis to maintain the upper layer of the vegetated basin. If pooling remains after 72 hours following a storm event remove and properly dispose of the upper layer of mulch, scarified and aerate the soil surface to increase permeability and replace with new layer of mulch on top. No need to remove established shrubs or trees within the system.
8. If standing water is observed within the rain gardens above the rim inlet 24 hours past a storm event, inspect the outlet piping for the presence of an obstruction. If clogging or an

obstacle exists within the pipe, arrange for the piping to be cleaned. If pooling persists and no apparent clogging is present refer to leaching system inspection.

9. At leaching systems locations, inspect the system by removing the cover and inspecting the interior. Measure the depth of standing water and compare to the actual depth of the structure. If the standing water is greater than half the depth of the structure, the leaching system shall be cleaned and inspected on a monthly basis. The leaching system is considered in failure when pooling occurs at the inlet structure serving the leaching system and investigation has determined no apparent clogging or obstructions within the drainpipe. To repair this situation, a contractor shall be hired to install the same size system in an adjacent area to the leaching system in failure, subject to subsurface soil investigations concerning permeability. The contractor shall connect the new system to the old failed system's inlet with the same size pipe and slope that currently exists.

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TSS Removal Calculation Worksheet

Name: NQF Building

Location: 360 Woods Hole

Proj. No.: 219029
Date: 8/15/2019
Computed by: LAC
Checked by:

Subarea A (0.991 ac) A BMP	B TSS Removal Rate	C Starting TSS Load*	D Amount Removed (BxC)	E Remaining Load (C-D)
Parking Lot Sweeping	10	1.00	0.1	0.90
Deep Sump Catch Basins	25	0.90	0.23	0.68
Extended Detention Basin	70	0.68	0.47	0.20

Total TSS Removal= **80%**

Notes:
*Starting TSS Load for first BMP= 1.00. TSS load for subsequent BMP's is equal to the Remaining Load (E) from the previous BMP.

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TSS Removal Calculation Worksheet

Name: NQF Building

Location: 360 Woods Hole

Proj. No.: 219029
Date: 8/15/2019
Computed by: LAC
Checked by:

Subarea B (0.54 ac)	A BMP	B TSS Removal Rate	C Starting TSS Load*	D Amount Removed (BxC)	E Remaining Load (C-D)
	Parking Lot Sweeping	10	1.00	0.1	0.90
	Forebay Filter	25	0.90	0.23	0.68
	Extended Detention Basin	70	0.68	0.47	0.20

Total TSS Removal= **80%**

Notes:
*Starting TSS Load for first BMP= 1.00. TSS load for subsequent BMP's is equal to the Remaining Load (E) from the previous BMP.

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TSS Removal Calculation Worksheet

Name: NQF Building

Location: 360 Woods Hole

Proj. No.: 219029
Date: 8/15/2019
Computed by: LAC
Checked by:

Subarea C (1.941 ac) A BMP	B TSS Removal Rate	C Starting TSS Load*	D Amount Removed (BxC)	E Remaining Load (C-D)
Parking Lot Sweeping	10	1.00	0.1	0.90
Deep Sump Catch Basins	25	0.90	0.23	0.68
Forebay Filter	25	0.68	0.17	0.51
Extended Detention Basin	70	0.51	0.35	0.15

Total TSS Removal= **85%**

Notes:

*Starting TSS Load for first BMP= 1.00. TSS load for subsequent BMP's is equal to the Remaining Load (E) from the previous BMP.

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TSS Removal Calculation Worksheet

Name: NQF Building

Location: 360 Woods Hole

Proj. No.: 219029
Date: 8/15/2019
Computed by: LAC
Checked by:

Subarea D (0.485 ac) A BMP	B TSS Removal Rate	C Starting TSS Load*	D Amount Removed (BxC)	E Remaining Load (C-D)
Parking Lot Sweeping	10	1.00	0.1	0.90
Forebay Filter	25	0.90	0.23	0.68
Extended Detention Basin	70	0.68	0.47	0.20

Total TSS Removal= **80%**

Notes:
*Starting TSS Load for first BMP= 1.00. TSS load for subsequent BMP's is equal to the Remaining Load (E) from the previous BMP.

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TSS Removal Calculation Worksheet

Name: NQF Building

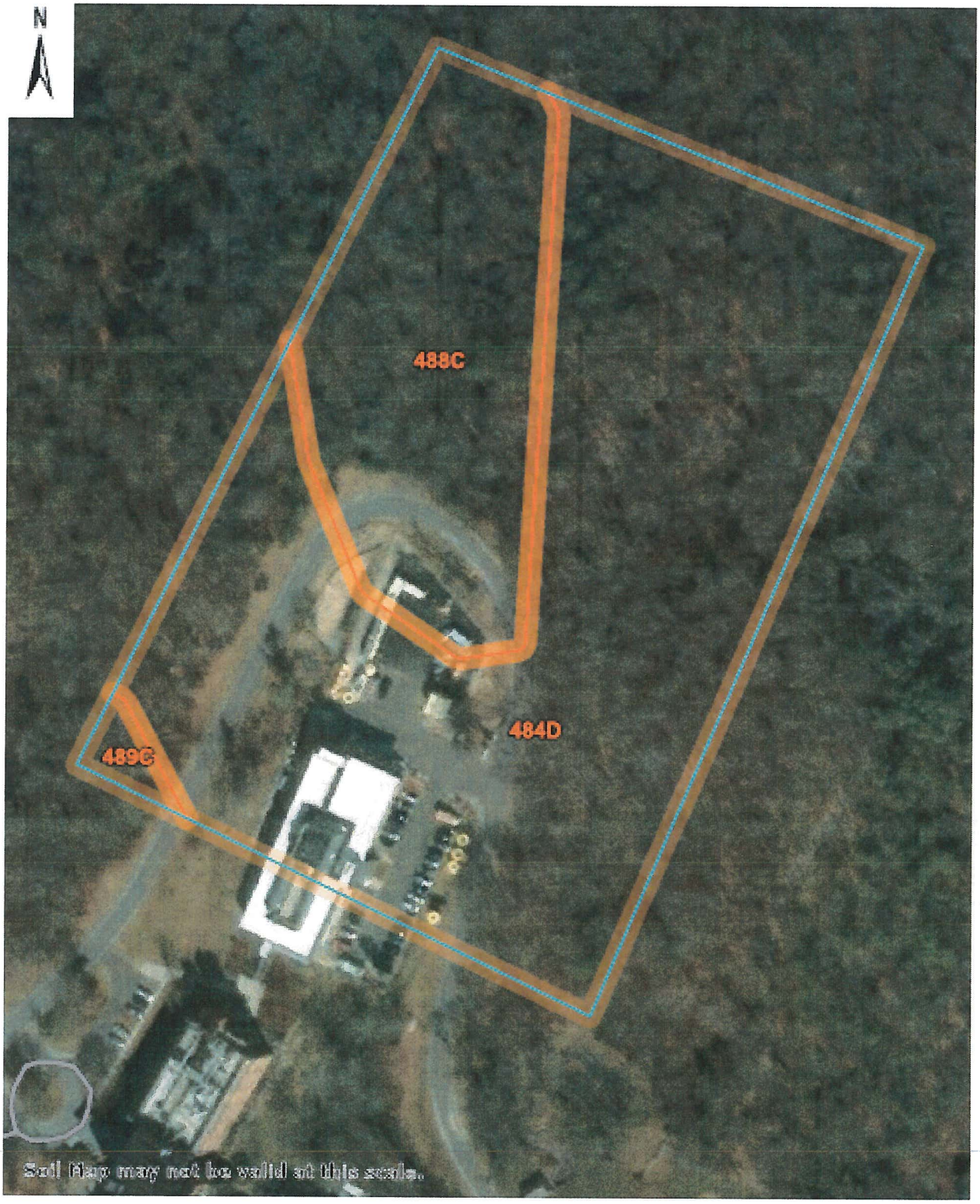
Location: 360 Woods Hole

Proj. No.: 219029
Date: 8/15/2019
Computed by: LAC
Checked by:

Subarea E (1.384 ac)	A BMP	B TSS Removal Rate	C Starting TSS Load*	D Amount Removed (BxC)	E Remaining Load (C-D)
	Parking Lot Sweeping	10	1.00	0.1	0.90
	Deep Sump Catch Basins	25	0.90	0.23	0.68
	Extended Detention Basin	70	0.68	0.48	0.20

Total TSS Removal= **80%**

Notes:
*Starting TSS Load for first BMP= 1.00. TSS load for subsequent BMP's is equal to the Remaining Load (E) from the previous BMP.



Overall Site Soil Survey Map

Parent Material Name— Summary by Map Unit — Barnstable County, Massachusetts (MA001)				
Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
484D	Plymouth-Barnstable complex, hilly, extremely bouldery	loose sandy glaciofluvial deposits and/or loose sandy ablation till	6.8	73.3%
488C	Barnstable-Plymouth complex, rolling, bouldery	friable loamy ablation till over reworked sandy glaciofluvial deposits	2.4	25.6%
489C	Barnstable-Plymouth complex, rolling, very bouldery	friable loamy ablation till over reworked sandy glaciofluvial deposits	0.1	1.2%

Hydrologic Soil Group— Summary by Map Unit — Barnstable County, Massachusetts (MA001)				
Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
484D	Plymouth-Barnstable complex, hilly, extremely bouldery	A	6.8	73.3%
488C	Barnstable-Plymouth complex, rolling, bouldery	A	2.4	25.6%
489C	Barnstable-Plymouth complex, rolling, very bouldery	A	0.1	1.2%

Drainage Class— Summary by Map Unit — Barnstable County, Massachusetts (MA001)				
Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
484D	Plymouth-Barnstable complex, hilly, extremely bouldery	Excessively drained	6.8	73.3%
488C	Barnstable-Plymouth complex, rolling, bouldery	Well drained	2.4	25.6%
489C	Barnstable-Plymouth complex, rolling, very bouldery	Well drained	0.1	1.2%

SOIL DEPTH FROM 0 INCHES TO 12 INCHES FROM SURFACE

Saturated Hydraulic Conductivity (Ksat)— Summary by Map Unit — Barnstable County, Massachusetts (MA001)				
Map unit symbol	Map unit name	Rating (micrometers per second)	Acres in AOI	Percent of AOI
484D	Plymouth-Barnstable complex, hilly, extremely bouldery	91.7400 =20 inches per hour	6.8	73.3%
488C	Barnstable-Plymouth complex, rolling, bouldery	28.2300 =4 inches per hour	2.4	25.6%
489C	Barnstable-Plymouth complex, rolling, very bouldery	28.2300 =4 inches per hour	0.1	1.2%

Soil Survey Information (Soil Characteristics)

Soil Test Pit Information

Exploratory Test Pits
Date: May 7-8, 2019
Site: WHOI Quissett Campus, Woods Hole, MA

Performed by: Holmes and McGrath, Inc.
Refer to enclosed plans for the location of the test pits within the site.

Soil Test Pit #1

Depth	Description
0 – 10"	sandy loam
10 – 29"	substratum sandy loam
29 – 96"	substratum, medium sand

Soil Test Pit #2

Depth	Description
0 – 9"	sandy loam
9 – 38"	substratum, sandy loam
38 – 96"	substratum, medium sand

Soil Test Pit #3

Depth	Description
0 – 12"	sandy loam
12 – 55"	substratum, sandy loam, pockets of silts
55 – 96"	substratum, medium sand

Soil Test Pit #4

Depth	Description
0 – 8"	sandy loam
8 – 36"	substratum, sandy loam
36 – 108"	substratum, medium sand

Soil Test Pit #5

Depth	Description
0 – 7"	sandy loam
7 – 61"	substratum, sandy loam
61 – 108"	substratum, medium sand

No groundwater observed at any soil exploratory test pit.
Groundwater estimated at elevation 7-feet NAVD88.
Five infiltration tests performed: 0.75, 0.81, 4.08, 0.75 and 3.66 minutes per inch

holmes and mcgrath, inc.
civil engineers and land surveyors
205 worcester court, unit A4 falmouth, ma

Job No.: 219029
WHOI - NQF Building

Date: May 7, 2019
Weather: sunny, 65ºF

Permeameter Readings Calculations

Instrument: 2800K1 Guelph Permeameter

Field Measurements: Test Pit No.: PT#1; depth at 78-90 inches, C layer (med. sand texture)

1st set of reading with First Head of Water in well hole, H_1 set at 5 cm.

Reading No.	Time (sec.)	Time Interval (sec.)	Water Level (cm)	Water Level Change (cm)	Rate of Change R_1 (cm/sec)
1	**0**	0	**0.0**	0.0	--
2	**5**	5	**17.2**	17.2	3.44
3	**10**	5	**23.3**	6.1	1.22
4	**15**	5	**34.2**	10.9	2.18
5	**20**	5	**39.3**	5.1	1.02
6	**25**	5	**46.2**	6.9	1.38
7	**30**	5	**52.0**	5.8	1.16
8	**35**	5	**58.2**	6.2	1.24
9	**40**	5	**65.0**	6.8	1.36
10	**45**	5	**72.0**	7.0	1.40
11	**50**	5		0.0	0.00
12	**55**	5		0.0	0.00
13	**60**	5		0.0	0.00
14	**65**	5		0.0	0.00
15	**70**	5		0.0	0.00
16	**75**	5		0.0	0.00
17	**80**	5			
18	**85**	5			
19	**90**	5			

Steady state rate for H_1, R_1 (cm/s) = 0.78

2nd set of reading with First Head of Water in well hole, H_2 set at 10 cm.

Reading No.	Time (sec.)	Time Interval (sec.)	Water Level (cm)	Water Level Change (cm)	Rate of Change R_2 (cm/sec)
1	**0**	0	**0.0**	0.0	--
2	**5**	5	**18.2**	18.2	3.64
3	**10**	5	**27.3**	9.1	1.82
4	**15**	5	**33.5**	6.2	1.24
5	**20**	5	**39.0**	5.5	1.10
6	**25**	5	**46.5**	7.5	1.50
7	**30**	5	**51.0**	4.5	0.90
8	**35**	5	**58.5**	7.5	1.50
9	**40**	5	**64.0**	5.5	1.10
10	**45**	5		0.0	0.00
11	**50**	5		0.0	0.00
12	**55**	5		0.0	0.00
13	**60**	5		0.0	0.00
14	**65**	5		0.0	0.00
15	**70**	5		0.0	0.00
16	**75**	5		0.0	0.00
17	**80**	5		0.0	0.00
18	**85**	5		0.0	0.00
19	**90**	5		0.0	0.00

Steady state rate for H_2, R_2 (cm/s) = 0.57

One Head Analysis:

Formulas (combined reservoir): Comb. reservoir const, X = 35.22 cm^2

Shape Factor, $C = [(H/a) / (2.074 + 0.093x(H/a)]^{0.754}$, where H = head and Well radius, a = 3 cm

$K_{fs} = [C Q / (2 \pi H^2 + \pi a^2 C + 2 \pi H/\alpha)]$, where Q = X R and Alpha parameter, α = 0.36 cm^{-1}

$\Phi_m = [C Q / \{(2 \pi H^2 + p a^2 C) \alpha + 2 \pi H\}]$

	First Head:	Second Head:	Average		
H (cm) =	5.0	10.0			
R (cm/sec) =	0.78	0.57			
C =	0.803	1.288			
Q (cm^3/sec) =	27.57	20.16			
K_{fs} (cm/sec) =	0.083	0.031	0.057	=	**80.69 in/hr**
Φ_m (cm^2/sec) =	0.230	0.086	0.158		**0.74 mpi**

Instrument: 2800K1 Guelph Permeameter

Field Measurements: Test Pit No.: PT#2; depth at 54-66 inches, C layer (med. sand texture)

1st set of reading with First Head of Water in well hole, H_1 set at 5 cm.

Reading No.	Time (sec.)	Time Interval (sec.)	Water Level (cm)	Water Level Change (cm)	Rate of Change R_1 (cm/sec)
1	**0**	0	**0.0**	0.0	--
2	**5**	5	**17.2**	17.2	3.44
3	**10**	5	**18.0**	0.8	0.16
4	**15**	5	**23.3**	5.3	1.06
5	**20**	5	**35.7**	12.4	2.48
6	**25**	5	**40.3**	4.6	0.92
7	**30**	5	**45.8**	5.5	1.10
8	**35**	5	**51.0**	5.2	1.04
9	**40**	5	**56.3**	5.3	1.06
10	**45**	5	**61.0**	4.7	0.94
11	**50**	5		0.0	0.00
12	**55**	5		0.0	0.00
13	**60**	5		0.0	0.00
14	**65**	5		0.0	0.00
15	**70**	5		0.0	0.00
16	**75**	5		0.0	0.00
17	**80**	5			
18	**85**	5			
19	**90**	5			

Steady state rate for H_1, R_1 (cm/s) = 0.63

2nd set of reading with First Head of Water in well hole, H_2 set at 10 cm.

Reading No.	Time (sec.)	Time Interval (sec.)	Water Level (cm)	Water Level Change (cm)	Rate of Change R_2 (cm/sec)
1	**0**	0	**0.0**	0.0	--
2	**5**	5	**15.0**	15.0	3.00
3	**10**	5	**23.2**	8.2	1.64
4	**15**	5	**32.4**	9.2	1.84
5	**20**	5	**35.4**	3.0	0.60
6	**25**	5	**47.4**	12.0	2.40
7	**30**	5	**49.0**	1.6	0.32
8	**35**	5	**58.5**	9.5	1.90
9	**40**	5	**62.3**	3.8	0.76
10	**45**	5	**66.0**	3.7	0.74
11	**50**	5		0.0	0.00
12	**55**	5		0.0	0.00
13	**60**	5		0.0	0.00
14	**65**	5		0.0	0.00
15	**70**	5		0.0	0.00
16	**75**	5		0.0	0.00
17	**80**	5		0.0	0.00
18	**85**	5		0.0	0.00
19	**90**	5		0.0	0.00

Steady state rate for H_2, R_2 (cm/s) = 0.64

One Head Analysis:

Formulas (combined reservoir): Comb. reservoir const, X = 35.22 cm^2

Shape Factor, $C = [(H/a) / (2.074 + 0.093x(H/a)]^{0.754}$, where H = head and Well radius, a = 3 cm

$K_{fs} = [C Q / (2 \pi H^2 + \pi a^2 C + 2 \pi H/\alpha)]$, where Q = X R and Alpha parameter, α = 0.36 cm^{-1}

$\Phi_m = [C Q / \{(2 \pi H^2 + p a^2 C) \alpha + 2 \pi H\}]$

	First Head:	Second Head:	Average		
H (cm) =	5.0	10.0			
R (cm/sec) =	0.63	0.64			
C =	0.803	1.288			
Q (cm^3/sec) =	22.04	22.45			
K_{fs} (cm/sec) =	0.066	0.034	0.050	=	**71.38 in/hr**
Φ_m (cm^2/sec) =	0.184	0.096	0.140		**0.84 mpi**

Instrument: 2800K1 Guelph Permeameter

Field Measurements: Test Pit No.: PT#3; depth at 65-73 inches, C layer (loamy sand texture)

1st set of reading with First Head of Water in well hole, H_1 set at 5 cm.

Reading No.	Time (sec.)	Time Interval (sec.)	Water Level (cm)	Water Level Change (cm)	Rate of Change R_1 (cm/sec)
1	**0**	0	**6.5**	6.5	--
2	**10**	10	**27.0**	20.5	2.050
3	**20**	10	**32.5**	5.5	0.550
4	**30**	10	**34.0**	1.5	0.150
5	**40**	10	**35.5**	1.5	0.150
6	**50**	10	**37.0**	1.5	0.150
7	**60**	10	**38.3**	1.3	0.130
8	**70**	10	**40.0**	1.7	0.170
9	**80**	10	**41.2**	1.2	0.120
10	**90**	10	**43.0**	1.8	0.180
11	**100**	10	**44.1**	1.1	0.110
12	**110**	10	**45.6**	1.5	0.150
13	**120**	10	**47.0**	1.4	0.140
14	**130**	10	**48.5**	1.5	0.150
15	**140**	10		0.0	0.000
16	**150**	10		0.0	0.000
17	**160**	10		0.0	0.000
18	**170**	10		0.0	0.000
19	**180**	10		0.0	0.000

Steady state rate for H_1, R_1 (cm/s) = 0.126

2nd set of reading with First Head of Water in well hole, H_2 set at 10 cm.

Reading No.	Time (sec.)	Time Interval (sec.)	Water Level (cm)	Water Level Change (cm)	Rate of Change R_2 (cm/sec)
1	**0**	0	**1.0**	1.0	--
2	**10**	10	**19.0**	18.0	1.80
3	**20**	10	**21.0**	2.0	0.200
4	**30**	10	**23.0**	2.0	0.200
5	**40**	10	**25.1**	2.1	0.210
6	**50**	10	**27.2**	2.1	0.210
7	**60**	10	**29.0**	1.8	0.180
8	**70**	10	**31.2**	2.2	0.220
9	**80**	10	**33.0**	1.8	0.180
10	**90**	10	**35.1**	2.1	0.210
11	**100**	10	**36.8**	1.7	0.170
12	**110**	10	**38.5**	1.7	0.170
13	**120**	10	**40.0**	1.5	0.150
14	**130**	10	**42.0**	2.0	0.200
15	**140**	10		0.0	0.000
16	**150**	10		0.0	0.000
17	**160**	10		0.0	0.000
18	**170**	10		0.0	0.000
19	**180**	10			

Steady state rate for H_2, R_2 (cm/s) = 0.136

One Head Analysis:

Formulas (combined reservoir): Comb. reservoir const, X = 35.22 cm^2

Shape Factor, $C = [(H/a) / (2.074 + 0.093x(H/a)]^{0.754}$, where H = head and Well radius, a = 3 cm

$K_{fs} = [C Q / (2 \pi H^2 + \pi a^2 C + 2 \pi H/\alpha)]$, where Q = X R and Alpha parameter, α = 0.36 cm^{-1}

$\Phi_m = [C Q / \{(2 \pi H^2 + p a^2 C) \alpha + 2 \pi H\}]$

	First Head:	Second Head:	Average		
H (cm) =	5.0	10.0			
R (cm/sec) =	0.126	0.136			
C =	0.803	1.288			
Q (cm^3/sec) =	4.45	4.78			
K_{fs} (cm/sec) =	0.013	0.007	0.010	=	**14.69 in/hr**
Φ_m (cm^2/sec) =	0.037	0.020	0.029		**4.08 mpi**

Instrument: 2800K1 Guelph Permeameter

Field Measurements: Test Pit No.:TP4, PT#4; depth at 66-75 inches, C layer (med. sand texture)

1st set of reading with First Head of Water in well hole, H_1 set at 5 cm.

Reading No.	Time (sec.)	Time Interval (sec.)	Water Level (cm)	Water Level Change (cm)	Rate of Change R_1 (cm/sec)
1	**0**	0	**0.0**	0.0	--
2	**5**	5	**12.0**	12.0	2.40
3	**10**	5	**22.2**	10.2	2.04
4	**15**	5	**26.3**	4.1	0.82
5	**20**	5	**32.0**	5.7	1.14
6	**25**	5	**38.3**	6.3	1.26
7	**30**	5	**43.2**	4.9	0.98
8	**35**	5	**48.3**	5.1	1.02
9	**40**	5	**55.2**	6.9	1.38
10	**45**	5	**61.1**	5.9	1.18
11	**50**	5	**65.3**	4.2	0.84
12	**55**	5		0.0	0.00
13	**60**	5		0.0	0.00
14	**65**	5		0.0	0.00
15	**70**	5		0.0	0.00
16	**75**	5		0.0	0.00
17	**80**	5			
18	**85**	5			
19	**90**	5			

Steady state rate for H_1, R_1 (cm/s) = 0.76

2nd set of reading with First Head of Water in well hole, H_2 set at 10 cm.

Reading No.	Time (sec.)	Time Interval (sec.)	Water Level (cm)	Water Level Change (cm)	Rate of Change R_2 (cm/sec)
1	**0**	0	**0.0**	0.0	--
2	**5**	5	**15.0**	15.0	3.00
3	**10**	5	**22.0**	7.0	1.40
4	**15**	5	**27.7**	5.7	1.14
5	**20**	5	**32.5**	4.8	0.96
6	**25**	5	**35.8**	3.3	0.66
7	**30**	5	**41.3**	5.5	1.10
8	**35**	5	**48.0**	6.7	1.34
9	**40**	5	**54.0**	6.0	1.20
10	**45**	5	**57.0**	3.0	0.60
11	**50**	5	**62.2**	5.2	1.04
12	**55**	5		0.0	0.00
13	**60**	5		0.0	0.00
14	**65**	5		0.0	0.00
15	**70**	5		0.0	0.00
16	**75**	5		0.0	0.00
17	**80**	5		0.0	0.00
18	**85**	5		0.0	0.00
19	**90**	5		0.0	0.00

Steady state rate for H_2, R_2 (cm/s) = 0.59

One Head Analysis:

Formulas (combined reservoir): Comb. reservoir const, X = 35.22 cm^2

Shape Factor, $C = [(H/a) / (2.074 + 0.093x(H/a)]^{0.754}$, where H = head and Well radius, a = 3 cm

$K_{fs} = [C Q / (2 \pi H^2 + \pi a^2 C + 2 \pi H/\alpha)]$, where Q = X R and Alpha parameter, α = 0.36 cm^{-1}

$\Phi_m = [C Q / \{(2 \pi H^2 + p a^2 C) \alpha + 2 \pi H\}]$

	First Head:	Second Head:	Average		
H (cm) =	5.0	10.0			
R (cm/sec) =	0.76	0.59			
C =	0.803	1.288			
Q (cm^3/sec) =	26.82	20.78			
K_{fs} (cm/sec) =	0.081	0.032	0.056	=	**79.75 in/hr**
Φ_m (cm^2/sec) =	0.224	0.089	0.156		**0.75 mpi**

Instrument: 2800K1 Guelph Permeameter

Field Measurements: Test Pit No.: PT#5; depth at 105-113 inches, C layer (loamy sand texture)

1st set of reading with First Head of Water in well hole, H_1 set at 5 cm.

Reading No.	Time (sec.)	Time Interval (sec.)	Water Level (cm)	Water Level Change (cm)	Rate of Change R_1 (cm/sec)
1	**0**	0	**0.0**	0.0	--
2	**5**	5	**14.0**	14.0	2.80
3	**10**	5	**16.2**	2.2	0.44
4	**15**	5	**17.3**	1.1	0.22
5	**20**	5	**18.0**	0.7	0.14
6	**25**	5	**18.3**	0.3	0.06
7	**30**	5	**19.0**	0.7	0.14
8	**35**	5	**19.3**	0.3	0.06
9	**40**	5	**19.9**	0.6	0.12
10	**45**	5	**20.2**	0.3	0.06
11	**50**	5	**20.6**	0.4	0.08
12	**55**	5	**21.0**	0.4	0.08
13	**60**	5	**21.8**	0.8	0.16
14	**65**	5	**22.0**	0.2	0.04
15	**70**	5	**22.6**	0.6	0.12
16	**75**	5	**23.0**	0.4	0.08
17	**80**	5	**23.2**	0.2	0.04
18	**85**	5	**23.8**	0.6	0.12
19	**90**	5	**24.0**	0.2	0.04

Steady state rate for H_1, R_1 (cm/s) = 0.12

2nd set of reading with First Head of Water in well hole, H_2 set at 10 cm.

Reading No.	Time (sec.)	Time Interval (sec.)	Water Level (cm)	Water Level Change (cm)	Rate of Change R_2 (cm/sec)
1	**0**	0	**0.0**	0.0	--
2	**5**	5	**20.5**	20.5	4.10
3	**10**	5	**23.3**	2.8	0.56
4	**15**	5	**25.0**	1.7	0.34
5	**20**	5	**26.3**	1.3	0.26
6	**25**	5	**27.2**	0.9	0.18
7	**30**	5	**28.3**	1.1	0.22
8	**35**	5	**29.0**	0.7	0.14
9	**40**	5	**30.0**	1.0	0.20
10	**45**	5	**30.8**	0.8	0.16
11	**50**	5	**31.3**	0.5	0.10
12	**55**	5	**32.0**	0.0	0.00
13	**60**	5	**32.6**	0.6	0.12
14	**65**	5	**33.4**	0.8	0.16
15	**70**	5	**34.2**	0.8	0.16
16	**75**	5	**35.0**	0.8	0.16
17	**80**	5	**35.6**	0.6	0.12
18	**85**	5	**36.2**	0.6	0.12
19	**90**	5	**36.8**	0.6	0.12

Steady state rate for H_2, R_2 (cm/s) = 0.19

One Head Analysis:

Formulas (combined reservoir): Comb. reservoir const, X = 35.22 cm^2

Shape Factor, $C = [(H/a) / (2.074 + 0.093x(H/a)]^{0.754}$, where H = head and Well radius, a = 3 cm

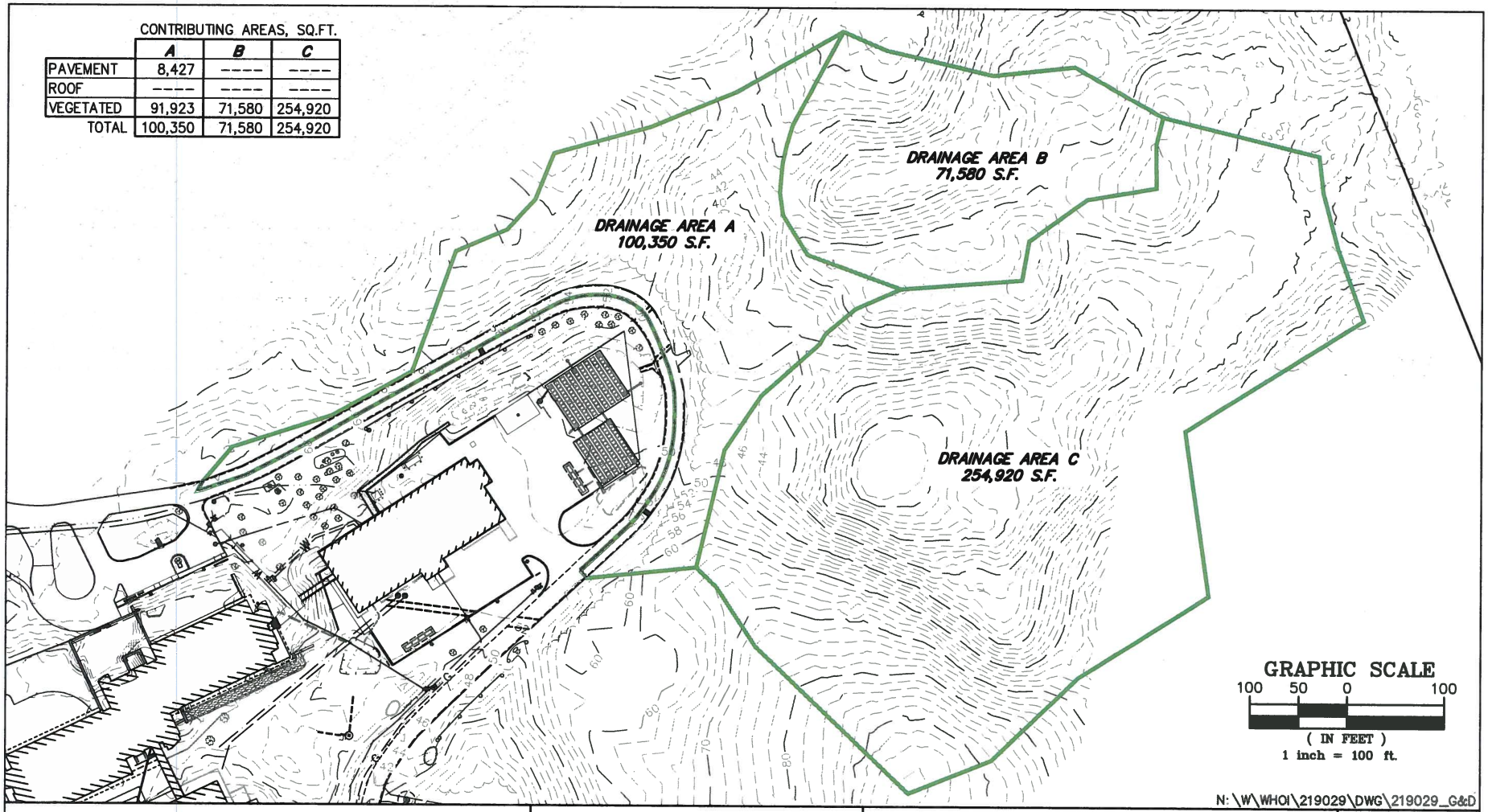
$K_{fs} = [C Q / (2 \pi H^2 + \pi a^2 C + 2 \pi H/\alpha)]$, where Q = X R and Alpha parameter, α = 0.36 cm^{-1}

$\Phi_m = [C Q / \{(2 \pi H^2 + p a^2 C) \alpha + 2 \pi H\}]$

	First Head:	Second Head:	Average		
H (cm) =	5.0	10.0			
R (cm/sec) =	0.12	0.19			
C =	0.803	1.288			
Q (cm^3/sec) =	4.31	6.60			
K_{fs} (cm/sec) =	0.013	0.010	0.012	=	**16.37 in/hr**
Φ_m (cm^2/sec) =	0.036	0.028	0.032		**3.66 mpi**

CONTRIBUTING AREAS, SQ.FT.

	A	B	C
PAVEMENT	8,427	-----	-----
ROOF	-----	-----	-----
VEGETATED	91,923	71,580	254,920
TOTAL	100,350	71,580	254,920



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NQF BUILDING SUBCATCHMENT DRAINAGE AREAS "PRE DEVELOPMENT"

PREPARED FOR

WOODS HOLE OCEANOGRAPHIC INSTITUTION

WOODS HOLE FALMOUTH MA

REV DATE:

JOB.NO.: 219029 | DATE: 6/17/19

DRAWN: LAC | CHECKED:

holmes and mcgrath, inc.
civil engineers and land surveyors
205 worcester court · suite a4 · falmouth, ma · 02540
508-548-3564 www.holmesandmcgrath.com

DWG.NO.: 79-3-17 | SHEET 1 OF 1

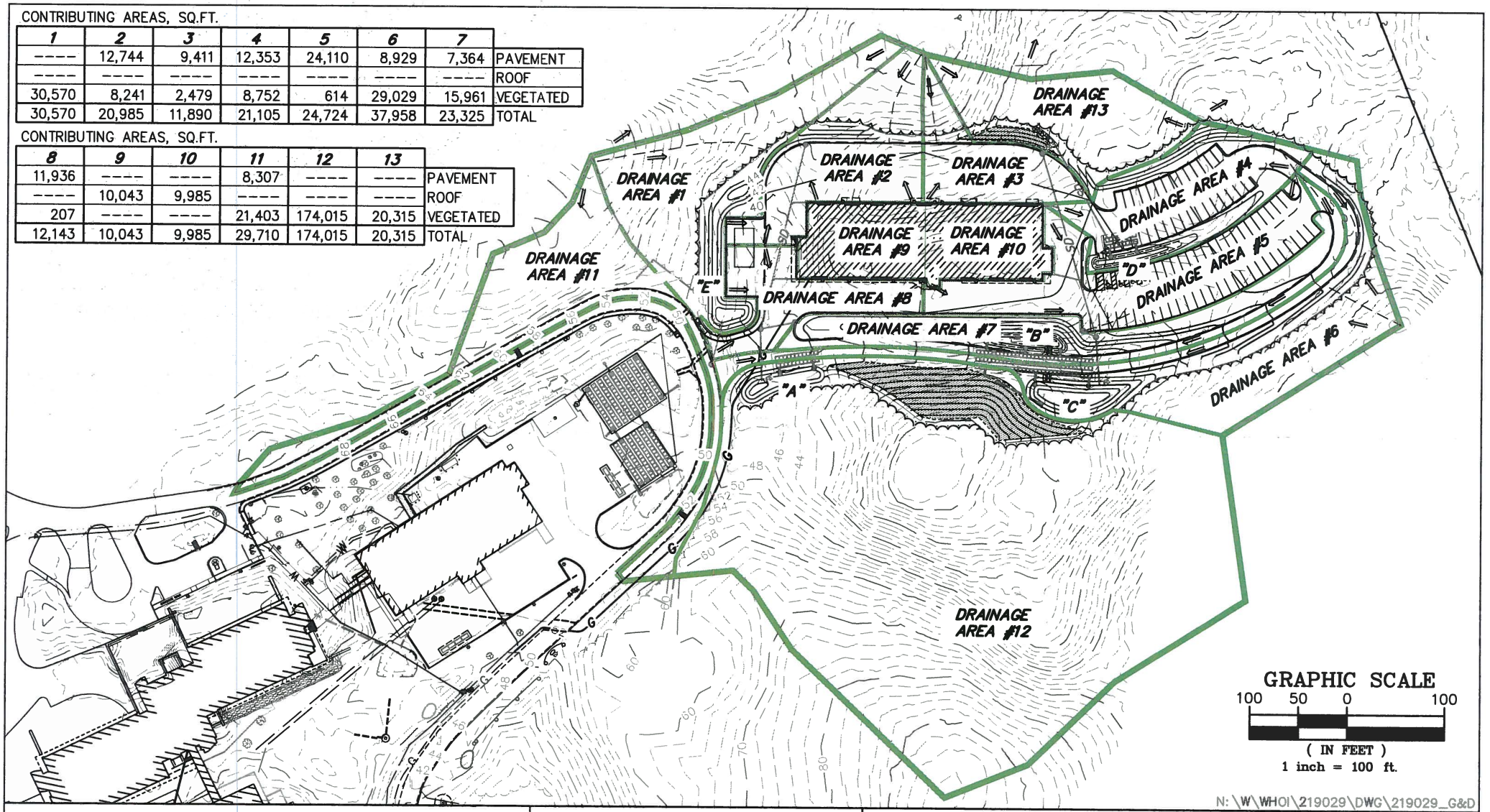
NAD 83

CONTRIBUTING AREAS, SQ.FT.

1	2	3	4	5	6	7	
----	12,744	9,411	12,353	24,110	8,929	7,364	PAVEMENT
----	----	----	----	----	----	----	ROOF
30,570	8,241	2,479	8,752	614	29,029	15,961	VEGETATED
30,570	20,985	11,890	21,105	24,724	37,958	23,325	TOTAL

CONTRIBUTING AREAS, SQ.FT.

8	9	10	11	12	13	
11,936	----	----	8,307	----	----	PAVEMENT
----	10,043	9,985	----	----	----	ROOF
207	----	----	21,403	174,015	20,315	VEGETATED
12,143	10,043	9,985	29,710	174,015	20,315	TOTAL



NQF BUILDING SUBCATCHMENT DRAINAGE AREAS "POST DEVELOPMENT"

PREPARED FOR

WOODS HOLE OCEANOGRAPHIC INSTITUTION

WOODS HOLE FALMOUTH MA

REV DATE:

JOB.NO.: 219029 | DATE: 6/17/19

DRAWN: LAC | CHECKED:

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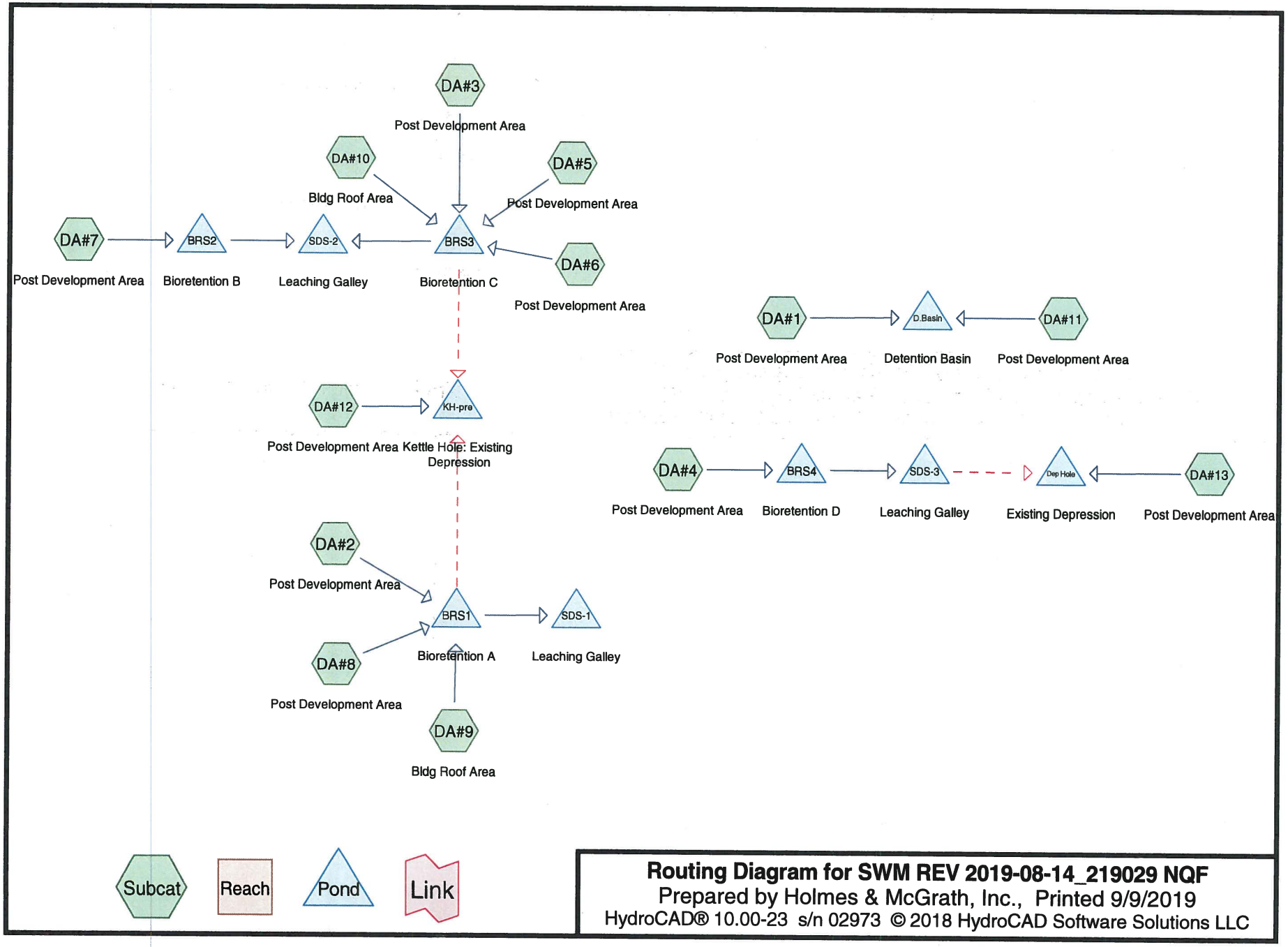
DWG.NO.: 79–3–17 | SHEET 1 OF 1

NAD 83



Routing Diagram for SWM REV 2019-08-14_219029 NQF
Prepared by Holmes & McGrath, Inc., Printed 9/9/2019
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Summary for Subcatchment DA#1: Post Development Area

Runoff = 0.01 cfs @ 15.09 hrs, Volume= 0.006 af, Depth> 0.10"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Rainfall=5.80"

Area (sf)	CN	Description
22,430	30	Woods, Good, HSG A
8,140	39	>75% Grass cover, Good, HSG A
30,570	32	Weighted Average
30,570		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.4	50	0.0900	0.13		**Sheet Flow, Woodland** Woods: Light underbrush n= 0.400 P2= 3.60"
1.0	120	0.1770	2.10		**Shallow Concentrated Flow, Woodland** Woodland Kv= 5.0 fps
0.2	45	0.0440	3.15		**Shallow Concentrated Flow, Grass D-Basin** Grassed Waterway Kv= 15.0 fps
7.6	215	Total			

Summary for Subcatchment DA#10: Bldg Roof Area

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 1.59 cfs @ 12.00 hrs, Volume= 0.106 af, Depth> 5.56"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Rainfall=5.80"

	Area (sf)	CN	Description
*	9,985	98	Bldg Roof Area
	9,985		100.00% Impervious Area

Summary for Subcatchment DA#11: Post Development Area

Runoff = 0.78 cfs @ 12.07 hrs, Volume= 0.063 af, Depth> 1.11"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Rainfall=5.80"

	Area (sf)	CN	Description
*	8,307	98	Ring Road, HSG A
	15,810	30	Woods, Good, HSG A
	5,593	39	>75% Grass cover, Good, HSG A
	29,710	51	Weighted Average
	21,403		72.04% Pervious Area
	8,307		27.96% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.4	100	0.0116	1.17		**Sheet Flow, Ring Road** Smooth surfaces n= 0.011 P2= 3.60"
1.9	480	0.0419	4.16		**Shallow Concentrated Flow, Ring Road** Paved Kv= 20.3 fps
3.3	580	Total			

Summary for Subcatchment DA#12: Post Development Area

Runoff = 0.02 cfs @ 16.75 hrs, Volume= 0.017 af, Depth> 0.05"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Rainfall=5.80"

Area (sf)	CN	Description
174,015	30	Woods, Good, HSG A
174,015		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Woodlands**

Summary for Subcatchment DA#13: Post Development Area

Runoff = 0.01 cfs @ 15.04 hrs, Volume= 0.004 af, Depth> 0.10"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Rainfall=5.80"

Area (sf)	CN	Description
16,745	30	Woods, Good, HSG A
3,570	39	>75% Grass cover, Good, HSG A
20,315	32	Weighted Average
20,315		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Woodlands**

Summary for Subcatchment DA#2: Post Development Area

Runoff = 1.51 cfs @ 12.11 hrs, Volume= 0.113 af, Depth> 2.83"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Rainfall=5.80"

Area (sf)	CN	Description
12,744	98	Paved parking, HSG A
2,416	39	>75% Grass cover, Good, HSG A
5,825	30	Woods, Good, HSG A
20,985	72	Weighted Average
8,241		39.27% Pervious Area
12,744		60.73% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.4	33	0.0700	1.32		**Shallow Concentrated Flow, Woodland** Woodland Kv= 5.0 fps
5.7	67	0.2100	0.19		**Sheet Flow, Woodland** Woods: Light underbrush n= 0.400 P2= 3.60"
1.5	85	0.0070	0.93		**Sheet Flow, Paved Parking Lot** Smooth surfaces n= 0.011 P2= 3.60"
7.6	185	Total			

Summary for Subcatchment DA#3: Post Development Area

Runoff = 1.47 cfs @ 12.04 hrs, Volume= 0.094 af, Depth> 4.11"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Rainfall=5.80"

Area (sf)	CN	Description
9,411	98	Paved parking, HSG A
492	49	50-75% Grass cover, Fair, HSG A
1,987	30	Woods, Good, HSG A
11,890	85	Weighted Average
2,479		20.85% Pervious Area
9,411		79.15% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.7	85	0.1880	2.17		**Shallow Concentrated Flow, Woodland** Woodland Kv= 5.0 fps
0.0	10	0.2500	3.50		**Shallow Concentrated Flow, lawn** Short Grass Pasture Kv= 7.0 fps
1.7	105	0.0080	1.02		**Sheet Flow, Paved Parking Lot** Smooth surfaces n= 0.011 P2= 3.60"
2.4	200	Total			

Summary for Subcatchment DA#4: Post Development Area

Runoff = 1.96 cfs @ 12.04 hrs, Volume= 0.122 af, Depth> 3.02"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Rainfall=5.80"

Area (sf)	CN	Description
12,353	98	Paved parking, HSG A
8,752	39	>75% Grass cover, Good, HSG A
21,105	74	Weighted Average
8,752		41.47% Pervious Area
12,353		58.53% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.6	85	0.0125	2.27		**Shallow Concentrated Flow, Driveway** Paved Kv= 20.3 fps
1.7	167	0.0200	1.62		**Sheet Flow, Paved Parking Lot** Smooth surfaces n= 0.011 P2= 3.60"
2.3	252	Total			

Summary for Subcatchment DA#5: Post Development Area

Runoff = 3.53 cfs @ 12.05 hrs, Volume= 0.257 af, Depth> 5.44"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Rainfall=5.80"

Area (sf)	CN	Description
24,110	98	Paved parking, HSG A
614	39	>75% Grass cover, Good, HSG A
24,724	97	Weighted Average
614		2.48% Pervious Area
24,110		97.52% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.6	85	0.0125	2.27		**Shallow Concentrated Flow, Driveway** Paved Kv= 20.3 fps
2.7	249	0.0150	1.56		**Sheet Flow, Paved Parking Lot** Smooth surfaces n= 0.011 P2= 3.60"
3.3	334	Total			

Summary for Subcatchment DA#6: Post Development Area

Runoff = 1.07 cfs @ 12.07 hrs, Volume= 0.086 af, Depth> 1.18"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Rainfall=5.80"

Area (sf)	CN	Description
8,929	98	Paved parking, HSG A
12,255	49	50-75% Grass cover, Fair, HSG A
16,774	30	Woods, Good, HSG A
37,958	52	Weighted Average
29,029		76.48% Pervious Area
8,929		23.52% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.6	70	0.0200	0.71		**Shallow Concentrated Flow, Woodland** Woodland Kv= 5.0 fps
0.1	30	0.3500	4.14		**Shallow Concentrated Flow, lawn** Short Grass Pasture Kv= 7.0 fps
2.2	300	0.0345	2.26		**Sheet Flow, Paved Parking Lot** Smooth surfaces n= 0.011 P2= 3.60"
3.9	400	Total			

Summary for Subcatchment DA#7: Post Development Area

Runoff = 1.06 cfs @ 12.05 hrs, Volume= 0.073 af, Depth> 1.63"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Rainfall=5.80"

Area (sf)	CN	Description
7,364	98	Paved parking, HSG A
15,961	39	>75% Grass cover, Good, HSG A
23,325	58	Weighted Average
15,961		68.43% Pervious Area
7,364		31.57% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.7	115	0.0175	2.69		**Shallow Concentrated Flow, Driveway** Paved Kv= 20.3 fps
2.1	297	0.0394	2.38		**Sheet Flow, Access Driveway** Smooth surfaces n= 0.011 P2= 3.60"
2.8	412	Total			

Summary for Subcatchment DA#8: Post Development Area

Runoff = 1.76 cfs @ 12.04 hrs, Volume= 0.126 af, Depth> 5.44"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Rainfall=5.80"

Area (sf)	CN	Description
11,936	98	Paved parking, HSG A
207	39	>75% Grass cover, Good, HSG A
12,143	97	Weighted Average
207		1.70% Pervious Area
11,936		98.30% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.2	35	0.0143	2.43		**Shallow Concentrated Flow, Paved Driveway** Paved Kv= 20.3 fps
2.7	129	0.0039	0.80		**Sheet Flow, Paved Parking Lot** Smooth surfaces n= 0.011 P2= 3.60"
2.9	164	Total			

Summary for Subcatchment DA#9: Bldg Roof Area

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 1.60 cfs @ 12.00 hrs, Volume= 0.107 af, Depth> 5.56"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Rainfall=5.80"

	Area (sf)	CN	Description
*	10,043	98	Bldg Roof Area
	10,043		100.00% Impervious Area

Summary for Pond BRS1: Bioretention A

[93] Warning: Storage range exceeded by 0.17'
[88] Warning: Qout>Qin may require smaller dt or Finer Routing
[85] Warning: Oscillations may require smaller dt or Finer Routing (severity=1)

Inflow Area = 0.991 ac, 80.43% Impervious, Inflow Depth > 4.20" for 25-Year event
Inflow = 4.07 cfs @ 12.04 hrs, Volume= 0.347 af
Outflow = 4.97 cfs @ 12.06 hrs, Volume= 0.296 af, Atten= 0%, Lag= 1.2 min
Discarded = 0.11 cfs @ 12.06 hrs, Volume= 0.133 af
Primary = 2.74 cfs @ 12.06 hrs, Volume= 0.153 af
Secondary = 2.11 cfs @ 12.06 hrs, Volume= 0.010 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 42.17' @ 12.06 hrs Surf.Area= 1,911 sf Storage= 3,834 cf

Plug-Flow detention time= 126.8 min calculated for 0.296 af (85% of inflow)
Center-of-Mass det. time= 62.4 min (837.2 - 774.9)

Volume	Invert	Avail.Storage	Storage Description
#1	39.00'	3,834 cf	**Open Depression Storage (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
39.00	485	152.0	0	0	485
40.00	1,149	178.0	794	794	1,187
41.00	1,517	191.0	1,329	2,122	1,611
41.10	1,556	192.0	154	2,276	1,647
41.20	1,594	193.0	157	2,433	1,684
41.30	1,633	194.0	161	2,595	1,720
41.40	1,672	196.0	165	2,760	1,785
41.50	1,711	197.0	169	2,929	1,822
42.00	1,911	203.0	905	3,834	2,038

Device	Routing	Invert	Outlet Devices
#1	Discarded	39.00'	**2.410 in/hr Exfiltration over Wetted area**
#2	Primary	41.50'	**2.0" x 2.0" Horiz. Orifice/Grate X 5.00 columns** X 5 rows C= 0.600 in 12.0" Grate (88% open area) Limited to weir flow at low heads
#3	Secondary	41.90'	**6.0' long x 8.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.43 2.54 2.70 2.69 2.68 2.68 2.66 2.64 2.64 2.64 2.65 2.65 2.66 2.66 2.68 2.70 2.74

Discarded OutFlow Max=0.11 cfs @ 12.06 hrs HW=42.17' (Free Discharge)
↑**1=Exfiltration** (Exfiltration Controls 0.11 cfs)

Primary OutFlow Max=2.74 cfs @ 12.06 hrs HW=42.17' (Free Discharge)
↑**2=Orifice/Grate** (Orifice Controls 2.74 cfs @ 3.95 fps)

Secondary OutFlow Max=2.11 cfs @ 12.06 hrs HW=42.17' (Free Discharge)
↑**3=Broad-Crested Rectangular Weir** (Weir Controls 2.11 cfs @ 1.29 fps)

Summary for Pond BRS2: Bioretention B

Inflow Area = 0.535 ac, 31.57% Impervious, Inflow Depth > 1.63" for 25-Year event
Inflow = 1.06 cfs @ 12.05 hrs, Volume= 0.073 af
Outflow = 0.74 cfs @ 12.12 hrs, Volume= 0.072 af, Atten= 30%, Lag= 4.2 min
Discarded = 0.06 cfs @ 12.12 hrs, Volume= 0.047 af
Primary = 0.68 cfs @ 12.12 hrs, Volume= 0.024 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 34.16' @ 12.12 hrs Surf.Area= 661 sf Storage= 553 cf

Plug-Flow detention time= 69.8 min calculated for 0.072 af (98% of inflow)
Center-of-Mass det. time= 59.7 min (926.9 - 867.3)

Volume	Invert	Avail.Storage	Storage Description
#1	33.00'	2,401 cf	**Open Drain Basin (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
33.00	302	106.0	0	0	302
34.00	614	144.0	449	449	1,068
34.10	643	145.0	63	512	1,095
34.20	672	146.0	66	577	1,123
34.30	702	147.0	69	646	1,150
34.40	731	149.0	72	718	1,200
34.50	761	150.0	75	792	1,228
35.00	973	169.0	432	1,225	1,717
36.00	1,391	192.0	1,176	2,401	2,402

Device	Routing	Invert	Outlet Devices
#1	Discarded	33.00'	**2.410 in/hr Exfiltration over Wetted area**
#2	Primary	34.00'	**2.0" x 2.0" Horiz. Orifice/Grate X 5.00 columns** X 5 rows C= 0.600 in 12.0" Grate (88% open area) Limited to weir flow at low heads

Discarded OutFlow Max=0.06 cfs @ 12.12 hrs HW=34.16' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.06 cfs)

Primary OutFlow Max=0.67 cfs @ 12.12 hrs HW=34.16' (Free Discharge)
↑—**2=Orifice/Grate** (Weir Controls 0.67 cfs @ 1.32 fps)

Summary for Pond BRS3: Bioretention C

[92] Warning: Device #3 is above defined storage

Inflow Area =	1.941 ac, 62.01% Impervious, Inflow Depth > 3.36"	for 25-Year event		
Inflow =	7.14 cfs @	12.04 hrs, Volume=	0.543 af	
Outflow =	3.69 cfs @	12.15 hrs, Volume=	0.461 af,	Atten= 48%, Lag= 6.7 min
Discarded =	0.19 cfs @	12.15 hrs, Volume=	0.196 af	
Primary =	3.49 cfs @	12.15 hrs, Volume=	0.265 af	
Secondary =	0.00 cfs @	0.00 hrs, Volume=	0.000 af	

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 34.09' @ 12.15 hrs Surf.Area= 2,593 sf Storage= 6,949 cf

Plug-Flow detention time= 126.8 min calculated for 0.461 af (85% of inflow)
Center-of-Mass det. time= 59.2 min (837.4 - 778.1)

Volume	Invert	Avail.Storage	Storage Description
#1	30.00'	9,499 cf	**Open Depression Storage (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
30.00	916	161.0	0	0	916
31.00	1,251	174.0	1,079	1,079	1,301
32.00	1,658	198.0	1,450	2,529	2,035
32.50	1,871	209.0	882	3,411	2,406
32.60	1,913	210.0	189	3,600	2,445
32.70	1,955	211.0	193	3,793	2,485
32.80	1,997	213.0	198	3,991	2,556
32.90	2,040	214.0	202	4,193	2,596
33.00	2,083	215.0	206	4,399	2,636
34.00	2,550	235.0	2,313	6,711	3,387
35.00	3,032	248.0	2,788	9,499	3,942

Device	Routing	Invert	Outlet Devices
#1	Discarded	30.00'	**2.410 in/hr Exfiltration over Wetted area**
#2	Primary	33.00'	**2.0" x 2.0" Horiz. Orifice/Grate X 5.00 columns** X 5 rows C= 0.600 in 12.0" Grate (88% open area) Limited to weir flow at low heads
#3	Secondary	35.00'	**9.0' long x 9.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.46 2.55 2.70 2.69 2.68 2.68 2.67 2.64 2.64 2.64 2.65 2.64 2.65 2.65 2.66 2.67 2.69

Discarded OutFlow Max=0.19 cfs @ 12.15 hrs HW=34.09' (Free Discharge)
↑**1=Exfiltration** (Exfiltration Controls 0.19 cfs)

Primary OutFlow Max=3.49 cfs @ 12.15 hrs HW=34.09' (Free Discharge)
↑**2=Orifice/Grate** (Orifice Controls 3.49 cfs @ 5.03 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=30.00' (Free Discharge)
↑**3=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Pond BRS4: Bioretention D

[92] Warning: Device #2 is above defined storage
[93] Warning: Storage range exceeded by 0.27'
[85] Warning: Oscillations may require smaller dt or Finer Routing (severity=23)

Inflow Area = 0.485 ac, 58.53% Impervious, Inflow Depth > 3.02" for 25-Year event
Inflow = 1.96 cfs @ 12.04 hrs, Volume= 0.122 af
Outflow = 1.65 cfs @ 12.14 hrs, Volume= 0.122 af, Atten= 16%, Lag= 6.2 min
Discarded = 0.22 cfs @ 12.14 hrs, Volume= 0.109 af
Primary = 1.42 cfs @ 12.14 hrs, Volume= 0.013 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 45.77' @ 12.14 hrs Surf.Area= 1,486 sf Storage= 1,494 cf

Plug-Flow detention time= 64.0 min calculated for 0.122 af (100% of inflow)
Center-of-Mass det. time= 63.3 min (890.0 - 826.7)

Volume	Invert	Avail.Storage	Storage Description
#1	44.00'	1,494 cf	**Open Drain Basin (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
44.00	546	233.0	0	0	546
45.00	1,150	290.0	829	829	2,933
45.10	1,238	307.0	119	949	3,741
45.20	1,300	309.0	127	1,076	3,844
45.30	1,362	310.0	133	1,209	3,902
45.40	1,424	311.0	139	1,348	3,960
45.50	1,486	312.0	145	1,494	4,019

Device	Routing	Invert	Outlet Devices
#1	Discarded	44.00'	**2.410 in/hr Exfiltration over Wetted area**
#2	Primary	45.50'	**2.0" x 2.0" Horiz. Orifice/Grate X 5.00 columns** X 5 rows C= 0.600 in 12.0" Grate (88% open area) Limited to weir flow at low heads

Discarded OutFlow Max=0.22 cfs @ 12.14 hrs HW=45.77' (Free Discharge)
↑**1=Exfiltration** (Exfiltration Controls 0.22 cfs)

Primary OutFlow Max=1.42 cfs @ 12.14 hrs HW=45.77' (Free Discharge)
↑**2=Orifice/Grate** (Weir Controls 1.42 cfs @ 1.69 fps)

Summary for Pond D.Basin: Detention Basin

Inflow Area = 1.384 ac, 13.78% Impervious, Inflow Depth > 0.60" for 25-Year event
Inflow = 0.78 cfs @ 12.07 hrs, Volume= 0.069 af
Outflow = 0.71 cfs @ 12.10 hrs, Volume= 0.069 af, Atten= 9%, Lag= 2.1 min
Discarded = 0.71 cfs @ 12.10 hrs, Volume= 0.069 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 43.12' @ 12.10 hrs Surf.Area= 649 sf Storage= 71 cf

Plug-Flow detention time= 1.1 min calculated for 0.069 af (100% of inflow)
Center-of-Mass det. time= 0.8 min (908.3 - 907.5)

Volume	Invert	Avail.Storage	Storage Description
#1	43.00'	7,061 cf	**Open Drain Basin (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
43.00	533	136.0	0	0	533
43.50	1,096	383.0	399	399	10,735
43.60	1,249	385.0	117	516	10,863
43.70	1,404	388.0	133	649	11,052
43.80	1,560	390.0	148	797	11,182
43.90	1,716	393.0	164	960	11,373
44.00	1,874	395.0	179	1,140	11,504
45.00	2,832	415.0	2,337	3,477	12,855
46.00	4,394	537.0	3,585	7,061	22,110

Device	Routing	Invert	Outlet Devices
#1	Discarded	43.00'	**14.700 in/hr Exfiltration over Wetted area**

Discarded OutFlow Max=0.71 cfs @ 12.10 hrs HW=43.12' (Free Discharge)
↑**1=Exfiltration** (Exfiltration Controls 0.71 cfs)

Summary for Pond Dep Hole: Existing Depression

Inflow Area = 0.466 ac, 0.00% Impervious, Inflow Depth > 0.10" for 25-Year event
Inflow = 0.01 cfs @ 15.04 hrs, Volume= 0.004 af
Outflow = 0.01 cfs @ 15.68 hrs, Volume= 0.004 af, Atten= 5%, Lag= 38.2 min
Discarded = 0.01 cfs @ 15.68 hrs, Volume= 0.004 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 36.02' @ 15.68 hrs Surf.Area= 57 sf Storage= 14 cf

Plug-Flow detention time= 36.5 min calculated for 0.004 af (96% of inflow)
Center-of-Mass det. time= 21.9 min (1,100.8 - 1,078.9)

Volume	Invert	Avail.Storage	Storage Description
#1	36.00'	5,674 cf	**Open Drain Basin (Irregular)** Listed below

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
36.00	40	38.0	0	0	40
38.00	1,455	206.0	1,157	1,157	3,311
40.00	3,172	257.0	4,517	5,674	5,246

Device	Routing	Invert	Outlet Devices
#1	Discarded	36.00'	**6.530 in/hr Exfiltration over Surface area** Conductivity to Groundwater Elevation = 5.00'

Discarded OutFlow Max=0.01 cfs @ 15.68 hrs HW=36.02' (Free Discharge)
↑**1=Exfiltration** (Controls 0.01 cfs)

Summary for Pond KH-pre: Kettle Hole: Existing Depression

Inflow Area = 3.995 ac, 0.00% Impervious, Inflow Depth > 0.08" for 25-Year event
Inflow = 2.11 cfs @ 12.06 hrs, Volume= 0.028 af
Outflow = 0.23 cfs @ 12.21 hrs, Volume= 0.027 af, Atten= 89%, Lag= 9.1 min
Discarded = 0.23 cfs @ 12.21 hrs, Volume= 0.027 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 18.08' @ 12.21 hrs Surf.Area= 3,723 sf Storage= 310 cf

Plug-Flow detention time= 22.9 min calculated for 0.027 af (98% of inflow)
Center-of-Mass det. time= 13.2 min (1,001.9 - 988.7)

Volume	Invert	Avail.Storage	Storage Description
#1	18.00'	527,942 cf	**Depresion storage (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
18.00	3,600	220.0	0	0	3,600
20.00	7,075	300.0	10,481	10,481	6,951
22.00	10,400	380.0	17,369	27,850	11,333
24.00	14,150	450.0	24,454	52,304	16,030
26.00	18,400	540.0	32,457	84,761	23,190
28.00	23,400	620.0	41,700	126,461	30,665
30.00	29,700	660.0	52,975	179,436	34,936
32.00	36,000	730.0	65,599	245,035	42,802
34.00	43,500	920.0	79,382	324,417	67,804
36.00	51,100	980.0	94,498	418,915	77,073
38.00	58,000	1,030.0	109,027	527,942	85,319

Device	Routing	Invert	Outlet Devices
#1	Discarded	18.00'	**6.000 in/hr Exfiltration @ 1.35 in/hr over Wetted area**

Discarded OutFlow Max=0.52 cfs @ 12.21 hrs HW=18.08' (Free Discharge)
↑**1=Exfiltration @ 1.35 in/hr** (Exfiltration Controls 0.52 cfs)

Summary for Pond SDS-1: Leaching Galley

Inflow Area = 0.991 ac, 80.43% Impervious, Inflow Depth = 1.85" for 25-Year event
Inflow = 2.74 cfs @ 12.06 hrs, Volume= 0.153 af
Outflow = 1.47 cfs @ 12.42 hrs, Volume= 0.153 af, Atten= 46%, Lag= 21.6 min
Discarded = 1.47 cfs @ 12.42 hrs, Volume= 0.153 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 36.84' @ 12.42 hrs Surf.Area= 984 sf Storage= 1,447 cf

Plug-Flow detention time= 8.3 min calculated for 0.153 af (100% of inflow)
Center-of-Mass det. time= 8.3 min (776.3 - 768.0)

Volume	Invert	Avail.Storage	Storage Description
#1A	33.50'	1,441 cf	**19.30'W x 51.00'L x 5.50'H Field A** 5,414 cf Overall - 1,295 cf Embedded = 4,118 cf x 35.0% Voids
#2A	35.00'	976 cf	**Concrete Galley 4x4x4** x 22 Inside #1 Inside= 42.0"W x 43.0"H => 12.67 sf x 3.50'L = 44.3 cf Outside= 52.8"W x 48.0"H => 14.72 sf x 4.00'L = 58.9 cf 22 Chambers in 2 Rows
		2,417 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	33.50'	**40.000 in/hr Exfiltration @ 40.0 in/hr over Wetted area** Conductivity to Groundwater Elevation = 3.00'

Discarded OutFlow Max=1.47 cfs @ 12.42 hrs HW=36.84' (Free Discharge)
1=Exfiltration @ 40.0 in/hr (Controls 1.47 cfs)

Summary for Pond SDS-2: Leaching Galley

[42] Hint: Gap in defined storage above volume #1 at 30.42'

Inflow Area = 2.477 ac, 55.43% Impervious, Inflow Depth = 1.40" for 25-Year event
Inflow = 4.15 cfs @ 12.13 hrs, Volume= 0.290 af
Outflow = 1.67 cfs @ 12.65 hrs, Volume= 0.290 af, Atten= 60%, Lag= 31.0 min
Discarded = 1.67 cfs @ 12.65 hrs, Volume= 0.290 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 27.49' @ 12.65 hrs Surf.Area= 3,454 sf Storage= 4,328 cf

Plug-Flow detention time= 22.9 min calculated for 0.290 af (100% of inflow)
Center-of-Mass det. time= 22.8 min (793.8 - 770.9)

Volume	Invert	Avail.Storage	Storage Description
#1A	24.50'	5,299 cf	**27.20'W x 127.00'L x 5.92'H Field A** 20,439 cf Overall - 5,299 cf Embedded = 15,140 cf x 35.0% Voids
#2A	26.42'	3,991 cf	**Concrete Galley 4x4x4** x 90 Inside #1 Inside= 42.0"W x 43.0"H => 12.67 sf x 3.50'L = 44.3 cf Outside= 52.8"W x 48.0"H => 14.72 sf x 4.00'L = 58.9 cf 90 Chambers in 3 Rows
		9,290 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	24.50'	**14.690 in/hr Exfiltration @ 14.69 in/hr over Wetted area** Conductivity to Groundwater Elevation = 3.00'

Discarded OutFlow Max=1.67 cfs @ 12.65 hrs HW=27.49' (Free Discharge)
1=Exfiltration @ 14.69 in/hr (Controls 1.67 cfs)

Summary for Pond SDS-3: Leaching Galley

Inflow Area = 0.485 ac, 58.53% Impervious, Inflow Depth = 0.32" for 25-Year event
Inflow = 1.42 cfs @ 12.14 hrs, Volume= 0.013 af
Outflow = 0.06 cfs @ 12.51 hrs, Volume= 0.013 af, Atten= 96%, Lag= 22.4 min
Discarded = 0.06 cfs @ 12.51 hrs, Volume= 0.013 af
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 39.23' @ 12.51 hrs Surf.Area= 733 sf Storage= 468 cf

Plug-Flow detention time= 72.0 min calculated for 0.013 af (100% of inflow)
Center-of-Mass det. time= 72.0 min (808.5 - 736.5)

Volume	Invert	Avail.Storage	Storage Description
#1A	37.50'	1,082 cf	**18.80'W x 39.00'L x 5.50'H Field A** 4,033 cf Overall - 942 cf Embedded = 3,091 cf x 35.0% Voids
#2A	39.00'	710 cf	**Concrete Galley 4x4x4** x 16 Inside #1 Inside= 42.0"W x 43.0"H => 12.67 sf x 3.50'L = 44.3 cf Outside= 52.8"W x 48.0"H => 14.72 sf x 4.00'L = 58.9 cf 16 Chambers in 2 Rows
		1,791 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	37.50'	**2.780 in/hr Exfiltration @ 2.78 in/hr over Wetted area** Conductivity to Groundwater Elevation = 3.00'
#2	Secondary	42.30'	**8.0" Vert. Orifice/Grate** C= 0.600

Discarded OutFlow Max=0.06 cfs @ 12.51 hrs HW=39.23' (Free Discharge)
↑—**1=Exfiltration @ 2.78 in/hr** (Controls 0.06 cfs)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=37.50' (Free Discharge)
↑—**2=Orifice/Grate** (Controls 0.00 cfs)

Time span=0.00-24.00 hrs, dt=0.01 hrs, 2401 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind method - Pond routing by Stor-Ind method

Subcatchment DA#1: Post Development Runoff Area=30,570 sf 0.00% Impervious Runoff Depth>0.20"
Flow Length=215' Tc=7.6 min CN=32 Runoff=0.02 cfs 0.011 af

Subcatchment DA#10: Bldg Roof Area Runoff Area=9,985 sf 100.00% Impervious Runoff Depth>6.16"
Tc=0.0 min CN=98 Runoff=1.75 cfs 0.118 af

Subcatchment DA#11: Post Development Runoff Area=29,710 sf 27.96% Impervious Runoff Depth>1.42"
Flow Length=580' Tc=3.3 min CN=51 Runoff=1.07 cfs 0.081 af

Subcatchment DA#12: Post Development Runoff Area=174,015 sf 0.00% Impervious Runoff Depth>0.12"
Tc=5.0 min CN=30 Runoff=0.06 cfs 0.040 af

Subcatchment DA#13: Post Development Runoff Area=20,315 sf 0.00% Impervious Runoff Depth>0.20"
Tc=5.0 min CN=32 Runoff=0.01 cfs 0.008 af

Subcatchment DA#2: Post Development Runoff Area=20,985 sf 60.73% Impervious Runoff Depth>3.32"
Flow Length=185' Tc=7.6 min CN=72 Runoff=1.77 cfs 0.133 af

Subcatchment DA#3: Post Development Runoff Area=11,890 sf 79.15% Impervious Runoff Depth>4.68"
Flow Length=200' Tc=2.4 min CN=85 Runoff=1.67 cfs 0.106 af

Subcatchment DA#4: Post Development Runoff Area=21,105 sf 58.53% Impervious Runoff Depth>3.52"
Flow Length=252' Tc=2.3 min CN=74 Runoff=2.29 cfs 0.142 af

Subcatchment DA#5: Post Development Runoff Area=24,724 sf 97.52% Impervious Runoff Depth>6.04"
Flow Length=334' Tc=3.3 min CN=97 Runoff=3.90 cfs 0.286 af

Subcatchment DA#6: Post Development Runoff Area=37,958 sf 23.52% Impervious Runoff Depth>1.50"
Flow Length=400' Tc=3.9 min CN=52 Runoff=1.44 cfs 0.109 af

Subcatchment DA#7: Post Development Runoff Area=23,325 sf 31.57% Impervious Runoff Depth>2.01"
Flow Length=412' Tc=2.8 min CN=58 Runoff=1.34 cfs 0.090 af

Subcatchment DA#8: Post Development Runoff Area=12,143 sf 98.30% Impervious Runoff Depth>6.04"
Flow Length=164' Tc=2.9 min CN=97 Runoff=1.95 cfs 0.140 af

Subcatchment DA#9: Bldg Roof Area Runoff Area=10,043 sf 100.00% Impervious Runoff Depth>6.16"
Tc=0.0 min CN=98 Runoff=1.76 cfs 0.118 af

Pond BRS1: Bioretention A Peak Elev=42.19' Storage=3,834 cf Inflow=4.59 cfs 0.392 af
Discarded=0.11 cfs 0.137 af Primary=2.77 cfs 0.182 af Secondary=2.29 cfs 0.019 af Outflow=5.17 cfs 0.338 af

Pond BRS2: Bioretention B Peak Elev=34.22' Storage=593 cf Inflow=1.34 cfs 0.090 af
Discarded=0.06 cfs 0.050 af Primary=1.09 cfs 0.037 af Outflow=1.15 cfs 0.088 af

Pond BRS3: Bioretention C Peak Elev=34.34' Storage=7,600 cf Inflow=8.18 cfs 0.619 af
Discarded=0.20 cfs 0.202 af Primary=3.87 cfs 0.330 af Secondary=0.00 cfs 0.000 af Outflow=4.07 cfs 0.531 af

Pond BRS4: Bioretention D Peak Elev=45.99' Storage=1,494 cf Inflow=2.29 cfs 0.142 af
Discarded=0.22 cfs 0.118 af Primary=2.34 cfs 0.024 af Outflow=2.56 cfs 0.142 af

Pond D.Basin: Detention Basin Peak Elev=43.17' Storage=102 cf Inflow=1.07 cfs 0.092 af
Outflow=0.97 cfs 0.092 af

Pond Dep Hole: Existing Depression Peak Elev=36.05' Storage=30 cf Inflow=0.01 cfs 0.008 af
Outflow=0.01 cfs 0.007 af

Pond KH-pre: Kettle Hole: Existing Depression Peak Elev=18.15' Storage=561 cf Inflow=2.29 cfs 0.059 af
Outflow=0.41 cfs 0.058 af

Pond SDS-1: Leaching Galley Peak Elev=37.39' Storage=1,722 cf Inflow=2.77 cfs 0.182 af
Outflow=1.56 cfs 0.182 af

Pond SDS-2: Leaching Galley Peak Elev=28.29' Storage=5,810 cf Inflow=4.84 cfs 0.367 af
Outflow=1.81 cfs 0.367 af

Pond SDS-3: Leaching Galley Peak Elev=40.36' Storage=891 cf Inflow=2.34 cfs 0.024 af
Discarded=0.07 cfs 0.024 af Secondary=0.00 cfs 0.000 af Outflow=0.07 cfs 0.024 af

Total Runoff Area = 9.797 ac Runoff Volume = 1.383 af Average Runoff Depth = 1.69"
73.01% Pervious = 7.153 ac 26.99% Impervious = 2.644 ac

Time span=0.00-24.00 hrs, dt=0.01 hrs, 2401 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind method - Pond routing by Stor-Ind method

Subcatchment DA#1: Post Development Runoff Area=30,570 sf 0.00% Impervious Runoff Depth>0.36"
Flow Length=215' Tc=7.6 min CN=32 Runoff=0.07 cfs 0.021 af

Subcatchment DA#10: Bldg Roof Area Runoff Area=9,985 sf 100.00% Impervious Runoff Depth>6.96"
Tc=0.0 min CN=98 Runoff=1.98 cfs 0.133 af

Subcatchment DA#11: Post Development Runoff Area=29,710 sf 27.96% Impervious Runoff Depth>1.87"
Flow Length=580' Tc=3.3 min CN=51 Runoff=1.48 cfs 0.106 af

Subcatchment DA#12: Post Development Runoff Area=174,015 sf 0.00% Impervious Runoff Depth>0.25"
Tc=5.0 min CN=30 Runoff=0.14 cfs 0.082 af

Subcatchment DA#13: Post Development Runoff Area=20,315 sf 0.00% Impervious Runoff Depth>0.36"
Tc=5.0 min CN=32 Runoff=0.05 cfs 0.014 af

Subcatchment DA#2: Post Development Runoff Area=20,985 sf 60.73% Impervious Runoff Depth>3.99"
Flow Length=185' Tc=7.6 min CN=72 Runoff=2.14 cfs 0.160 af

Subcatchment DA#3: Post Development Runoff Area=11,890 sf 79.15% Impervious Runoff Depth>5.44"
Flow Length=200' Tc=2.4 min CN=85 Runoff=1.92 cfs 0.124 af

Subcatchment DA#4: Post Development Runoff Area=21,105 sf 58.53% Impervious Runoff Depth>4.22"
Flow Length=252' Tc=2.3 min CN=74 Runoff=2.74 cfs 0.170 af

Subcatchment DA#5: Post Development Runoff Area=24,724 sf 97.52% Impervious Runoff Depth>6.84"
Flow Length=334' Tc=3.3 min CN=97 Runoff=4.40 cfs 0.323 af

Subcatchment DA#6: Post Development Runoff Area=37,958 sf 23.52% Impervious Runoff Depth>1.96"
Flow Length=400' Tc=3.9 min CN=52 Runoff=1.97 cfs 0.143 af

Subcatchment DA#7: Post Development Runoff Area=23,325 sf 31.57% Impervious Runoff Depth>2.54"
Flow Length=412' Tc=2.8 min CN=58 Runoff=1.73 cfs 0.114 af

Subcatchment DA#8: Post Development Runoff Area=12,143 sf 98.30% Impervious Runoff Depth>6.84"
Flow Length=164' Tc=2.9 min CN=97 Runoff=2.19 cfs 0.159 af

Subcatchment DA#9: Bldg Roof Area Runoff Area=10,043 sf 100.00% Impervious Runoff Depth>6.96"
Tc=0.0 min CN=98 Runoff=1.99 cfs 0.134 af

Pond BRS1: Bioretention A Peak Elev=42.29' Storage=3,834 cf Inflow=5.29 cfs 0.453 af
Discarded=0.11 cfs 0.141 af Primary=2.96 cfs 0.221 af Secondary=3.65 cfs 0.033 af Outflow=6.73 cfs 0.395 af

Pond BRS2: Bioretention B Peak Elev=34.28' Storage=635 cf Inflow=1.73 cfs 0.114 af
Discarded=0.06 cfs 0.054 af Primary=1.55 cfs 0.056 af Outflow=1.62 cfs 0.110 af

Pond BRS3: Bioretention C Peak Elev=34.67' Storage=8,514 cf Inflow=9.62 cfs 0.723 af
Discarded=0.21 cfs 0.209 af Primary=4.32 cfs 0.421 af Secondary=0.00 cfs 0.000 af Outflow=4.53 cfs 0.629 af

Pond BRS4: Bioretention D Peak Elev=46.43' Storage=1,494 cf Inflow=2.74 cfs 0.170 af
Discarded=0.22 cfs 0.131 af Primary=3.23 cfs 0.040 af Outflow=3.45 cfs 0.170 af

Pond D.Basin: Detention Basin Peak Elev=43.23' Storage=148 cf Inflow=1.48 cfs 0.127 af
Outflow=1.36 cfs 0.127 af

Pond Dep Hole: Existing Depression Peak Elev=36.14' Storage=81 cf Inflow=0.05 cfs 0.014 af
Outflow=0.02 cfs 0.014 af

Pond KH-pre: Kettle Hole: Existing Depression Peak Elev=18.25' Storage=961 cf Inflow=3.65 cfs 0.115 af
Outflow=0.55 cfs 0.114 af

Pond SDS-1: Leaching Galley Peak Elev=38.03' Storage=2,044 cf Inflow=2.96 cfs 0.221 af
Outflow=1.68 cfs 0.221 af

Pond SDS-2: Leaching Galley Peak Elev=29.40' Storage=7,877 cf Inflow=5.63 cfs 0.477 af
Outflow=2.01 cfs 0.477 af

Pond SDS-3: Leaching Galley Peak Elev=41.97' Storage=1,493 cf Inflow=3.23 cfs 0.040 af
Discarded=0.09 cfs 0.040 af Secondary=0.00 cfs 0.000 af Outflow=0.09 cfs 0.040 af

Total Runoff Area = 9.797 ac Runoff Volume = 1.683 af Average Runoff Depth = 2.06"
73.01% Pervious = 7.153 ac 26.99% Impervious = 2.644 ac