ALLEN & MAJOR
ASSOCIATES, INC.

SITE LOCUS

#230 BEAL STREET

HINGHAM, MASSACHUSETTS

DRAINAGE REPORT

DATE PREPARED: AUGUST 12, 2016

DATE REVISED: OCTOBER 25, 2016

CLIENT:
ALLIANCE RESIDENTIAL COMPANY NEW ENGLAND
184 HIGH STREET, SUITE 401
BOSTON, MA 02110

PREPARED BY:
ALLEN & MAJOR ASSOCIATES, INC.
100 COMMERCE WAY
WOBURN, MASSACHUSETTS 01888

COMMONWEALTH OF MASSACHUSETTS
CARLTON M.
QUINN
CIVIL
No. 49923
REGISTERED
PROFESSIONAL ENGINEER

10-25-2016

A&M PROJECT NO. : 2118-02

DRAINAGE REPORT

BROADSTONE BARE COVE

HINGHAM, MA

PROPONENT:

ALLIANCE RESIDENTIAL COMPANY NEW ENGLAND
184 HIGH STREET, SUITE 401
BOSTON, MA 02110

PREPARED BY:

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P.O. BOX 2118
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ISSUED:
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Section 1.0

Section 2.0

Section 3.0

Section 4.0

Section 5.0

Section 6.0

INTRODUCTION

The purpose of this drainage report is to provide an overview of the proposed stormwater management system (SMS) for the multi-family residential development, Broadstone Bare Cove, in Hingham, MA. The report will show by means of narrative, calculations and exhibits that the proposed stormwater management system will meet or exceed the 10 Massachusetts Department of Environment Protection (DEP) stormwater standards.

The proposed site improvements include one 3/4-story building and one 2/4-story multi-family residential buildings with 220 total units, outdoor pool & courtyard, fitness center, loading/unloading area, sub-grade parking garage, surface parking, and associated site-work.

The SMS incorporates structural and non-structural Best Management Practices (BMPs) to provide stormwater peak flow mitigation, quality treatment, and conveyance. The SMS includes deep-sump catch basins, drain manholes, hydrodynamic separators, underground infiltration systems, headwalls, drainage channel, outlet protection, and a long-term Operation and Maintenance Plan.

SITE CATEGORIZATION FOR STORMWATER REGULATIONS

The proposed site improvements at Broadstone Bare Cove are considered a new development under the DEP Stormwater Management Standards due to the net increase in impervious area. A “new development” project is required to meet the all of Stormwater Management Standards listed within the MA DEP Stormwater Handbook.

SITE LOCATION AND ACCESS

The subject property is located at 230 Beal Street and is approximately 12.06± acres in size. The property is located in the northwesterly portion of the Town of Hingham, Massachusetts near the border of the Town of Weymouth, and is located entirely with the Town limits. Hingham is located in Plymouth County and is approximately 14 miles southeasterly of the City of Boston. The site is located approximately 500 feet south of the intersection of Beal Street and Route 3A and approximately 120 feet east/northeast of Beal Cove on the northern edge of Bare Cove Park. Exhibit 1 shows the location of the property on Beal Street.

The parcel is abutted by an undeveloped, municipally-owned land to the west, the 484± acre Bare Cove Park to the south, an 8± acre ball field complex to the north, and to the east are the Back River Townhomes; a 45 unit luxury condo development. Across the street from the site is a retail development including Stop & Shop and Marshall’s.

EXISTING SITE CONDITIONS

The site is currently developed and includes a 43,600± square foot (SF), one-story commercial building with an approximately 700 foot long, 24' wide paved access driveway and parking lot containing approximately 120 parking spaces. The driveway has a curb cut on Beal Street approximately 100 feet wide and the existing building is set back approximately 600 feet from Beal Street.

The area east of the paved access driveway is mostly open space comprised of trees and forest. The topography in this area slopes from east to west (ranging from EL. 30 to EL. 18) toward a low point abutting the paved access drive, where water is collected by a catch basin. The area west of the entrance drive slopes away from the drive (2:1 max). All stormwater in this area sheet flows offsite to the abutting wetlands. Stormwater from the entrace drive is collected by catch basins and discharges, untreated, to the abutting wetlands to the west of the site.

The developed area consisiting of the existing building and parking area varies in elevation from EL. 33 west of the building to EL. 18 south of the building. Stormwater from the parking area and building ultimately discharges, untreated, to the wetlands at the southern portion of the site.

The southern portion of the site, beyond the existing building, is undeveloped and consists of wetlands, grass areas, and heavy forest. The terrain in this area slopes north to south and ranges from EL. 39 at the top of the ridge to EL. 2 at the southwest wetland area.

WATERSHED

The subject property is located within the Weymouth Back River Watershed, which is part of the larger Boston Harbor Watershed. The Weymouth Back River is primarily a tidal river, which flows from Whitman's Pond north to Hingham Bay, and ultimately Boston Harbor.

The Boston Harbor watershed has a drainage area of approximately 293 square miles, includes all or part of 45 Massachusetts municipalities, as well as most of downtown Boston, and is located in and around Boston Harbor. The watershed also includes the Mystic River watershed to the north and the Neponset, Fore, Back, and Weir River watersheds to the south.

The Boston Harbor Watershed is not protected under the Watershed Protection Act and has no associated land use restrictions. However, the Weymouth Back River Watershed is contained within the 950-acre Back River Area of Critical Environmental Concern (ACEC). See section entitled "Environmentally Sensitive Zones" and "MA DEP Stormwater Performance Standards" for further information.

EXISTING SOIL CONDITIONS

The on-site soils were identified using the USDA Natural Resources Conservation Services (NRCS) Soil Survey for Plymouth County. The sites soil types and corresponding Hydrologic Soil Groups (HSG) include:

- 254B (HSG-A) - Merrimac fine sandy loam, 3-8% slopes
- 654B (HSG-B) - Udorthents, loamy, 0-8% slopes
- 656B (HSG-B) - Udorthents, Urban land complex, 0-8% slopes
- 657A (HSG-D) - Aquepts, 0-3% slopes
- 659B (HSG-B) - Udorthents; 0-8% slopes, gravelly
- 660C (HSG-B) - Udorthents, 0-8% slopes, gravelly

Urban land consists of areas where the soil has been altered or obscured by buildings, or paved areas. A copy of the soil mapping is included in the Appendix of this report.

FEMA FLOODPLAIN/ENVIRONMENTAL DUE DILIGENCE

The Flood Insurance Rate Map (FIRM) (Map Number 25023C0081J) for the Town of Hingham dated July 17, 2012indicates that the parcel lies within the FEMA *Zone X*. The FEMA *Zone X* at this location is defined as "areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual flood."

The entirety of the site is located outside the 100-year floodplain, and all proposed developed portions of the site are outside of the 500-year Floodplain. See Exhibit 3: FEMA FIRM Map.

ENVIRONMENTALLY SENSATIVE ZONES

The Commonwealth of Massachusetts asserts control over numerous protected and regulated areas including: Areas of Critical Environmental Concern (ACEC); Outstanding Resource Waters (ORWs); areas protected under the Wetlands Protection Act and the Rivers Protection Act, as well as Priority and Protected Habitat for rare and endangered species.

A portion of the south west of the site is located within an ORW and is defined as an "ORW for ACEC"; see Exhibit 4. The site is in a Zone SA (most highly protected coastal and marine classes). This designation will require Stormwater discharges to meet a higher water quality than standard stormwater water quality design practices per Standard 6 of the DEP Stormwater Regulations.

In addition, a review of the latest Massachusetts Heritage Atlas; 13th Edition, reveals that there is a Certified Vernal Pool approximately 350 feet west of the site. There are no Estimated Priority Habitats on or directly adjacent to the site.

DRAINAGE ANALYSIS METHODOLOGY

A peak rate of runoff will be determined using techniques and data found in the following:

1. Urban Hydrology for Small Watersheds – Technical Release 55 by the United States Department of Agriculture Soils Conservation Service, June 1986. Runoff curve numbers and 24-hour precipitation values were obtained from this reference.

2. HydroCAD© Stormwater Modeling System by HydroCAD Software Solutions LLC, version 10.00, 2013. The HydroCAD program was used to generate the runoff hydrographs for the watershed areas, to determine discharge/stage/storage characteristics for the stormwater BMPs, to perform drainage routing and to combine the results of the runoff hydrographs. HydroCAD uses the TR-20 methodology of the SCS Unit Hydrograph procedure (SCS-UH).

3. Soil Survey of Plymouth County Massachusetts by United States Department of Agriculture, NRCS. Soil types and boundaries were obtained from this reference.

PEAK RATE OF RUNOFF

The storm water runoff analysis of the existing and proposed conditions includes an estimate of the peak rate of runoff from various rainfall events. Peak runoff rates were developed using TR-55 Urban Hydrology for Small Watersheds, developed by the U.S. Department of Commerce, Engineering Division and the HydroCAD computer program. Further, the analysis has been prepared in accordance with the MA DEP and the Town of Hingham requirements and standard engineering practices. The peak rate of runoff has been estimated for each watershed during the 2, 10 and 100-year storm events.

Proposed Underground Infiltration Systems receive storm water directly from the proposed roof and pretreated site areas. The systems have been designed to mitigate the required recharge and water quality volume. The systems provide greater than four feet of separation from groundwater and drain down within the recommended 72 hours.

As part of the site design both proposed buildings shall have sub-surface parking garages. Catch Basins 3A and 3B (CB#3A, CB#3B) collect water sheet flowing down the access ramp to this parking garage at Building #1. Due to the low elevation of the catch basin inverts, coupled with the discharge elevation at the west side of the entrance drive, it was not possible to design a SMS using entirely gravity pipes. Therefore, a 12,000-gallon storage tank and pump station are included in the design. Water is collected by CB#3A and 3B, flows through 12” HDPE gravity pipes to the storage tank where it is pumped approximately 10 vertical feet to Contech CDS Unit #3.

The storage chamber has been designed to hold the 100-year storm, and the pump shall be designed to discharge to 100-year peak flow rate. See HydroCAD and DEP Calculations in the appendix of this report.

The stormwater runoff model shows that the proposed site development reduces the rate of runoff during all storm events at the identified points of analysis. The following tables provide a summary of the estimated peak rate at each Study Point during each of the design storm events. The HydroCAD worksheets are included in Section 4 of this report.

STUDY POINT #1 (Flow to wetlands west of site)

	2-Year	10-Year	100-Year
Existing Runoff (CFS)	1.87	5.18	12.85
Proposed Runoff (CFS)	1.25	4.38	12.19
% REDUCTION	33.2%	15.4%	5.14%

STUDY POINT #2 (Flow to low point at southeast corner of site)

	2-Year	10-Year	100-Year
Existing Runoff (CFS)	4.61	8.36	15.65
Proposed Runoff (CFS)	3.17	6.65	12.79
% REDUCTION	31.2%	20.5%	18.3%

STUDY POINT #3 (Flow to wetlands at southwest corner of site)

	2-Year	10-Year	100-Year
Existing Runoff (CFS)	1.04	2.49	5.63
Proposed Runoff (CFS)	0.94	2.36	5.44
% REDUCTION	9.62%	5.22%	3.20%

MA DEP STORMWATER PERFORMANCE STANDARDS

The MA DEP Stormwater Management Policy was developed to improve water quality by implementing performance standards for storm water management. The intent is to implement the stormwater management standards through the review of Notice of Intent filings by the issuing authority (Conservation Commission or DEP). The following section outlines how the proposed Stormwater Management System meets the standards set forth by the Policy.

BMP’s implemented in the design include:

- Deep sump Catch Basins
- Hydro-dynamic (Proprietary) Separators
- Infiltration System

Drainage Channel
Specific maintenance schedule

Stormwater Best Management Practices have been incorporated into the design of the project to mitigate the anticipated pollutant loading. An Operations and Maintenance Plan has been developed for the project, which addresses the long-term maintenance requirements of the proposed system.

Temporary erosion and sedimentation controls will be incorporated into the construction phase of the project. These temporary controls may include straw bale and/or silt fence barriers, inlet sediment traps, diversion channels, slope stabilization, and stabilized construction entrances.

The Massachusetts Department of Environmental Protection has established ten (10) Stormwater Management Standards. A project that meets or exceeds the standards is presumed to satisfy the regulatory requirements regarding stormwater management. The Standards are enumerated below as well as descriptions and supporting calculations as to how the Project will comply with the Standards:

1. *No new stormwater conveyances (e.g. outfalls) may discharge untreated stormwater directly to or cause erosion in wetlands or waters of the Commonwealth.*

The proposed development will not introduce any new stormwater conveyances (e.g. outfalls) that discharge untreated stormwater directly to or cause erosion in wetlands or waters of the Commonwealth.

For computations demonstrating discharges are adequately treated please see computations for Standard 4 through Standard 6. Additionally, all outfalls have been designed to provide standard Rip Rap outfalls as calculated in Section 6.16.

2. *Stormwater management systems shall be designed so that post-development peak discharge rates do not exceed pre-development peak discharge rates. This Standard may be waived for discharges to land subject to coastal storm flowage as defined in 310 CMR 10.04.*

The proposed development will be designed so that the post-development peak discharge rates do not exceed the pre-development peak discharge rates.

3. *Loss of annual recharge to groundwater shall be eliminated or minimized through the use of infiltration measures including environmentally sensitive site design, low impact development techniques, stormwater best management practices, and good operation and maintenance. At a minimum, the annual recharge from the post-development site shall approximate the annual recharge from pre-development conditions based on soil type. This Standard is met when the stormwater management system is designed to infiltrate the required recharge volume as determined in accordance with the Massachusetts Stormwater Handbook.*

The existing annual recharge for the site will be approximated in the developed condition. Subsurface infiltration systems will be designed to meet this requirement. The proposed Recharge Volume for Underground Infiltration Systems #2-4 will be based on the Static Method, while Underground Infiltration System #1 was designed using the Simple Dynamic Method per the MA DEP Stormwater Management Standards, Volume 3, Chapter 1. See below for calculation of minimum recharge volume for Underground Infiltration System #1 using the "*Simple Dynamic*" Method.

Rv = Required Recharge Volume = 2,636 C.F.
A = Minimum required surface area [A = Rv/ (D + Kt)]
V = Required Volume using "*Simple Dynamic*" Method (V = A x D)
K = Saturated hydraulic conductivity (Rawl's Rate for Sand) = 8.27 → 8.3 inches/hour
T = the allowable drawdown time during the peak storm = 2 hours
D = Depth of Infiltration Basin = 5.5 feet
A = Rv/ (D + Kt)
A = (2,636 C.F.)/ (5.5 feet + (8.3inches/hour x 2 hours x 1ft/12inches) = 382.95 S.F.
V = A x D = 382.95 S.F. x 5.5 FT. = 2,106 C.F.

See Section 6.15 for water quality/recharge calculations for Underground Infiltration Systems 2-5.

4. *Stormwater management systems shall be designed to remove 80% of the average annual post-construction load of Total Suspended Solids (TSS). This Standard is met when:*

    a. *Suitable practices for source control and pollution prevention are identified in a long-term pollution prevention plan, and thereafter are implemented and maintained;*

b. *Structural stormwater best management practices are sized to capture the required water quality volume determined in accordance with the Massachusetts Stormwater Handbook; and*
c. *Pretreatment is provided in accordance with the Massachusetts Stormwater Handbook.*

The proposed stormwater management system will be designed so that the 80% TSS removal standard will be met for each drainage area. Standard #4 is met when structural stormwater best management practices are sized to capture and treat the required water quality volume and pretreatment is provided in accordance with the Massachusetts Stormwater Handbook. Standard #4 also requires that suitable source control measures are identified in the Long-Term Pollution Prevention Plan.

Additionally, because discharge is from land uses with higher potential pollutant loads, the proposed stormwater management system will be designed so that prior to each discharge to an infiltration structure, the 44% TSS removal standard will be met using some combination of the following: Deep Sump Catch Basins and Proprietary Separators.

The water quality volume for the site development will be captured and treated using Deep Sump Catch Basins, Proprietary Separators, and Underground Infiltration Systems equipped with isolator rows. All systems will be sized to meet the water quality flow rate for the 1” storm event. See DEP Calculations in the appendix of this report.

5. *For land uses with higher potential pollutant loads, source control and pollution prevention shall be implemented in accordance with the Massachusetts Stormwater Handbook to eliminate or reduce the discharge of stormwater runoff from such land uses to the maximum extent practicable. If through source control and/or pollution prevention all land uses with higher potential pollutant loads cannot be completely protected from exposure to rain, snow, snow melt, and stormwater runoff, the proponent shall use the specific structural stormwater BMPs determined by the Department to be suitable for such uses as provided in the Massachusetts Stormwater Handbook. Stormwater discharges from land uses with higher potential pollutant loads shall also comply with the requirements of the Massachusetts Clean Waters Act, M.G.L. c. 21, §§ 26-53 and the regulations promulgated thereunder at 314 CMR 3.00, 314 CMR 4.00 and 314 CMR 5.00.*

The proposed development may be considered a source of higher potential pollutant loads because there are greater than 1,000 vehicle trips per day. Pre-treatment and source reduction is provided to the maximum extent practicable. The drainage system will be designed to treat 1” water quality volume and provide 44% TSS removal prior to discharge to an infiltration device.

6. *Stormwater discharges within the Zone II or Interim Wellhead Protection Area of a public water supply, and stormwater discharges near or to any other critical area, require the use of the specific source control and pollution prevention measures and the specific structural stormwater best management practices determined by the Department to be suitable for managing discharges to such areas, as provided in the Massachusetts Stormwater Handbook. A discharge is near a critical area if there is a strong likelihood of a significant impact occurring to said area, taking into account site-specific factors. Stormwater discharges to Outstanding Resource Waters and Special Resource Waters shall be removed and set back from the receiving water or wetland and receive the highest and best practical method of treatment. A "storm water discharge" as defined in 314 CMR 3.04(2)(a)1 or (b) to an Outstanding Resource Water or Special Resource Water shall comply with 314 CMR 3.00 and 314 CMR 4.00. Stormwater discharges to a Zone I or Zone A are prohibited unless essential to the operation of a public water supply.*

The project site lies within an Outstanding Resource Waters for Areas of Critical Environmental Concern (Zone SA) as designated in 314 CMR 4.00. The Site is within the Weymouth Back River Watershed. The watershed is contained within the 950-acre Back River Area of Critical Concern (ACEC). Currently, stormwater generated on paved surfaces flow unmitigated (untreated) to the neighboring wetlands, and ultimately to the Weymouth Back River.

As such, the Site's proposed stormwater management system has been designed to the highest and best practical treatment standards prior to infiltration to the groundwater. In conclusion, the proposed stormwater management system will be a vast improvement over the existing conditions.

7. *A redevelopment project is required to meet the following Stormwater Management Standards only to the maximum extent practicable: Standard 2, Standard 3, and the pretreatment and structural best management practice requirements of Standards 4, 5, and 6. Existing stormwater discharges shall comply with Standard 1 only to the maximum extent practicable. A redevelopment project shall also comply with all other requirements of the Stormwater Management Standards and improve existing conditions.*

The proposed project is not considered a re-development project under the Stormwater Management Handbook guidelines as there is an increase in the amount of impervious area.

8. *A plan to control construction-related impacts including erosion, sedimentation and other pollutant sources during construction and land disturbance activities (construction period erosion, sedimentation, and pollution prevention plan) shall be developed and implemented.*

A plan to control construction-related impacts, including erosion, sedimentation and other pollutant sources during construction and land disturbance activities will be developed. The proponent will prepare and submit a Stormwater Pollution Prevention Plan (SWPPP) prior to commencement of construction activities that will result in the disturbance of one acre of land or more.

9. *A long-term operation and maintenance plan shall be developed and implemented to ensure that stormwater management systems function as designed.*

A Long-Term Operation and Maintenance (O&M) Plan has been developed for the proposed stormwater management system and is included within this document. See Section 2.0 of this report.

10. *All illicit discharges to the stormwater management system are prohibited.*

There are no expected illicit discharges to the stormwater management system. The applicant will submit the Illicit Discharge Compliance Statement prior to the discharge of stormwater runoff to the post-construction stormwater best management practices.

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands Program

Checklist for Stormwater Report

A. Introduction

Important: When filling out forms on the computer, use only the tab key to move your cursor - do not use the return key.

A Stormwater Report must be submitted with the Notice of Intent permit application to document compliance with the Stormwater Management Standards. The following checklist is NOT a substitute for the Stormwater Report (which should provide more substantive and detailed information) but is offered here as a tool to help the applicant organize their Stormwater Management documentation for their Report and for the reviewer to assess this information in a consistent format. As noted in the Checklist, the Stormwater Report must contain the engineering computations and supporting information set forth in Volume 3 of the Massachusetts Stormwater Handbook. The Stormwater Report must be prepared and certified by a Registered Professional Engineer (RPE) licensed in the Commonwealth.

The Stormwater Report must include:

- The Stormwater Checklist completed and stamped by a Registered Professional Engineer (see page 2) that certifies that the Stormwater Report contains all required submittals.[1] This Checklist is to be used as the cover for the completed Stormwater Report.
- Applicant/Project Name
- Project Address
- Name of Firm and Registered Professional Engineer that prepared the Report
- Long-Term Pollution Prevention Plan required by Standards 4-6
- Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan required by Standard 8[2]
- Operation and Maintenance Plan required by Standard 9

In addition to all plans and supporting information, the Stormwater Report must include a brief narrative describing stormwater management practices, including environmentally sensitive site design and LID techniques, along with a diagram depicting runoff through the proposed BMP treatment train. Plans are required to show existing and proposed conditions, identify all wetland resource areas, NRCS soil types, critical areas, Land Uses with Higher Potential Pollutant Loads (LUHPPL), and any areas on the site where infiltration rate is greater than 2.4 inches per hour. The Plans shall identify the drainage areas for both existing and proposed conditions at a scale that enables verification of supporting calculations.

As noted in the Checklist, the Stormwater Management Report shall document compliance with each of the Stormwater Management Standards as provided in the Massachusetts Stormwater Handbook. The soils evaluation and calculations shall be done using the methodologies set forth in Volume 3 of the Massachusetts Stormwater Handbook.

To ensure that the Stormwater Report is complete, applicants are required to fill in the Stormwater Report Checklist by checking the box to indicate that the specified information has been included in the Stormwater Report. If any of the information specified in the checklist has not been submitted, the applicant must provide an explanation. The completed Stormwater Report Checklist and Certification must be submitted with the Stormwater Report.

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[1] The Stormwater Report may also include the Illicit Discharge Compliance Statement required by Standard 10. If not included in the Stormwater Report, the Illicit Discharge Compliance Statement must be submitted prior to the discharge of stormwater runoff to the post-construction best management practices.

[2] For some complex projects, it may not be possible to include the Construction Period Erosion and Sedimentation Control Plan in the Stormwater Report. In that event, the issuing authority has the discretion to issue an Order of Conditions that approves the project and includes a condition requiring the proponent to submit the Construction Period Erosion and Sedimentation Control Plan before commencing any land disturbance activity on the site.

Checklist for Stormwater Report

B. Stormwater Checklist and Certification

The following checklist is intended to serve as a guide for applicants as to the elements that ordinarily need to be addressed in a complete Stormwater Report. The checklist is also intended to provide conservation commissions and other reviewing authorities with a summary of the components necessary for a comprehensive Stormwater Report that addresses the ten Stormwater Standards.

Note: Because stormwater requirements vary from project to project, it is possible that a complete Stormwater Report may not include information on some of the subjects specified in the Checklist. If it is determined that a specific item does not apply to the project under review, please note that the item is not applicable (N.A.) and provide the reasons for that determination.

A complete checklist must include the Certification set forth below signed by the Registered Professional Engineer who prepared the Stormwater Report.

Registered Professional Engineer's Certification

I have reviewed the Stormwater Report, including the soil evaluation, computations, Long-term Pollution Prevention Plan, the Construction Period Erosion and Sedimentation Control Plan (if included), the Long-term Post-Construction Operation and Maintenance Plan, the Illicit Discharge Compliance Statement (if included) and the plans showing the stormwater management system, and have determined that they have been prepared in accordance with the requirements of the Stormwater Management Standards as further elaborated by the Massachusetts Stormwater Handbook. I have also determined that the information presented in the Stormwater Checklist is accurate and that the information presented in the Stormwater Report accurately reflects conditions at the site as of the date of this permit application.

Registered Professional Engineer Block and Signature

COMMONWEALTH OF MASSACHUSETTS
CARLTON M. QUINN
CIVIL
No. 49923
REGISTERED PROFESSIONAL ENGINEER

10/25/2016

Signature and Date

Checklist

Project Type: Is the application for new development, redevelopment, or a mix of new and redevelopment?

☒ New development

☐ Redevelopment

☐ Mix of New Development and Redevelopment

Checklist (continued)

LID Measures: Stormwater Standards require LID measures to be considered. Document what environmentally sensitive design and LID Techniques were considered during the planning and design of the project:

☒ No disturbance to any Wetland Resource Areas

☐ Site Design Practices (e.g. clustered development, reduced frontage setbacks)

☐ Reduced Impervious Area (Redevelopment Only)

☒ Minimizing disturbance to existing trees and shrubs

☐ LID Site Design Credit Requested:

- ☐ Credit 1
- ☐ Credit 2
- ☐ Credit 3

☐ Use of “country drainage” versus curb and gutter conveyance and pipe

☐ Bioretention Cells (includes Rain Gardens)

☐ Constructed Stormwater Wetlands (includes Gravel Wetlands designs)

☐ Treebox Filter

☐ Water Quality Swale

☐ Grass Channel

☐ Green Roof

☒ Other (describe): Drainage Channel (No TSS credit taken)

Standard 1: No New Untreated Discharges

☒ No new untreated discharges

☒ Outlets have been designed so there is no erosion or scour to wetlands and waters of the Commonwealth

☒ Supporting calculations specified in Volume 3 of the Massachusetts Stormwater Handbook included.

Checklist (continued)

Standard 2: Peak Rate Attenuation

☐ Standard 2 waiver requested because the project is located in land subject to coastal storm flowage and stormwater discharge is to a wetland subject to coastal flooding.

☐ Evaluation provided to determine whether off-site flooding increases during the 100-year 24-hour storm.

☒ Calculations provided to show that post-development peak discharge rates do not exceed pre-development rates for the 2-year and 10-year 24-hour storms. If evaluation shows that off-site flooding increases during the 100-year 24-hour storm, calculations are also provided to show that post-development peak discharge rates do not exceed pre-development rates for the 100-year 24-hour storm.

Standard 3: Recharge

☒ Soil Analysis provided.

☒ Required Recharge Volume calculation provided.

☐ Required Recharge volume reduced through use of the LID site Design Credits.

☒ Sizing the infiltration, BMPs is based on the following method: Check the method used.

☒ Static ☒ Simple Dynamic ☐ Dynamic Field[1]

☒ Runoff from all impervious areas at the site discharging to the infiltration BMP.

☐ Runoff from all impervious areas at the site is *not* discharging to the infiltration BMP and calculations are provided showing that the drainage area contributing runoff to the infiltration BMPs is sufficient to generate the required recharge volume.

☒ Recharge BMPs have been sized to infiltrate the Required Recharge Volume.

☐ Recharge BMPs have been sized to infiltrate the Required Recharge Volume *only* to the maximum extent practicable for the following reason:

- ☐ Site is comprised solely of C and D soils and/or bedrock at the land surface
- ☐ M.G.L. c. 21E sites pursuant to 310 CMR 40.0000
- ☐ Solid Waste Landfill pursuant to 310 CMR 19.000
- ☐ Project is otherwise subject to Stormwater Management Standards only to the maximum extent practicable.

☒ Calculations showing that the infiltration BMPs will drain in 72 hours are provided.

☐ Property includes a M.G.L. c. 21E site or a solid waste landfill and a mounding analysis is included.

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[1] 80% TSS removal is required prior to discharge to infiltration BMP if Dynamic Field method is used.

Checklist (continued)

Standard 3: Recharge (continued)

☐ The infiltration BMP is used to attenuate peak flows during storms greater than or equal to the 10-year 24-hour storm and separation to seasonal high groundwater is less than 4 feet and a mounding analysis is provided.

☐ Documentation is provided showing that infiltration BMPs do not adversely impact nearby wetland resource areas.

Standard 4: Water Quality

The Long-Term Pollution Prevention Plan typically includes the following:

- Good housekeeping practices;
- Provisions for storing materials and waste products inside or under cover;
- Vehicle washing controls;
- Requirements for routine inspections and maintenance of stormwater BMPs;
- Spill prevention and response plans;
- Provisions for maintenance of lawns, gardens, and other landscaped areas;
- Requirements for storage and use of fertilizers, herbicides, and pesticides;
- Pet waste management provisions;
- Provisions for operation and management of septic systems;
- Provisions for solid waste management;
- Snow disposal and plowing plans relative to Wetland Resource Areas;
- Winter Road Salt and/or Sand Use and Storage restrictions;
- Street sweeping schedules;
- Provisions for prevention of illicit discharges to the stormwater management system;
- Documentation that Stormwater BMPs are designed to provide for shutdown and containment in the event of a spill or discharges to or near critical areas or from LUHPPL;
- Training for staff or personnel involved with implementing Long-Term Pollution Prevention Plan;
- List of Emergency contacts for implementing Long-Term Pollution Prevention Plan.

☒ A Long-Term Pollution Prevention Plan is attached to Stormwater Report and is included as an attachment to the Wetlands Notice of Intent.

☒ Treatment BMPs subject to the 44% TSS removal pretreatment requirement and the one inch rule for calculating the water quality volume are included, and discharge:

  ☐ is within the Zone II or Interim Wellhead Protection Area

  ☒ is near or to other critical areas

  ☒ is within soils with a rapid infiltration rate (greater than 2.4 inches per hour)

  ☒ involves runoff from land uses with higher potential pollutant loads.

☐ The Required Water Quality Volume is reduced through use of the LID site Design Credits.

☒ Calculations documenting that the treatment train meets the 80% TSS removal requirement and, if applicable, the 44% TSS removal pretreatment requirement, are provided.

Checklist (continued)

Standard 4: Water Quality (continued)

☒ The BMP is sized (and calculations provided) based on:

- ☒ The ½" or 1" Water Quality Volume or
- ☒ The equivalent flow rate associated with the Water Quality Volume and documentation is provided showing that the BMP treats the required water quality volume.

☒ The applicant proposes to use proprietary BMPs, and documentation supporting use of proprietary BMP and proposed TSS removal rate is provided. This documentation may be in the form of the propriety BMP checklist found in Volume 2, Chapter 4 of the Massachusetts Stormwater Handbook and submitting copies of the TARP Report, STEP Report, and/or other third party studies verifying performance of the proprietary BMPs.

☐ A TMDL exists that indicates a need to reduce pollutants other than TSS and documentation showing that the BMPs selected are consistent with the TMDL is provided.

Standard 5: Land Uses With Higher Potential Pollutant Loads (LUHPPLs)

☐ The NPDES Multi-Sector General Permit covers the land use and the Stormwater Pollution Prevention Plan (SWPPP) has been included with the Stormwater Report.

☒ The NPDES Multi-Sector General Permit covers the land use and the SWPPP will be submitted ***prior to*** the discharge of stormwater to the post-construction stormwater BMPs.

☐ The NPDES Multi-Sector General Permit does ***not*** cover the land use.

☐ LUHPPLs are located at the site and industry specific source control and pollution prevention measures have been proposed to reduce or eliminate the exposure of LUHPPLs to rain, snow, snow melt and runoff, and been included in the long term Pollution Prevention Plan.

☐ All exposure has been eliminated.

☐ All exposure has ***not*** been eliminated and all BMPs selected are on MassDEP LUHPPL list.

☒ The LUHPPL has the potential to generate runoff with moderate to higher concentrations of oil and grease (e.g. all parking lots with >1000 vehicle trips per day) and the treatment train includes an oil grit separator, a filtering bioretention area, a sand filter or equivalent.

Standard 6: Critical Areas

☒ The discharge is near or to a critical area and the treatment train includes only BMPs that MassDEP has approved for stormwater discharges to or near that particular class of critical area.

☒ Critical areas and BMPs are identified in the Stormwater Report.

Checklist (continued)

Standard 7: Redevelopments and Other Projects Subject to the Standards only to the maximum extent practicable

☐ The project is subject to the Stormwater Management Standards only to the maximum Extent Practicable as a:

- ☐ Limited Project
- ☐ Small Residential Projects: 5-9 single family houses or 5-9 units in a multi-family development provided there is no discharge that may potentially affect a critical area.
- ☐ Small Residential Projects: 2-4 single family houses or 2-4 units in a multi-family development with a discharge to a critical area
- ☐ Marina and/or boatyard provided the hull painting, service and maintenance areas are protected from exposure to rain, snow, snow melt and runoff
- ☐ Bike Path and/or Foot Path
- ☐ Redevelopment Project
- ☐ Redevelopment portion of mix of new and redevelopment.

☐ Certain standards are not fully met (Standard No. 1, 8, 9, and 10 must always be fully met) and an explanation of why these standards are not met is contained in the Stormwater Report.

☐ The project involves redevelopment and a description of all measures that have been taken to improve existing conditions is provided in the Stormwater Report. The redevelopment checklist found in Volume 2 Chapter 3 of the Massachusetts Stormwater Handbook may be used to document that the proposed stormwater management system (a) complies with Standards 2, 3 and the pretreatment and structural BMP requirements of Standards 4-6 to the maximum extent practicable and (b) improves existing conditions.

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Control

A Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan must include the following information:

- Narrative;
- Construction Period Operation and Maintenance Plan;
- Names of Persons or Entity Responsible for Plan Compliance;
- Construction Period Pollution Prevention Measures;
- Erosion and Sedimentation Control Plan Drawings;
- Detail drawings and specifications for erosion control BMPs, including sizing calculations;
- Vegetation Planning;
- Site Development Plan;
- Construction Sequencing Plan;
- Sequencing of Erosion and Sedimentation Controls;
- Operation and Maintenance of Erosion and Sedimentation Controls;
- Inspection Schedule;
- Maintenance Schedule;
- Inspection and Maintenance Log Form.

☒ A Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan containing the information set forth above has been included in the Stormwater Report.

Checklist (continued)

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Control (continued)

☐ The project is highly complex and information is included in the Stormwater Report that explains why it is not possible to submit the Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan with the application. A Construction Period Pollution Prevention and Erosion and Sedimentation Control has ***not*** been included in the Stormwater Report but will be submitted ***before*** land disturbance begins.

☐ The project is ***not*** covered by a NPDES Construction General Permit.

☐ The project is covered by a NPDES Construction General Permit and a copy of the SWPPP is in the Stormwater Report.

☒ The project is covered by a NPDES Construction General Permit but no SWPPP been submitted. The SWPPP will be submitted BEFORE land disturbance begins.

Standard 9: Operation and Maintenance Plan

☒ The Post Construction Operation and Maintenance Plan is included in the Stormwater Report and includes the following information:

- ☒ Name of the stormwater management system owners;
- ☒ Party responsible for operation and maintenance;
- ☒ Schedule for implementation of routine and non-routine maintenance tasks;
- ☒ Plan showing the location of all stormwater BMPs maintenance access areas;
- ☒ Description and delineation of public safety features;
- ☒ Estimated operation and maintenance budget; and
- ☒ Operation and Maintenance Log Form.

☐ The responsible party is ***not*** the owner of the parcel where the BMP is located and the Stormwater Report includes the following submissions:

- ☐ A copy of the legal instrument (deed, homeowner's association, utility trust or other legal entity) that establishes the terms of and legal responsibility for the operation and maintenance of the project site stormwater BMPs;
- ☐ A plan and easement deed that allows site access for the legal entity to operate and maintain BMP functions.

Standard 10: Prohibition of Illicit Discharges

☒ The Long-Term Pollution Prevention Plan includes measures to prevent illicit discharges;

☒ An Illicit Discharge Compliance Statement is attached;

☐ NO Illicit Discharge Compliance Statement is attached but will be submitted ***prior to*** the discharge of any stormwater to post-construction BMPs.

OPERATION AND MAINTENANCE PLAN

In accordance with the standards set forth by the Stormwater Management Policy issued by the Department of Environmental Protection (DEP), Allen & Major Associates, Inc. (A&M) has prepared the following Operation and Maintenance plan for the Broadstone Bare Cove drainage improvements.

This plan is broken into two major sections. The first section describes construction-related erosion and sedimentation controls. The second section is devoted to a post-development operation and maintenance plan. An operation and maintenance schedule has been included with this report.

Stormwater Management System Owner: Alliance Residential Company
184 High Street
Suite 401
Boston, MA 02110

Emergency Contact Information:

- Alliance Residential Company (Owner) Phone (617) 356-1000
- Allen & Major Associates, Inc. (Site Civil Engineer) Phone (781) 935-6889
- Hingham Public Works Phone (781) 741-1430
- Hingham Fire Department (business line) Phone (781) 741-1416

INTRODUCTION

The stormwater management system (SMS) for this project is owned by Alliance Residential Company and shall be legally responsible for long-term operation and maintenance for this SMS as outlined in this Operation and Maintenance (O&M) Plan. Should ownership of the SMS change the succeeding owner will be presented with this O&M Plan and supporting attachments at or before legal conveyance of ownership and will assume the obligations of the O&M Plan.

In the event that the SMS will be operated and maintained by an entity other than that listed in this document, the applicant shall provide a plan and easement deed that provides a right of access for the legal entity to be able to perform said operation and maintenance functions. In the event the SMS will serve multiple lots/owners, the applicant shall also provide a copy of the legal instrument (deed, homeowner's association, utility trust or other legal entity) that establishes the terms of and legal responsibility for the operation and maintenance of the entire SMS.

DEMOLITION & CONSRUCTION MAINTENANCE PLAN

1. Contact the Town of Hingham at least three (3) days prior to start of demolition and/or construction activities.

2. Install Erosion Control measures as shown on the Plans prepared by A&M. The Town of Hingham shall review the installation of straw bales and silt fencing prior to the start of any site demotion work. Install Construction fencing if determined to be necessary at the commencement of construction.

3. Install construction entrances & straw bales and silt fence at the locations shown on the Erosion Control Plan prepared by A&M.

4. Site access shall be achieved only from the designated construction entrances.

5. Stockpiles of materials subject to erosion shall be stabilized with erosion control matting or temporary seeding whenever practicable, but in no case more than 14 days after the construction activity in that portion of the site has temporarily or permanently ceased.

6. Install silt sacks and straw bales around each drain inlet prior to any demolition and or construction activities.

7. All erosion control measures shall be inspected weekly and after every rainfall event. Records of these inspections shall be kept on site for review.

8. All erosion control measures shall be maintained, repaired or replaced as required or at the direction of the owner’s engineer or the Town of Hingham.

9. Sediment accumulation up-gradient of the straw bales, silt fence, and stone check dams greater than 6” in depth shall be removed and disposed of in accordance with all applicable regulations.

10. If it appears that sediment is exiting the site, silt sacks shall be installed in all catch basins adjacent to the site. Sediment accumulation on all adjacent catch basin inlets shall be removed and the silt sack replaced if torn or damaged.

11. Install stone check dams on site during construction as needed. Refer to the erosion control details. Temporary sediment basins combined with stone check dams shall be installed on site during construction to control and collect runoff from upland areas of this site during demolition and construction activities.

12. The contractor shall comply with the Sedimentation and Erosion Control Notes as shown on the Site Development Plans and Specifications.

13. The stabilized construction entrances shall be inspected weekly and records of inspections kept. The entrances shall be maintained by adding additional clean, angular, durable stone to remove the soil from the construction vehicle's tires when exiting the site. If soil is still leaving the site via the construction vehicle tires, adjacent roadways shall be kept clean by street sweeping.

14. Dust pollution shall be controlled using on-site water trucks and or an approved soil stabilization product.

15. During demolition and construction activities Status Reports on compliance with this O&M Document shall be submitted weekly. The report shall document any deficiencies and corrective actions taken by the applicant.

POST CONSRUCTION MAINTENANCE PLAN

The SMS shall be inspected immediately after construction. A maintenance log will be kept (i.e. report) summarizing inspections, maintenance, and any corrective actions taken. The log will include the date on which each inspection or maintenance task was performed, a description of the inspection findings or maintenance completed, and the name of the inspector or maintenance personnel performing the task. If a maintenance task requires the clean-out of any sediments or debris, the location where the sediment and debris was disposed after removal will be indicated. The log will be made accessible to department staff and a copy provided to the department upon request.

Inspection and Maintenance Frequency and Corrective Measures:
In accordance with MA DEP Stormwater Handbook: Volume 2, Chapter 2; the following areas, facilities, and measures will be inspected and the identified deficiencies will be corrected. Clean-out must include the removal and legal disposal of any accumulated sediments, trash, and debris. In any and all cases, operations, inspections, and maintenance activities shall utilize best practical measures to avoid and minimize impacts to wetland resource areas outside the foot print of the SMS.

Structural Pretreatment BMPs: Regular maintenance of these BMPs is especially critical because they typically receive the highest concentration of suspended solids during the first flush of a storm event.

Deep Sump Catch Basins:
Inspect catch basins 2 times per year (specifically after foliage and snow season) to ensure that the catch basins are working in their intended fashion and that they are free of debris. Structures will be skimmed of floatable debris at each inspection and sediment will be removed when or before sump is determined to be 50% full. If the basin outlet is designed with a hood to trap floatable materials (i.e. Snout), check to ensure watertight seal is working.

Proprietary Separators:
Separators shall be operated and maintained in strict accordance with manufacturer's recommend practices. Available manufacturer specific O&M plans attached as Appendix. Separators shall be inspected to ensure that they are working in their intended fashion and that they are free of debris. Structures shall be cleaned with a vacuum truck at least once annually (typically after snow season) or when sediment has accumulated to a depth of six inches (6"), whichever is more frequent.

Infiltration BMPs:

Stormwater Infiltration Facilities:
Maintenance of upstream pre-treatment measures is critically important to the function of infiltration BMPs. Pre-treatment BMPs should be inspected for sediment and floatables accumulation and maintained at least twice per year (every other month recommended) and after every major storm event.

Sub-surface Structures:
The sub-surface structures will be inspected within the first three months after construction within 72 hours of a half-inch storm event to ensure it is draining properly. Thereafter, the filter should be inspected for sediment, trash and debris at least twice per year. Trash, debris, and visible sediment should be removed. The filter should also be inspected annually within 72 hours of a half-inch storm event to ensure it is draining properly. Inspection can be accomplished by using the observation well, inspection port, and/or access structure for underground chamber systems.

Other BMPs and Accessories:

Pipe Outlets:
Inspect pipe outlets 2 times per year (preferably in Spring and Fall) to ensure that the outlets are working in their intended fashion and that they are free of debris. Remove any obstructions to flow; remove accumulated sediments and debris at the inlet, at the outlet, and within the conduit and to repair any erosion damage at the outlet.

Vegetated Areas:
Inspect slopes and embankments early in the growing season to identify active or potential erosion problems. Replant bare areas or areas with sparse growth. Where rill erosion is evident, armor the area with an appropriate lining or divert the erosive flows to on-site areas able to withstand the concentrated flows.

Roadways and Parking Surfaces:
Clear accumulations of winter sand in parking lots and along roadways at least once a year, preferably in the spring. Accumulations on pavement may be removed by pavement sweeping. Accumulations of sand along road shoulders may be removed by grading excess sand to the pavement edge and removing it manually or by a front-end loader.

Level Spreaders, Check Dams, Rip-Rap:
These accessories will be inspected twice per year for erosion, debris accumulation, and unwanted vegetation. Erosion will be stabilized and sediment, debris, and woody vegetation will be removed.

MANAGEMENT OF DEICING CHEMICALS AND SNOW
It will be the responsibility of the snow removal contractor to properly dispose of transported snow according to the Massachusetts DEP, Bureau of Resource Protection – Snow Disposal Guideline #BRPG01-0, governing the proper disposal of snow. It will be the responsibility of the snow removal contractor to follow these guidelines and all applicable laws and regulations. A copy of the MA DEP Snow Disposal Guideline #BRPG01-01 has been included at the end of Section 2 for reference.

The sites maintenance staff (or its designee) will be responsible for the clearing of the sidewalk and building entrances. The site may be required to use a de-icing agent such as potassium chloride (or approved equal) to maintain a safe walking surface; however, these are to be used at the minimum amount practicable. The de-icing agent for the walkways and building entrances will be kept within the storage rooms located within the buildings. De-icing agents will not be stored outside.

OPERATION & MAINTENANCE PLAN SCHEDULE

Project: Broadstone Bare Cove
Address: 230 Beal Street
Hingham, MA

/ Responsible for O & M Plan: Alliance Residential Company
Address: 184 High Street
Suite 401
Boston, MA 02110
Phone: 617-356-1000

Date: 8/12/2016
Revised: 10/25/2016

Structure or Task	Maintenance Activity	Schedule/Notes	Annual Maintenance Cost	Inspection Performed Date:	Inspection Performed By:
Street Sweeping	Sweep, power broom or vacuum paved areas.	Sweep paved areas as needed, but not less than four times annually.	$2,000		
		Submit information that confirms that all street sweepings have been disposed in accordance with state and local requirements			
Drainage Channel	Inspect grass along side slopes for erosion and formation of rills or gullies and correct.	Perform every six months and after rain event larger than 3".	$500		
	Remove trash, debris, leaves and grass clippings				
	Check Outlets for clogging				
	Remove tree seedings before they become established				
	Inspect trench for ponded water. Adress as needed to remove clogging	72 hours after major rain events. See also note #1 below.			
Deep Sump Catch Basins(s)	Clam shell or vacuum sumps	Inspect at least twice annually. Clean when sediment is within 2.5 feet of the outlet invert.	$500		
		Submit information that confirms that all catch basin sediments have been disposed in accordance with state and local requirements			
Storm Water Management System					
Proprietary Separators	See the ConTECH Maintenance package for the inspection and cleaning procedure.	Inspect at least four times annually as well as following storms exceeding 1" of rainfall. Devices shall be cleaned at leaast once annually or when sediment reaches 6 inches of depth whichever is more frequent. See also note #1 below.	$250		
		Submit information that confirms that all water quality inlets sediments have been disposed in accordance with state and local requirements			
Subsurface Infiltration Systems	Inspect to ensure it is draining properly.	Perform every other month as well as after every storm event over 1/2". See also note #1 below.	$500		
	Inspect isolator row using inspection ports and remove any accumulated sediment when average depth reaches 1" per the manufacturers recommendation.	On a semi-annual basis.			
Outlet Control Structure(s)	Vacuum.	Periodic cleaning of Outlet Control Structures as needed.	$50		
Mosquito Control	CB management targeted larviciding treatment to CB's and all storm drains to control mosquitoes in their aquatic stages.	Surveillance is a non chemical inspection method that involves classification of mosquito breeding sites, larval presents, and survey.	$100		
Snow Storage	Debris shall be cleared from the site and properly disposed of at the end of the snow season, but shall be cleared no later than May 15.	Avoid dumping snow removal over catch basins, in detention ponds, sediment forebays, rivers, wetlands, and flood plain. It is also prohibited to dump snow in the bioretention basins or gravel swales. (See Site Plan for appropriate locations)	$500		

Snow Disposal Guidance

Effective Date: March 8, 2001

Guideline No. BRPG01-01

Applicability: Applies to all federal, state, regional and local agencies, as well as to private businesses.

Supersedes: BRP Snow Disposal Guideline BRPG97-1 issued 12/19/97, and all previous snow disposal guidance

Approved by: Glenn Haas, Assistant Commissioner for Resource Protection

PURPOSE: To provide guidelines to all government agencies and private businesses regarding snow disposal site selection, site preparation and maintenance, and emergency snow disposal options that are acceptable to the Department of Environmental Protection, Bureau of Resource Protection.

APPLICABILITY: These Guidelines are issued by the Bureau of Resource Protection on behalf of all Bureau Programs (including Drinking Water Supply, Wetlands and Waterways, Wastewater Management, and Watershed Planning and Permitting). They apply to public agencies and private businesses disposing of snow in the Commonwealth of Massachusetts.

INTRODUCTION

Finding a place to dispose of collected snow poses a challenge to municipalities and businesses as they clear roads, parking lots, bridges, and sidewalks. While we are all aware of the threats to public safety caused by snow, collected snow that is contaminated with road salt, sand, litter, and automotive pollutants such as oil also threatens public health and the environment.

As snow melts, road salt, sand, litter, and other pollutants are transported into surface water or through the soil where they may eventually reach the groundwater. Road salt and other pollutants can contaminate water supplies and are toxic to aquatic life at certain levels. Sand washed into waterbodies can create sand bars or fill in wetlands and ponds, impacting aquatic life, causing flooding, and affecting our use of these resources.

There are several steps that communities can take to minimize the impacts of snow disposal on public health and the environment. These steps will help communities avoid the costs of a contaminated water supply, degraded waterbodies, and flooding. Everything we do on the land has the potential to impact our water resources. Given the authority of local government over the use of the land, municipal officials and staff have a critically important role to play in protecting our water resources.

The purpose of these guidelines is to help municipalities and businesses select, prepare, and maintain appropriate snow disposal sites before the snow begins to accumulate through the winter.

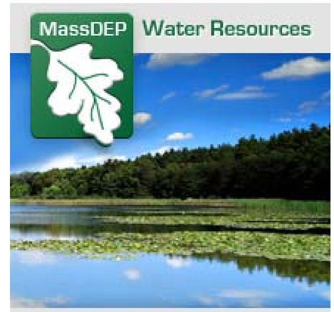
RECOMMENDED GUIDELINES

These snow disposal guidelines address: (1) site selection; (2) site preparation and maintenance; and (3) emergency snow disposal.

1. SITE SELECTION

The key to selecting effective snow disposal sites is to locate them adjacent to or on pervious surfaces in upland areas away from water resources and wells. At these locations, the snow meltwater can filter in to the soil, leaving behind sand and debris which can be removed in the springtime. The following areas should be avoided:

- Avoid dumping of snow into any waterbody, including rivers, the ocean, reservoirs, ponds, or wetlands. In addition to water quality impacts and flooding, snow disposed of in open water can cause navigational hazards when it freezes into ice blocks.
- Do not dump snow within a Zone II or Interim Wellhead Protection Area (IWPA) of a public water supply well or within 75 feet of a private well, where road salt may contaminate water supplies.
- Avoid dumping snow on MassDEP-designated high and medium-yield aquifers where it may contaminate groundwater (see the next page for information on ordering maps from MassGIS showing the locations of aquifers, Zone II's, and IWPAs in your community).
- Avoid dumping snow in sanitary landfills and gravel pits. Snow meltwater will create more contaminated leachate in landfills posing a greater risk to groundwater, and in gravel pits, there is little opportunity for pollutants to be filtered out of the meltwater because groundwater is close to the land surface.



A to Z Quick Links

Water Resources Index

- Avoid disposing of snow on top of storm drain catch basins or in stormwater drainage swales or ditches. Snow combined with sand and debris may block a storm drainage system, causing localized flooding. A high volume of sand, sediment, and litter released from melting snow also may be quickly transported through the system into surface water.

Site Selection Procedures

1. It is important that the municipal Department of Public Works or Highway Department, Conservation Commission, and Board of Health work together to select appropriate snow disposal sites. The following steps should be taken:
2. Estimate how much snow disposal capacity is needed for the season so that an adequate number of disposal sites can be selected and prepared.
3. Identify sites that could potentially be used for snow disposal such as municipal open space (e.g., parking lots or parks).
4. Sites located in upland locations that are not likely to impact sensitive environmental resources should be selected first.
5. If more storage space is still needed, prioritize the sites with the least environmental impact (using the site selection criteria, and local or MassGIS maps as a guide).

MassGIS Maps of Open Space and Water Resources

If local maps do not show the information you need to select appropriate snow disposal sites, you may order maps from MassGIS (Massachusetts Geographic Information System) which show publicly owned open spaces and approximate locations of sensitive environmental resources (locations should be field-verified where possible). Different coverages or map themes depicting sensitive environmental resources are available from MassGIS on the map you order. At a minimum, you should order the Priority Resources Map. The Priority Resources Map includes aquifers, public water supplies, MassDEP-approved Zone II's, Interim Wellhead Protection Areas, Wetlands, Open Space, Areas of Critical Environmental Concern, NHESP Wetlands Habitats, MassDEP Permitted Solid Waste facilities, Surface Water Protection areas (Zone A's) and base map features. The cost of this map is $25.00. Other coverages or map themes you may consider, depending on the location of your city or town, include Outstanding Resource Waters and MassDEP Eelgrass Resources. These are available at $25.00 each, with each map theme being depicted on a separate map. Maps should be ordered from MassGIS . Maps may also be ordered by fax at 617-626-1249 (order form available from the MassGIS web site) or mail. For further information, contact MassGIS at 617-626-1189.

2. SITE PREPARATION AND MAINTENANCE

In addition to carefully selecting disposal sites before the winter begins, it is important to prepare and maintain these sites to maximize their effectiveness. The following maintenance measures should be undertaken for all snow disposal sites:

- A silt fence or equivalent barrier should be placed securely on the downgradient side of the snow disposal site.
- To filter pollutants out of the meltwater, a 50-foot vegetative buffer strip should be maintained during the growth season between the disposal site and adjacent waterbodies.
- Debris should be cleared from the site prior to using the site for snow disposal.
- Debris should be cleared from the site and properly disposed of at the end of the snow season and no later than May 15.

3. EMERGENCY SNOW DISPOSAL

As mentioned earlier, it is important to estimate the amount of snow disposal capacity you will need so that an adequate number of upland disposal sites can be selected and prepared.

If despite your planning, upland disposal sites have been exhausted, snow may be disposed of near waterbodies. A vegetated buffer of at least 50 feet should still be maintained between the site and the waterbody in these situations. Furthermore, it is essential that the other guidelines for preparing and maintaining snow disposal sites be followed to minimize the threat to adjacent waterbodies.

Under extraordinary conditions, when all land-based snow disposal options are exhausted, disposal of snow that is not obviously contaminated with road salt, sand, and other pollutants may be allowed in certain waterbodies under certain conditions. In these dire situations, notify your Conservation Commission and the appropriate MassDEP Regional Service Center before disposing of snow in a waterbody.

Use the following guidelines in these emergency situations:

- Dispose of snow in open water with adequate flow and mixing to prevent ice dams from forming.
- Do not dispose of snow in saltmarshes, vegetated wetlands, certified vernal pools, shellfish beds, mudflats, drinking water reservoirs and their tributaries, Zone IIs or IWPAs of public water supply wells, Outstanding Resource Waters, or Areas of Critical Environmental Concern.
- Do not dispose of snow where trucks may cause shoreline damage or erosion.
- Consult with the municipal Conservation Commission to ensure that snow disposal in open water complies with local

ordinances and bylaws.

FOR MORE INFORMATION

If you need more information, contact one of MassDEP's Regional Service Centers:

Northeast Regional Office, Wilmington, 978-694-3200
Southeast Regional Office, Lakeville, 508-946-2714
Central Regional Office, Worcester, 508-792-7683
Western Regional Office, Springfield, 413-755-2214

or

Call Thomas Maguire of DEP's Bureau of Resource Protection in Boston at 617-292-5602.

Chapter 5
Miscellaneous Stormwater Topics

Mosquito Control in Stormwater Management Practices

Both aboveground and underground stormwater BMPs have the potential to serve as mosquito breeding areas. Good design, proper operation and maintenance and treatment with larvicides can minimize this potential.

EPA recommends that stormwater treatment practices dewater within 3 days (72 hours) to reduce the number of mosquitoes that mature to adults, since the aquatic stage of many mosquito species is 7 to 10 days. Massachusetts has had a 72-hour dewatering rule in its Stormwater Management Standards since 1996. The 2008 technical specifications for BMPs set forth in Volume 2, Chapter 2 of the Massachusetts Stormwater Handbook also concur with this practice by requiring that all stormwater practices designed to drain do so within 72 hours.

Some stormwater practices are designed to include permanent wet pools. These practices – if maintained properly – can limit mosquito breeding by providing habitat for mosquito predators. Additional measures that can be taken to reduce mosquito populations include increasing water circulation, attracting mosquito predators by adding suitable habitat, and applying larvicides.

The Massachusetts State Reclamation and Mosquito Control Board (SRMCB), through the Massachusetts Mosquito Control Districts, can undertake further mosquito control actions specifically for the purpose of mosquito control pursuant to Massachusetts General Law Chapter 252. The Mosquito Control Board, http://www.mass.gov/agr/mosquito/, describes mosquito control methods and is in the process of developing guidance documents that describe Best Management Practices for mosquito control projects.

The SRMCB and Mosquito Control Districts are not responsible for operating and maintaining stormwater BMPs to reduce mosquito populations. The owners of property that construct the stormwater BMPs or municipalities that "accept" them through local subdivision approval are responsible for their maintenance.[1] The SRMCB is composed of officials from MassDEP, Department of Agricultural Resources, and Department of Conservation and Recreation. The nine (9) Mosquito Control Districts overseen by the SRMCB are located throughout Massachusetts, covering 176 municipalities.

<u>Construction Period Best Management Practices for Mosquito Control</u>

To minimize mosquito breeding during construction, it is essential that the following actions be taken to minimize the creation of standing pools by taking the following actions:

- ***Minimize Land Disturbance:*** Minimizing land disturbance reduces the likelihood of mosquito breeding by reducing silt in runoff that will cause construction period controls to clog and retain standing pools of water for more than 72 hours.
- ***Catch Basin inlets:*** Inspect and refresh filter fabric, hay bales, filter socks or stone dams on a regular basis to ensure that any stormwater ponded at the inlet drains within 8 hours after precipitation stops. Shorter periods may be necessary to avoid hydroplaning in roads

[1] MassDEP and MassHighway understand that the numerous stormwater BMPs along state highways pose a unique challenge. To address this challenge, the 2004 MassHighway Stormwater Handbook will provide additional information on appropriate operation and maintenance practices for mosquito control when the Handbook is revised to reflect the 2008 changes to the Stormwater Management Standards..

caused by water ponded at the catch basin inlet. Treat catch basin sumps with larvicides such as *Bacillus sphaericus* (*Bs*) using a licensed pesticide applicator.

- ***Check Dams:*** If temporary check dams are used during the construction period to lag peak rate of runoff or pond runoff for exfiltration, inspect and repair the check dams on a regular basis to ensure that any stormwater ponded behind the check dam drains within 72 hours.
- ***Design construction period sediment traps*** to dewater within 72 hours after precipitation. Because these traps are subject to high silt loads and tend to clog, treat them with the larvicide *Bs* after it rains from June through October, until the first frost occurs.
- ***Construction period open conveyances:*** When temporary manmade ditches are used for channelizing construction period runoff, inspect them on a regular basis to remove any accumulated sediment to restore flow capacity to the temporary ditch.
- ***Revegetating Disturbed Surfaces:*** Revegetating disturbed surfaces reduces sediment in runoff that will cause construction period controls to clog and retain standing pools of water for greater than 72 hours.
- ***Sediment fences/hay bale barriers:*** When inspections find standing pools of water beyond the 24-hour period after a storm, take action to restore barrier to its normal function.

<u>Post-Construction Stormwater Treatment Practices</u>

- Mosquito control begins with the environmentally sensitive site design. Environmentally sensitive site design that minimizes impervious surfaces reduces the amount of stormwater runoff. Disconnecting runoff using the LID Site Design credits outlined in the Massachusetts Stormwater Handbook reduces the amount of stormwater that must be conveyed to a treatment practice. Utilizing green roofs minimizes runoff from smaller storms. Storage media must be designed to dewater within 72 hours after precipitation.
- Mosquito control continues with the selection of structural stormwater BMPs that are unlikely to become breeding grounds for mosquitoes, such as:
    - ***Bioretention Areas/Rain Gardens/Sand Filter:*** These practices tend not to result in mosquito breeding. If any level spreaders, weirs or sediment forebays are used as part of the design, inspect them and correct them as necessary to prevent standing pools of water for more than 72 hours.
    - ***Infiltration Trenches:*** This practice tends not to result in mosquito breeding. If any level spreaders, weirs, or sediment forebays are used as part of the design, inspect them and correct them as necessary to prevent standing pools of water for more than 72 hours.
- Another mosquito control strategy is to select BMPs that can become habitats for mosquito predators, such as:
    - ***Constructed Stormwater Wetlands:*** Habitat features can be incorporated in constructed stormwater wetlands to attract dragonflies, amphibians, turtles, birds, bats, and other natural predators of mosquitoes.
    - ***Wet Basins:*** Wet basins can be designed to incorporate fish habitat features, such as deep pools. Introduce fish in consultation with Massachusetts Division of Fisheries and Wildlife. Vegetation within wet basins designed as fish habitat must be properly managed to ensure that vegetation does not overtake the habitat. Proper design to ensure that no low circulation or "dead" zones are created may reduce the potential for mosquito breeding. Introducing bubblers may increase water circulation in the wet basin.

Effective mosquito controls require proponents to design structural BMPs to prevent ponding and facilitate maintenance and, if necessary, the application of larvicides. Examples of such design practices include the following:

- ***Basins:*** Provide perimeter access around wet basins, extended dry detention basins and dry detention basins for both larviciding and routine maintenance. Control vegetation to ensure that access pathways stay open.
- ***BMPs without a permanent pool of water:*** All structural BMPs that do not rely on a permanent pool of water must drain and completely dewater within 72 hours after precipitation. This includes dry detention basins, extended dry detention basins, infiltration basins, and dry water quality swales. Use underdrains at extended dry detention basins to drain the small pools that form due to accumulation of silts. Wallace indicates that extended dry extended detention basins may breed more mosquitoes than wet basins. It is, therefore, imperative to design outlets from extended dry detention basins to completely dewater within the 72-hour period.
- ***Energy Dissipators and Flow Spreaders:*** Currier and Moeller, 2000 indicate that shallow recesses in energy dissipators and flow spreaders trap water where mosquitoes breed. Set the riprap in grout to reduce the shallow recesses and minimize mosquito breeding.
- ***Outlet control structures:*** Debris trapped in small orifices or on trash racks of outlet control structures such as multiple stage outlet risers may clog the orifices or the trash rack, causing a standing pool of water. Optimize the orifice size or trash rack mesh size to provide required peak rate attenuation/water quality detention/retention time while minimizing clogging.
- ***Rain Barrels and Cisterns:*** Seal lids to reduce the likelihood of mosquitoes laying eggs in standing water. Install mosquito netting over inlets. The cistern system should be designed to ensure that all collected water is drained into it within 72 hours.
- ***Subsurface Structures, Deep Sump Catch Basins, Oil Grit Separators, and Leaching Catch Basins:*** Seal all manhole covers to reduce likelihood of mosquitoes laying eggs in standing water. Install mosquito netting over the outlet (CALTRANS 2004).

The Operation and Maintenance Plan should provide for mosquito prevention and control.

- ***Check dams:*** Inspect permanent check dams on the schedule set forth in the O&M Plan. Inspect check dams 72 hours after storms for standing water ponding behind the dam. Take corrective action if standing water is found.
- ***Cisterns:*** Apply *Bs* larvicide in the cistern if any evidence of mosquitoes is found. The Operation and Maintenance Plan shall specify how often larvicides should be applied to waters in the cistern.
- ***Water quality swales:*** Remove and properly dispose of any accumulated sediment as scheduled in the Operation and Maintenance Plan.
- ***Larvicide Treatment:*** The Operation and Maintenance Plan must include measures to minimize mosquito breeding, including larviciding.
- The party identified in the Operation and Maintenance Plan as responsible for maintenance shall see that larvicides are applied as necessary to the following stormwater treatment practices: catch basins, oil/grit separators, wet basins, wet water quality swales, dry extended detention basins, infiltration basins, and constructed stormwater wetlands. The Operation and Maintenance Plan must ensure that all larvicides are applied by a licensed pesticide applicator and in compliance with all pesticide label requirements.
- The Operation and Maintenance Plan should identify the appropriate larvicide and the time and method of application. For example, *Bacillus sphaericus (Bs*), the preferred

larvicide for stormwater BMPs, should be hand-broadcast.[2] Alternatively, Altosid, a Methopren product, may be used. Because some practices are designed to dewater between storms, such as dry extended detention and infiltration basins, the Operation and Maintenance Plan should provide that larviciding must be conducted during or immediately after wet weather, when the detention or infiltration basin has a standing pool of water, unless a product is used that can withstand extended dry periods.

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[2] *Bacillus thuringienis israelensis* or *Bti* is usually applied by helicopter to wetlands and floodplains

CONTECH®
ENGINEERED SOLUTIONS

CDS Guide
Operation, Design, Performance and Maintenance

CDS®

Using patented continuous deflective separation technology, the CDS system screens, separates and traps debris, sediment, and oil and grease from stormwater runoff. The indirect screening capability of the system allows for 100% removal of floatables and neutrally buoyant material without blinding. Flow and screening controls physically separate captured solids, and minimize the re-suspension and release of previously trapped pollutants. Inline units can treat up to 6 cfs, and internally bypass flows in excess of 50 cfs (1416 L/s). Available precast or cast-in-place, offline units can treat flows from 1 to 300 cfs (28.3 to 8495 L/s). The pollutant removal capacity of the CDS system has been proven in lab and field testing.

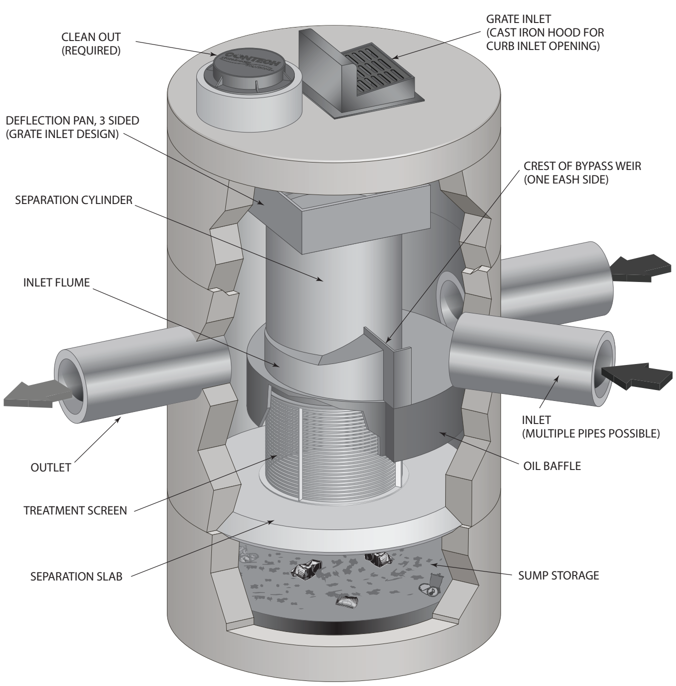
Operation Overview

Stormwater enters the diversion chamber where the diversion weir guides the flow into the unit's separation chamber and pollutants are removed from the flow. All flows up to the system's treatment design capacity enter the separation chamber and are treated.

Swirl concentration and screen deflection force floatables and solids to the center of the separation chamber where 100% of floatables and neutrally buoyant debris larger than the screen apertures are trapped.

Stormwater then moves through the separation screen, under the oil baffle and exits the system. The separation screen remains clog free due to continuous deflection.

During the flow events exceeding the treatment design capacity, the diversion weir bypasses excessive flows around the separation chamber, so captured pollutants are retained in the separation cylinder.



Design Basics

There are three primary methods of sizing a CDS system. The Water Quality Flow Rate Method determines which model size provides the desired removal efficiency at a given flow rate for a defined particle size. The Rational Rainfall Method™ or the and Probabilistic Method is used when a specific removal efficiency of the net annual sediment load is required.

Typically in the Unites States, CDS systems are designed to achieve an 80% annual solids load reduction based on lab generated performance curves for a gradation with an average particle size (d50) of 125 microns (μm). For some regulatory environments, CDS systems can also be designed to achieve an 80% annual solids load reduction based on an average particle size (d50) of 75 microns (μm) or 50 microns (μm).

Water Quality Flow Rate Method

In some cases, regulations require that a specific treatment rate, often referred to as the water quality design flow (WQQ), be treated. This WQQ represents the peak flow rate from either an event with a specific recurrence interval, e.g. the six-month storm, or a water quality depth, e.g. 1/2-inch (13 mm) of rainfall.

The CDS is designed to treat all flows up to the WQQ. At influent rates higher than the WQQ, the diversion weir will direct most flow exceeding the WQQ around the separation chamber. This allows removal efficiency to remain relatively constant in the separation chamber and eliminates the risk of washout during bypass flows regardless of influent flow rates.

Treatment flow rates are defined as the rate at which the CDS will remove a specific gradation of sediment at a specific removal efficiency. Therefore the treatment flow rate is variable, based on the gradation and removal efficiency specified by the design engineer.

Rational Rainfall Method™

Differences in local climate, topography and scale make every site hydraulically unique. It is important to take these factors into consideration when estimating the long-term performance of any stormwater treatment system. The Rational Rainfall Method combines site-specific information with laboratory generated performance data, and local historical precipitation records to estimate removal efficiencies as accurately as possible.

Short duration rain gauge records from across the United States and Canada were analyzed to determine the percent of the total annual rainfall that fell at a range of intensities. US stations' depths were totaled every 15 minutes, or hourly, and recorded in 0.01-inch increments. Depths were recorded hourly with 1-mm resolution at Canadian stations. One trend was consistent at all sites; the vast majority of precipitation fell at low intensities and high intensity storms contributed relatively little to the total annual depth.

These intensities, along with the total drainage area and runoff coefficient for each specific site, are translated into flow rates using the Rational Rainfall Method. Since most sites are relatively small and highly impervious, the Rational Rainfall Method is appropriate. Based on the runoff flow rates calculated for each intensity, operating rates within a proposed CDS system are determined. Performance efficiency curve determined from full scale laboratory tests on defined sediment PSDs is applied to calculate solids removal efficiency. The relative removal efficiency at each operating rate is added to produce a net annual pollutant removal efficiency estimate.

Probabilistic Rational Method

The Probabilistic Rational Method is a sizing program Contech developed to estimate a net annual sediment load reduction for a particular CDS model based on site size, site runoff coefficient, regional rainfall intensity distribution, and anticipated pollutant characteristics.

The Probabilistic Method is an extension of the Rational Method used to estimate peak discharge rates generated by storm events of varying statistical return frequencies (e.g. 2-year storm event). Under the Rational Method, an adjustment factor is used to adjust the runoff coefficient estimated for the 10-year event, correlating a known hydrologic parameter with the target storm event. The rainfall intensities vary depending on the return frequency of the storm event under consideration. In general, these two frequency dependent parameters (rainfall intensity and runoff coefficient) increase as the return frequency increases while the drainage area remains constant.

These intensities, along with the total drainage area and runoff coefficient for each specific site, are translated into flow rates using the Rational Method. Since most sites are relatively small and highly impervious, the Rational Method is appropriate. Based on the runoff flow rates calculated for each intensity, operating rates within a proposed CDS are determined. Performance efficiency curve on defined sediment PSDs is applied to calculate solids removal efficiency. The relative removal efficiency at each operating rate is added to produce a net annual pollutant removal efficiency estimate.

Treatment Flow Rate

The inlet throat area is sized to ensure that the WQQ passes through the separation chamber at a water surface elevation equal to the crest of the diversion weir. The diversion weir bypasses excessive flows around the separation chamber, thus preventing re-suspension or re-entrainment of previously captured particles.

Hydraulic Capacity

The hydraulic capacity of a CDS system is determined by the length and height of the diversion weir and by the maximum allowable head in the system. Typical configurations allow hydraulic capacities of up to ten times the treatment flow rate. The crest of the diversion weir may be lowered and the inlet throat may be widened to increase the capacity of the system at a given water surface elevation. The unit is designed to meet project specific hydraulic requirements.

Performance

Full-Scale Laboratory Test Results

A full-scale CDS system (Model CDS2020-5B) was tested at the facility of University of Florida, Gainesville, FL. This CDS unit was evaluated under controlled laboratory conditions of influent flow rate and addition of sediment.

Two different gradations of silica sand material (UF Sediment & OK-110) were used in the CDS performance evaluation. The particle size distributions (PSDs) of the test materials were analyzed using standard method "Gradation ASTM D-422 "Standard Test Method for Particle-Size Analysis of Soils" by a certified laboratory.

UF Sediment is a mixture of three different products produced by the U.S. Silica Company: "Sil-Co-Sil 106", "#1 DRY" and "20/40 Oil Frac". Particle size distribution analysis shows that the UF Sediment has a very fine gradation (d50 = 20 to 30 μm) covering a wide size range (Coefficient of Uniformity, C averaged at 10.6). In comparison with the hypothetical TSS gradation specified in the NJDEP (New Jersey Department of Environmental Protection) and NJCAT (New Jersey Corporation for Advanced Technology) protocol for lab testing, the UF Sediment covers a similar range of particle size but with a finer d50 (d50 for NJDEP is approximately 50 μm) (NJDEP, 2003).

The OK-110 silica sand is a commercial product of U.S. Silica Sand. The particle size distribution analysis of this material, also included in Figure 1, shows that 99.9% of the OK-110 sand is finer than 250 microns, with a mean particle size (d50) of 106 microns. The PSDs for the test material are shown in Figure 1.

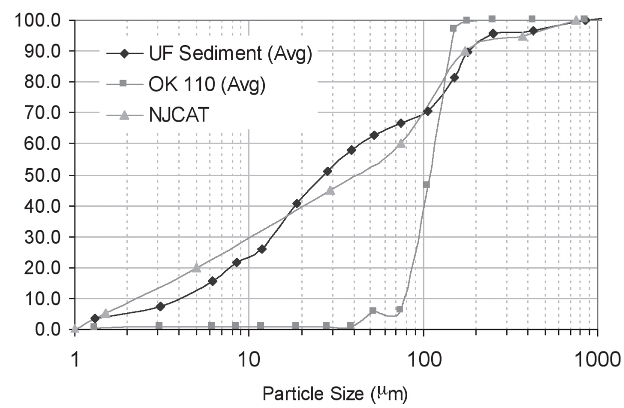


Figure 1. Particle size distributions

Tests were conducted to quantify the performance of a specific CDS unit (1.1 cfs (31.3-L/s) design capacity) at various flow rates, ranging from 1% up to 125% of the treatment design capacity of the unit, using the 2400 micron screen. All tests were conducted with controlled influent concentrations of approximately 200 mg/L. Effluent samples were taken at equal time intervals across the entire duration of each test run. These samples were then processed with a Dekaport Cone sample splitter to obtain representative sub-samples for Suspended Sediment Concentration (SSC) testing using ASTM D3977-97 "Standard Test Methods for Determining Sediment Concentration in Water Samples", and particle size distribution analysis.

Results and Modeling

Based on the data from the University of Florida, a performance model was developed for the CDS system. A regression analysis was used to develop a fitting curve representative of the scattered data points at various design flow rates. This model, which demonstrated good agreement with the laboratory data, can then be used to predict CDS system performance with respect to SSC removal for any particle size gradation, assuming the particles are inorganic sandy-silt. Figure 2 shows CDS predictive performance for two typical particle size gradations (NJCAT gradation and OK-110 sand) as a function of operating rate.

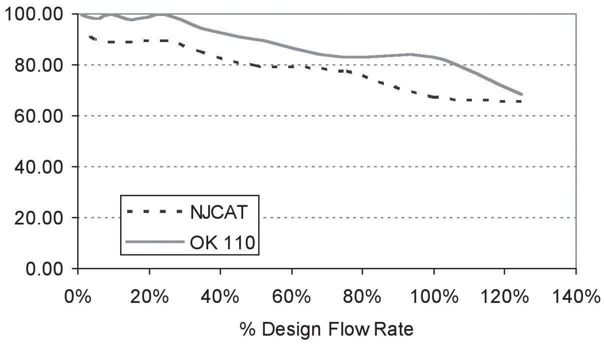


Figure 2. CDS stormwater treatment predictive performance for various particle gradations as a function of operating rate.

Many regulatory jurisdictions set a performance standard for hydrodynamic devices by stating that the devices shall be capable of achieving an 80% removal efficiency for particles having a mean particle size (d50) of 125 microns (e.g. Washington State Department of Ecology — WASDOE - 2008). The model can be used to calculate the expected performance of such a PSD (shown in Figure 3). The model indicates (Figure 4) that the CDS system with 2400 micron screen achieves approximately 80% removal at the design (100%) flow rate, for this particle size distribution (d50 = 125 μm).

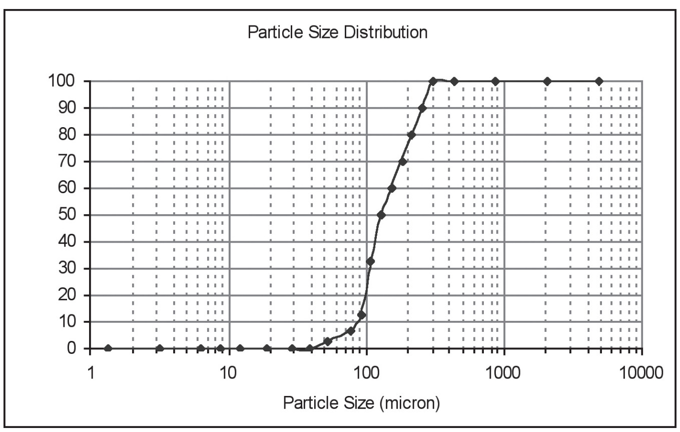


Figure 3. WASDOE PSD

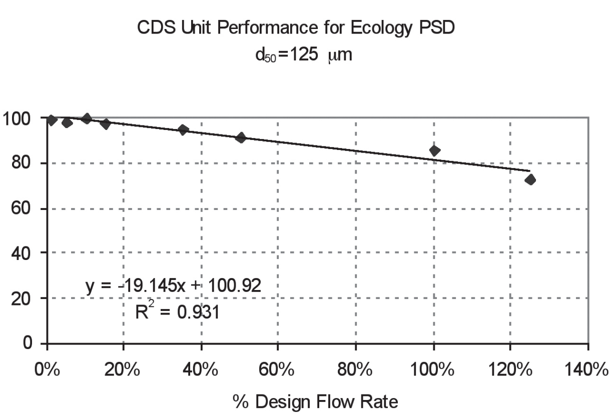


Figure 4. Modeled performance for WASDOE PSD.

Maintenance

The CDS system should be inspected at regular intervals and maintained when necessary to ensure optimum performance. The rate at which the system collects pollutants will depend more heavily on site activities than the size of the unit. For example, unstable soils or heavy winter sanding will cause the grit chamber to fill more quickly but regular sweeping of paved surfaces will slow accumulation.

Inspection

Inspection is the key to effective maintenance and is easily performed. Pollutant transport and deposition may vary from year to year and regular inspections will help ensure that the system is cleaned out at the appropriate time. At a minimum, inspections should be performed twice per year (e.g. spring and fall) however more frequent inspections may be necessary in climates where winter sanding operations may lead to rapid accumulations, or in equipment washdown areas. Installations should also be inspected more frequently where excessive amounts of trash are expected.

The visual inspection should ascertain that the system components are in working order and that there are no blockages or obstructions in the inlet and separation screen. The inspection should also quantify the accumulation of hydrocarbons, trash, and sediment in the system. Measuring pollutant accumulation can be done with a calibrated dipstick, tape measure or other measuring instrument. If absorbent material is used for enhanced removal of hydrocarbons, the level of discoloration of the sorbent material should also be identified

during inspection. It is useful and often required as part of an operating permit to keep a record of each inspection. A simple form for doing so is provided.

Access to the CDS unit is typically achieved through two manhole access covers. One opening allows for inspection and cleanout of the separation chamber (cylinder and screen) and isolated sump. The other allows for inspection and cleanout of sediment captured and retained outside the screen. For deep units, a single manhole access point would allows both sump cleanout and access outside the screen.

The CDS system should be cleaned when the level of sediment has reached 75% of capacity in the isolated sump or when an appreciable level of hydrocarbons and trash has accumulated. If absorbent material is used, it should be replaced when significant discoloration has occurred. Performance will not be impacted until 100% of the sump capacity is exceeded however it is recommended that the system be cleaned prior to that for easier removal of sediment. The level of sediment is easily determined by measuring from finished grade down to the top of the sediment pile. To avoid underestimating the level of sediment in the chamber, the measuring device must be lowered to the top of the sediment pile carefully. Particles at the top of the pile typically offer less resistance to the end of the rod than consolidated particles toward the bottom of the pile. Once this measurement is recorded, it should be compared to the as-built drawing for the unit to determine weather the height of the sediment pile off the bottom of the sump floor exceeds 75% of the total height of isolated sump.

Cleaning

Cleaning of a CDS systems should be done during dry weather conditions when no flow is entering the system. The use of a vacuum truck is generally the most effective and convenient method of removing pollutants from the system. Simply remove the manhole covers and insert the vacuum hose into the sump. The system should be completely drained down and the sump fully evacuated of sediment. The area outside the screen should also be cleaned out if pollutant build-up exists in this area.

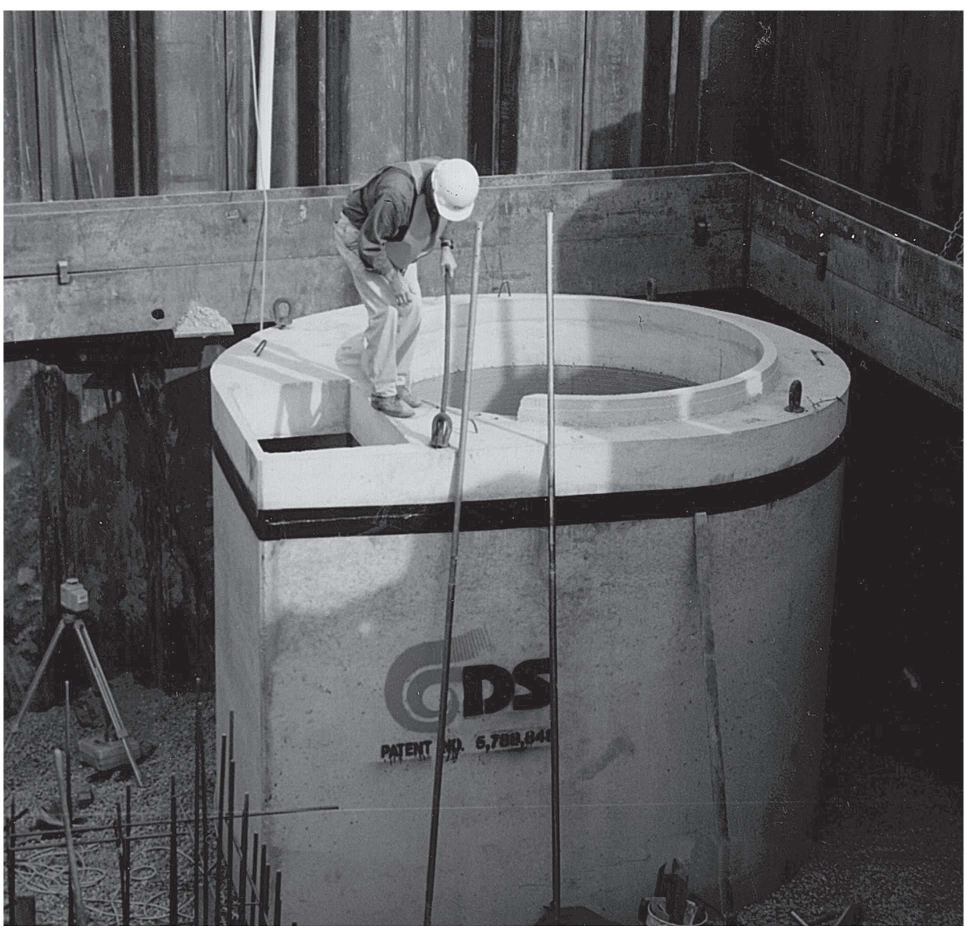
In installations where the risk of petroleum spills is small, liquid contaminants may not accumulate as quickly as sediment. However, the system should be cleaned out immediately in the event of an oil or gasoline spill. Motor oil and other hydrocarbons that accumulate on a more routine basis should be removed when an appreciable layer has been captured. To remove these pollutants, it may be preferable to use absorbent pads since they are usually less expensive to dispose than the oil/water emulsion that may be created by vacuuming the oily layer. Trash and debris can be netted out to separate it from the other pollutants. The screen should be cleaned to ensure it is free of trash and debris.

Manhole covers should be securely seated following cleaning activities to prevent leakage of runoff into the system from above and also to ensure that proper safety precautions have been followed. Confined space entry procedures need to be followed if physical access is required. Disposal of all material removed from the CDS system should be done in accordance with local regulations. In many jurisdictions, disposal of the sediments may be handled in the same manner as the disposal of sediments removed from catch basins or deep sump manholes. Check your local regulations for specific requirements on disposal.

CDS Model	Diameter		Distance from Water Surface to Top of Sediment Pile		Sediment Storage Capacity	
	ft	m	ft	m	yd3	m3
CDS2015-4	4	1.2	3.0	0.9	0.5	0.4
CDS2015	5	1.5	3.0	0.9	1.3	1.0
CDS2020	5	1.5	3.5	1.1	1.3	1.0
CDS2025	5	1.5	4.0	1.2	1.3	1.0
CDS3020	6	1.8	4.0	1.2	2.1	1.6
CDS3030	6	1.8	4.6	1.4	2.1	1.6
CDS3035	6	1.8	5.0	1.5	2.1	1.6
CDS4030	8	2.4	4.6	1.4	5.6	4.3
CDS4040	8	2.4	5.7	1.7	5.6	4.3
CDS4045	8	2.4	6.2	1.9	5.6	4.3

Table 1: CDS Maintenance Indicators and Sediment Storage Capacities

Note: To avoid underestimating the volume of sediment in the chamber, carefully lower the measuring device to the top of the sediment pile. Finer silty particles at the top of the pile may be more difficult to feel with a measuring stick. These finer particles typically offer less resistance to the end of the rod than larger particles toward the bottom of the pile.



CDS Inspection & Maintenance Log

CDS Model: ______________________________ Location: ______________________________

Date	Water depth to sediment[1]	Floatable Layer Thickness[2]	Describe Maintenance Performed	Maintenance Personnel	Comments

1. The water depth to sediment is determined by taking two measurements with a stadia rod: one measurement from the manhole opening to the top of the sediment pile and the other from the manhole opening to the water surface. If the difference between these measurements is less than the values listed in table 1 the system should be cleaned out. **Note: to avoid underestimating the volume of sediment in the chamber, the measuring device must be carefully lowered to the top of the sediment pile**.

2. For optimum performance, the system should be cleaned out when the floating hydrocarbon layer accumulates to an appreciable thickness. In the event of an oil spill, the system should be cleaned immediately.

Support

• Drawings and specifications are available at www.ContechES.com.

• Site-specific design support is available from our engineers.

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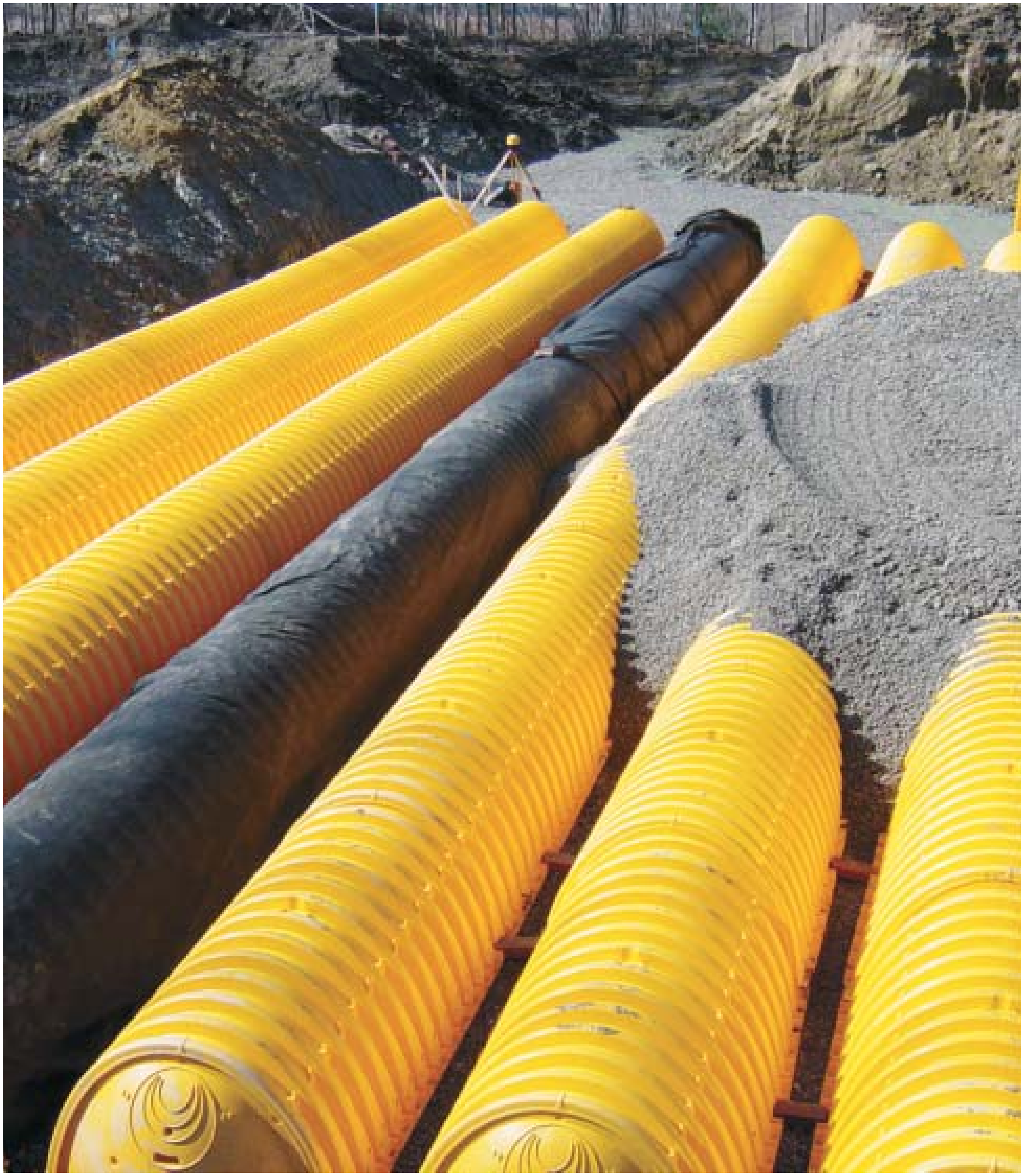


Isolator™ Row O&M Manual

StormTech® Chamber System for Stormwater Management

1.0 The Isolator™ Row

1.1 INTRODUCTION

An important component of any Stormwater Pollution Prevention Plan is inspection and maintenance. The StormTech Isolator Row is a patent pending technique to inexpensively enhance Total Suspended Solids (TSS) removal and provide easy access for inspection and maintenance.

Looking down the Isolator Row from the manhole opening, woven geotextile is shown between the chamber and stone base.

1.2 THE ISOLATOR™ ROW

The Isolator Row is a row of StormTech chambers, either SC-740 or SC-310 models, that is surrounded with filter fabric and connected to a closely located manhole for easy access. The fabric-wrapped chambers provide for settling and filtration of sediment as storm water rises in the Isolator Row and ultimately passes through the filter fabric. The open bottom chambers and perforated sidewalls allow storm water to flow both vertically and horizontally out of the chambers. Sediments are captured in the Isolator Row protecting the storage areas of the adjacent stone and chambers from sediment accumulation.

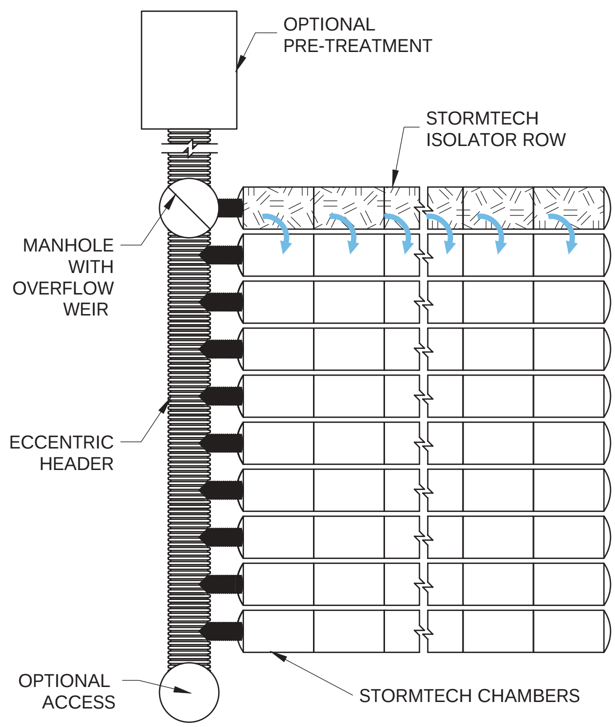
Two different fabrics are used for the Isolator Row. A woven geotextile fabric is placed between the stone and the Isolator Row chambers. The tough geotextile provides a media for storm water filtration and provides a durable surface for maintenance operations. It is also designed to prevent scour of the underlying stone and remain intact during high pressure jetting. A non-woven fabric is placed over the chambers to provide a filter media for flows passing through the perforations in the sidewall of the chamber.

The Isolator Row is typically designed to capture the "first flush" and offers the versatility to be sized on a volume basis or flow rate basis. An upstream manhole not only provides access to the Isolator Row but typically includes a high flow weir such that storm water flowrates or volumes that exceed the capacity of the Isolator Row overtop the over flow weir and discharge through a manifold to the other chambers.

The Isolator Row may also be part of a treatment train. By treating storm water prior to entry into the chamber system, the service life can be extended and pollutants such as hydrocarbons can be captured. Pre-treatment best management practices can be as simple as deep sump catch basins, oil-water separators or can be innovative storm water treatment devices. The design of the treatment train and selection of pretreatment devices by the design engineer is often driven by regulatory requirements. Whether pretreatment is used or not, the Isolator Row is recommended by StormTech as an effective means to minimize maintenance requirements and maintenance costs.

Note: See the StormTech Design Manual for detailed information on designing inlets for a StormTech system, including the Isolator Row.

StormTech Isolator Row with Overflow Spillway
(not to scale)



2.1 INSPECTION

The frequency of Inspection and Maintenance varies by location. A routine inspection schedule needs to be established for each individual location based upon site specific variables. The type of land use (i.e. industrial, commercial residential), anticipated pollutant load, percent imperviousness, climate, etc. all play a critical role in determining the actual frequency of inspection and maintenance practices.

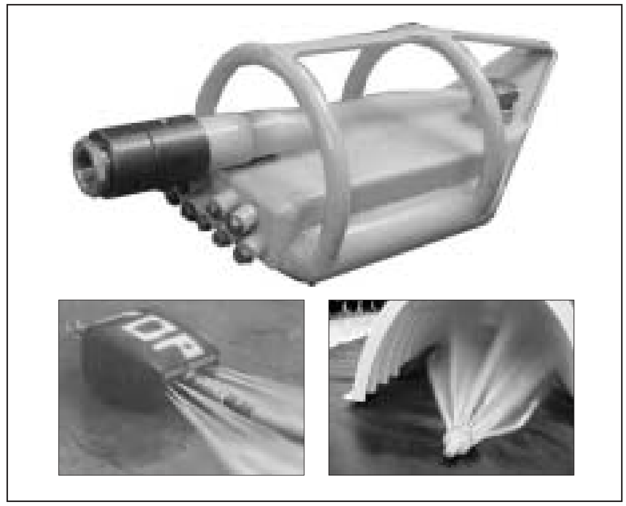
At a minimum, StormTech recommends annual inspections. Initially, the Isolator Row should be inspected every 6 months for the first year of operation. For subsequent years, the inspection should be adjusted based upon previous observation of sediment deposition.

The Isolator Row incorporates a combination of standard manhole(s) and strategically located inspection ports (as needed). The inspection ports allow for easy access to the system from the surface, eliminating the need to perform a confined space entry for inspection purposes.

If upon visual inspection it is found that sediment has accumulated, a stadia rod should be inserted to determine the depth of sediment. When the average depth of sediment exceeds 3 inches throughout the length of the Isolator Row, clean-out should be performed.

2.2 MAINTENANCE

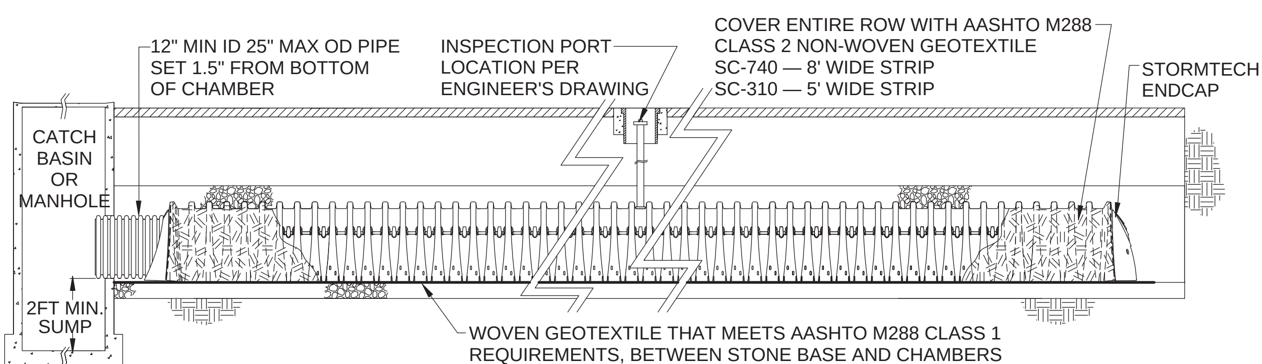
The Isolator Row was designed to reduce the cost of periodic maintenance. By “isolating” sediments to just one row, costs are dramatically reduced by eliminating the need to clean out each row of the entire storage bed. If inspection indicates the potential need for maintenance, access is provided via a manhole(s) located on the end(s) of the row for cleanout. If entry into the manhole is required, please follow local and OSHA rules for a confined space entries.



Examples of culvert cleaning nozzles appropriate for Isolator Row maintenance. (These are not StormTech products.)

Maintenance is accomplished with the JetVac process. The JetVac process utilizes a high pressure water nozzle to propel itself down the Isolator Row while scouring and suspending sediments. As the nozzle is retrieved, the captured pollutants are flushed back into the manhole for vacuuming. Most sewer and pipe maintenance companies have vacuum/JetVac combination vehicles. Selection of an appropriate JetVac nozzle will improve maintenance efficiency. Fixed nozzles designed for culverts or large diameter pipe cleaning are preferable. Rear facing jets with an effective spread of at least 45” are best. Most JetVac reels have 400 feet of hose allowing maintenance of an Isolator Row up to 50 chambers long. **The JetVac process shall only be performed on StormTech Isolator Rows that have AASHTO class 1 woven geotextile (as specified by StormTech) over their angular base stone.**

StormTech Isolator Row (not to scale)



3.0 Isolator Row Step By Step Maintenance Procedures

Step 1) Inspect Isolator Row for sediment

A) Inspection ports (if present)

i. Remove lid from floor box frame

ii. Remove cap from inspection riser

iii. Using a flashlight and stadia rod, measure depth of sediment and record results on maintenance log.

iv. If sediment is at, or above, 3 inch depth proceed to Step 2. If not proceed to step 3.

B) All Isolator Rows

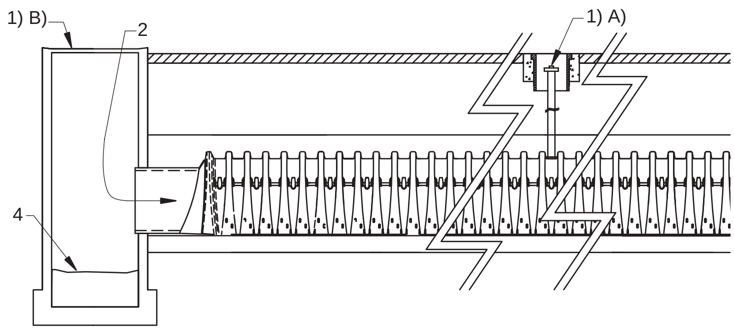
i. Remove cover from manhole at upstream end of Isolator Row

ii. Using a flashlight, inspect down Isolator Row through outlet pipe

1. Mirrors on poles or cameras may be used to avoid a confined space entry
2. Follow OSHA regulations for confined space entry if entering manhole

iii. If sediment is at or above the lower row of sidewall holes (approximately 3 inches) proceed to Step 2. If not proceed to Step 3.

StormTech Isolator Row (not to scale)



Step 2) Clean out Isolator Row using the JetVac process

A) A fixed culvert cleaning nozzle with rear facing nozzle spread of 45 inches or more is preferable

B) Apply multiple passes of JetVac until backflush water is clean

C) Vacuum manhole sump as required

Step 3) Replace all caps, lids and covers, record observations and actions

Step 4) Inspect & clean catch basins and manholes upstream of the StormTech system

Sample Maintenance Log

Date	Stadia Rod Readings		Sediment Depth (1) - (2)	Observations/Actions	Inspector
	Fixed point to chamber bottom (1)	Fixed point to top of sediment (2)			
3/15/01	6.3 ft.	none		New installation. Fixed point is CI frame at grade	djm
9/24/01		6.2	0.1 ft.	Some grit felt	sm
6/20/03		5.8	0.5 ft.	Mucky feel, debris visible in manhole and in Isolator row, maintenance due	rv
7/7/03	6.3 ft.		0	System jetted and vacuumed	djm

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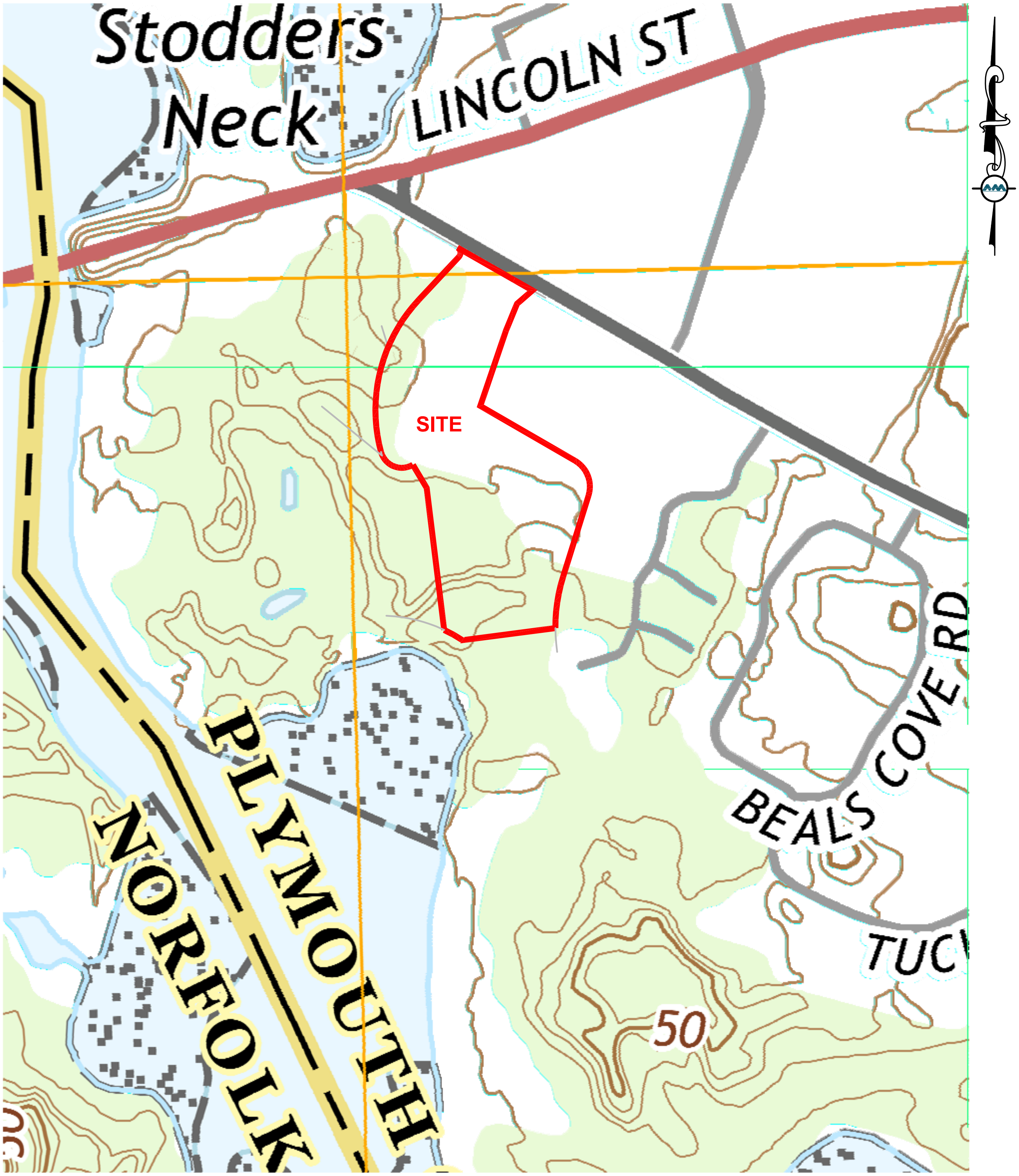

PREPARED BY:

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WOBURN, MA ◆ LAKEVILLE, MA ◆ MANCHESTER, NH

PROJECT:
230 BEAL STREET
HINGHAM, MA

USGS SITE LOCUS MAP

PROJECT NO.	2118-02	DATE:	10/25/2016
SCALE:	1"=500'	DWG. NAME:	C2118-02
DESIGNED BY:	SJL	CHECKED BY:	CMQ

SHEET No.
EX-1

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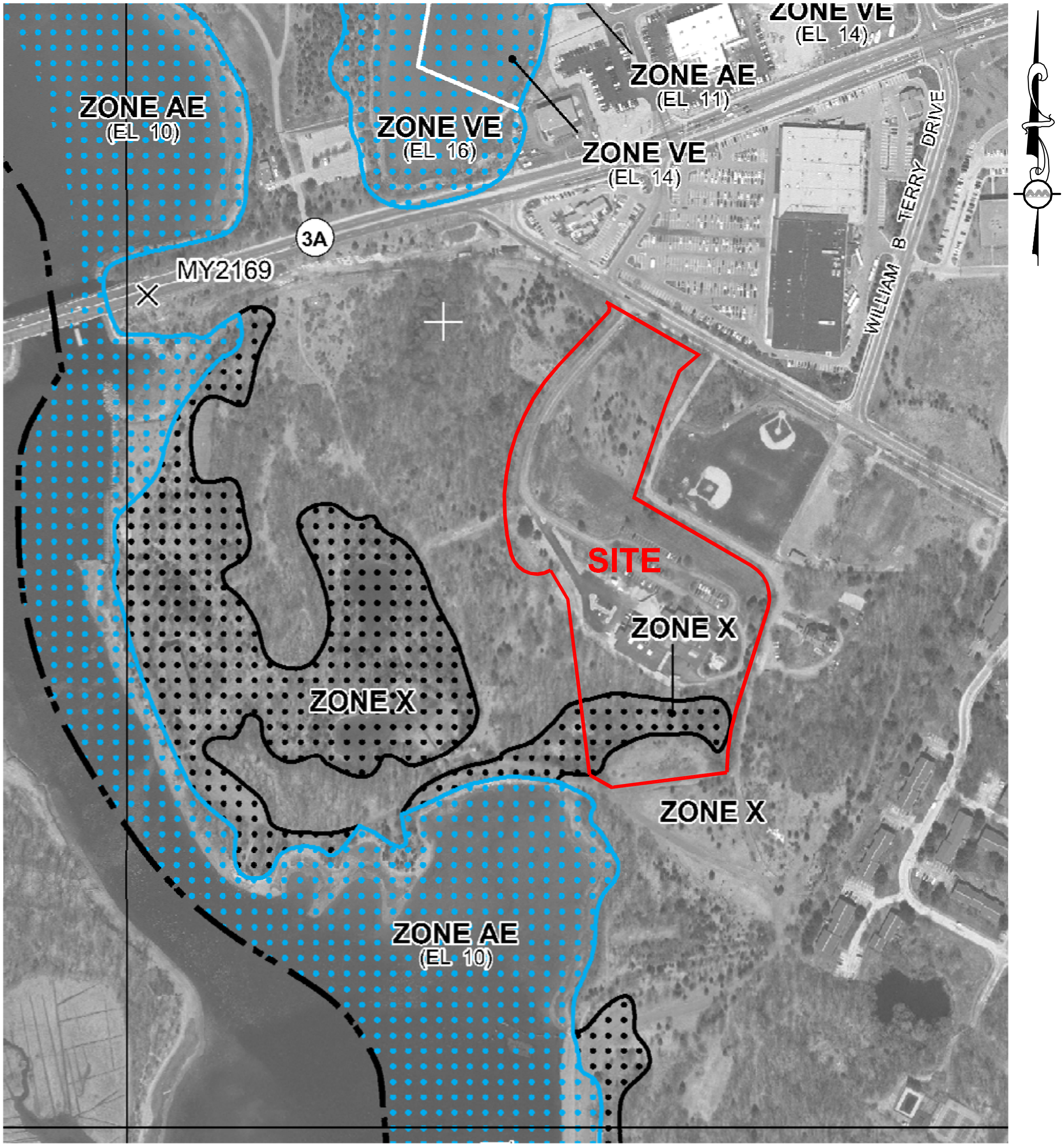
PROJECT:
230 BEAL STREET
HINGHAM, MA

AERIAL PHOTO

PROJECT NO.	2118-02	DATE:	10/25/2016
SCALE:	NOT TO SCALE	DWG. NAME:	C2118-02
DESIGNED BY:	SJL	CHECKED BY:	CMQ

SHEET No.
EX-2



FEMA FLOOD INSURANCE RATE MAP
PLYMOUTH COUNTY, MASSACHUSETTS
MAP NUMBER: 25023C0081J
JULY 17, 2012

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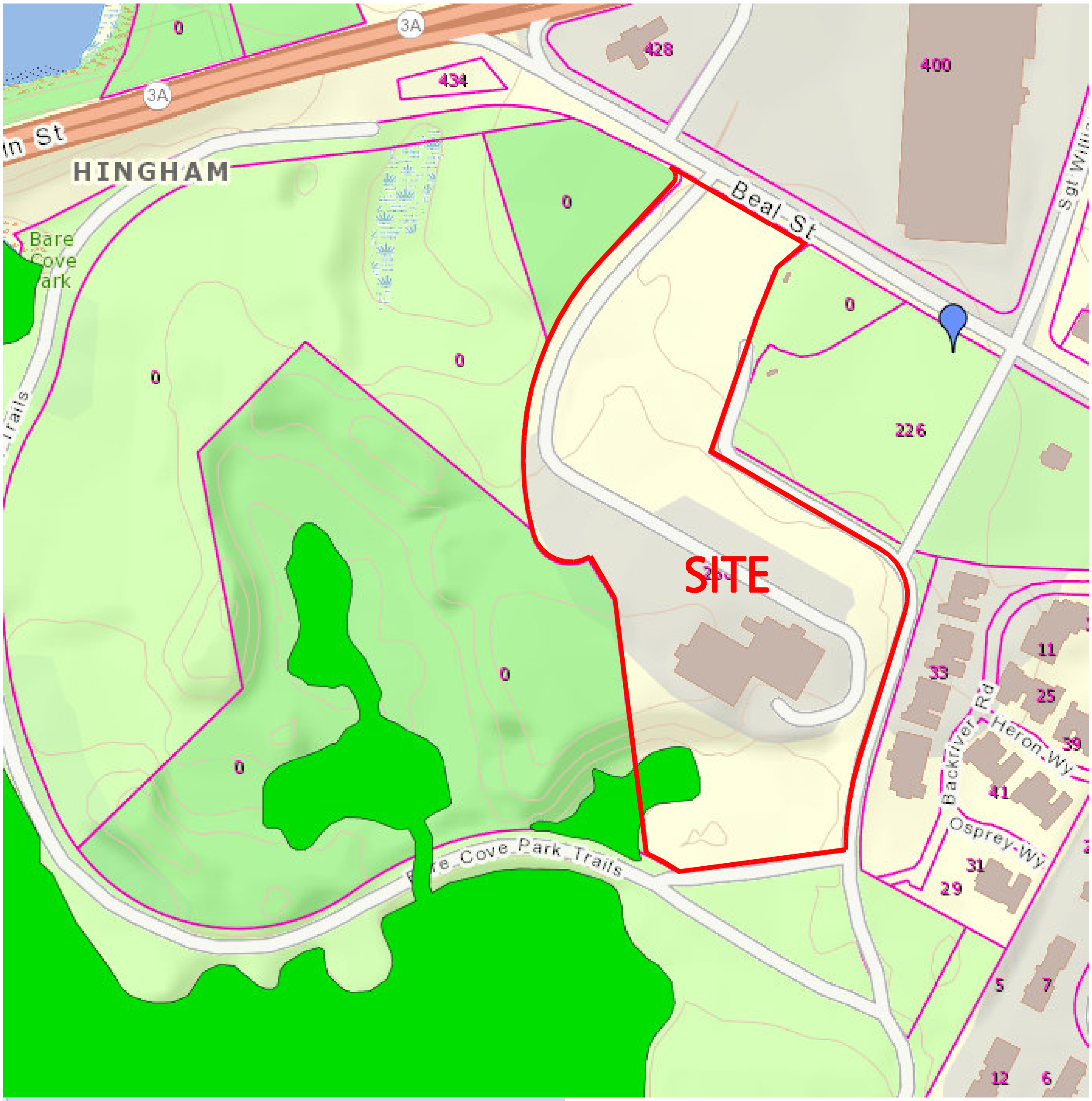
PROJECT:
230 BEAL STREET
HINGHAM, MA

FEMA FIRM MAP

PROJECT NO.	2118-02	DATE:	10/25/2016
SCALE:	NOT TO SCALE	DWG. NAME:	C2118-02
DESIGNED BY:	SJL	CHECKED BY:	CMQ

SHEET No.
EX-3



Outstanding Resource Waters

- PUBLIC WATER SUPPLY CONTRIBUTOR
- ORW FOR ACEC
- ORW FOR BOTH WATER SUPPLY AND OTHER

Tax Parcels for Query

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PROJECT:
230 BEAL STREET
HINGHAM, MA

OUTSTANDING RESOURCE WATER MAP

PROJECT NO.	2118-02	DATE:	10/25/2016
SCALE:	NOT TO SCALE	DWG. NAME:	C2118-02
DESIGNED BY:	SJL	CHECKED BY:	CMQ

SHEET No.
EX-4

LEGEND:

66 A: IPSWICH-PAWTUCKET-MATUNUCK COMPLEX; 0-2%
654 B: UDORTHENTS, LOAMY; 0-8%
254 B: MERRIMAC FINE SANDY LOAM; 3-8%
641 B: URBAN LAND, OUTWASH SUBSTRATUM; 0-8%
656 B: UDORTHENTS - URBAN LAND COMPLEX; 0-8%
657 A: AQUEPTS; 0-3%
659 B: UDORTHENTS; 0-8%, GRAVELLY
660 C: UDORTHENTS; 8-15%, GRAVELLY

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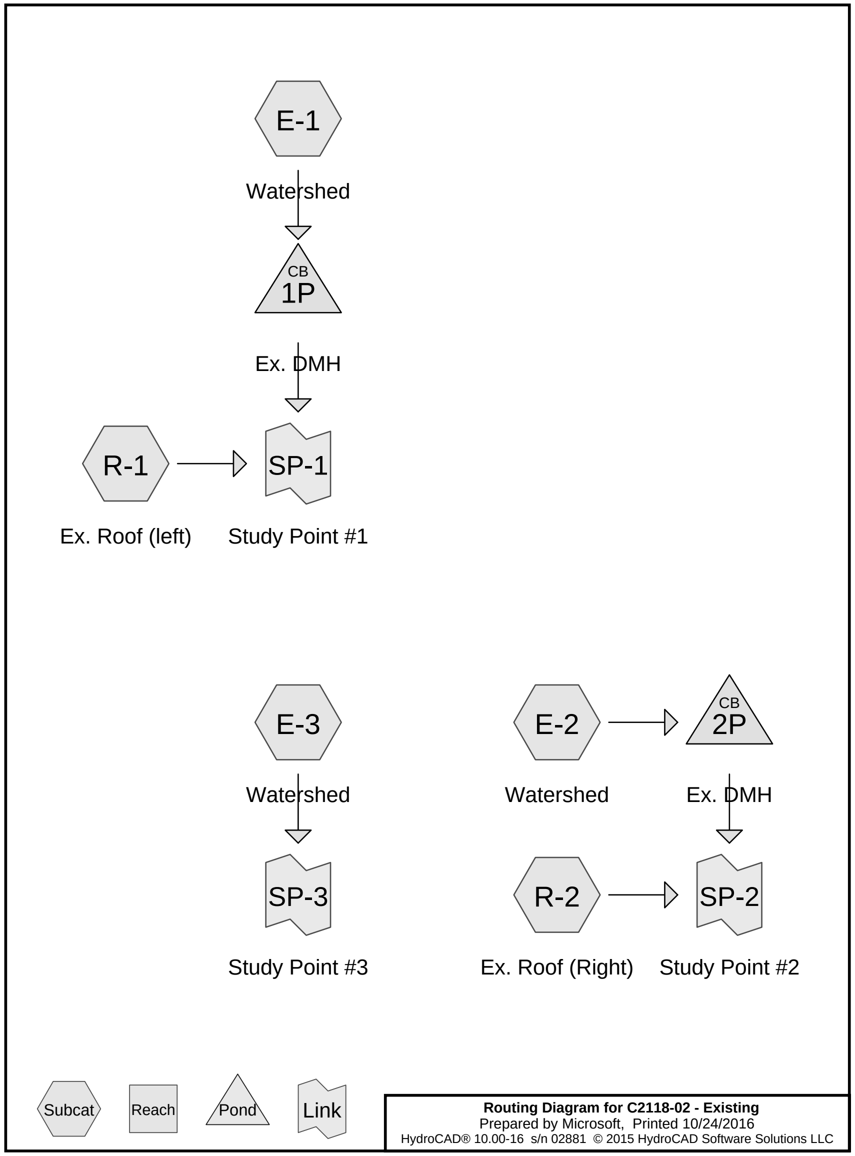
PROJECT:
230 BEAL STREET
HINGHAM, MA

SOILS MAP

PROJECT NO.	2118-02	DATE:	10/25/2016
SCALE:	NOT TO SCALE	DWG. NAME:	C2118-02
DESIGNED BY:	SJL	CHECKED BY:	CMQ

SHEET No.
EX-5



Time span=0.00-36.00 hrs, dt=0.05 hrs, 721 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment E-1: Watershed Runoff Area=278,929 sf 14.82% Impervious Runoff Depth=0.49"
Flow Length=842' Tc=22.3 min CN=60 Runoff=1.60 cfs 11,368 cf

Subcatchment E-2: Watershed Runoff Area=132,543 sf 34.94% Impervious Runoff Depth=1.11"
Flow Length=100' Tc=6.0 min CN=73 Runoff=3.71 cfs 12,293 cf

Subcatchment E-3: Watershed Runoff Area=89,191 sf 4.43% Impervious Runoff Depth=0.70"
Flow Length=316' Tc=14.4 min CN=65 Runoff=1.04 cfs 5,204 cf

Subcatchment R-1: Ex. Roof (left) Runoff Area=12,344 sf 100.00% Impervious Runoff Depth=3.17"
Tc=6.0 min CN=98 Runoff=0.91 cfs 3,258 cf

Subcatchment R-2: Ex. Roof (Right) Runoff Area=12,284 sf 100.00% Impervious Runoff Depth=3.17"
Tc=6.0 min CN=98 Runoff=0.91 cfs 3,242 cf

Pond 1P: Ex. DMH Peak Elev=12.31' Inflow=1.60 cfs 11,368 cf
18.0" Round Culvert n=0.015 L=32.0' S=0.0625 '/' Outflow=1.60 cfs 11,368 cf

Pond 2P: Ex. DMH Peak Elev=19.41' Inflow=3.71 cfs 12,293 cf
18.0" Round Culvert n=0.015 L=190.0' S=0.0232 '/' Outflow=3.71 cfs 12,293 cf

Link SP-1: Study Point #1 Inflow=1.87 cfs 14,625 cf
Primary=1.87 cfs 14,625 cf

Link SP-2: Study Point #2 Inflow=4.61 cfs 15,534 cf
Primary=4.61 cfs 15,534 cf

Link SP-3: Study Point #3 Inflow=1.04 cfs 5,204 cf
Primary=1.04 cfs 5,204 cf

Total Runoff Area = 525,291 sf Runoff Volume = 35,364 cf Average Runoff Depth = 0.81"
77.87% Pervious = 409,062 sf 22.13% Impervious = 116,229 sf

Summary for Subcatchment E-1: Watershed

Runoff = 1.60 cfs @ 12.43 hrs, Volume= 11,368 cf, Depth= 0.49"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (sf)	CN	Description
25,611	98	Paved parking, HSG A
15,727	98	Paved parking, HSG B
24,418	39	>75% Grass cover, Good, HSG A
111,979	61	>75% Grass cover, Good, HSG B
38,171	32	Woods/grass comb., Good, HSG A
63,023	58	Woods/grass comb., Good, HSG B
278,929	60	Weighted Average
237,591		85.18% Pervious Area
41,338		14.82% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.9	50	0.0260	0.17		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.40"
7.4	356	0.0130	0.80		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
6.1	207	0.0130	0.57		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
1.5	45	0.0050	0.49		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
2.3	119	0.0310	0.88		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
0.1	65	0.0630	12.93	22.85	**Pipe Channel, RCP_Round 18"** 18.0" Round Area= 1.8 sf Perim= 4.7' r= 0.38' n= 0.015 Concrete sewer w/manholes & inlets
22.3	842	Total			

Summary for Subcatchment E-2: Watershed

Runoff = 3.71 cfs @ 12.10 hrs, Volume= 12,293 cf, Depth= 1.11"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (sf)	CN	Description
46,311	98	Paved parking, HSG B
55,350	61	>75% Grass cover, Good, HSG B
30,882	58	Woods/grass comb., Good, HSG B
132,543	73	Weighted Average
86,232		65.06% Pervious Area
46,311		34.94% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	100		0.28		**Direct Entry, Min. Tc.**

Summary for Subcatchment E-3: Watershed

Runoff = 1.04 cfs @ 12.24 hrs, Volume= 5,204 cf, Depth= 0.70"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (sf)	CN	Description
1,396	98	Water Surface, 0% imp, HSG B
3,952	98	Paved parking, HSG B
31,835	61	>75% Grass cover, Good, HSG B
1,152	32	Woods/grass comb., Good, HSG A
34,494	58	Woods/grass comb., Good, HSG B
16,362	79	Woods/grass comb., Good, HSG D
89,191	65	Weighted Average
85,239		95.57% Pervious Area
3,952		4.43% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	50	0.0110	0.12		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.40"
4.4	132	0.0050	0.49		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
1.2	114	0.1030	1.60		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
1.9	20	0.0050	0.18		**Shallow Concentrated Flow,** Forest w/Heavy Litter Kv= 2.5 fps
14.4	316	Total			

Summary for Subcatchment R-1: Ex. Roof (left)

Runoff = 0.91 cfs @ 12.09 hrs, Volume= 3,258 cf, Depth= 3.17"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (sf)	CN	Description
1,647	98	Unconnected roofs, HSG A
10,697	98	Unconnected roofs, HSG B
12,344	98	Weighted Average
12,344		100.00% Impervious Area
12,344		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, Min. Tc.**

Summary for Subcatchment R-2: Ex. Roof (Right)

Runoff = 0.91 cfs @ 12.09 hrs, Volume= 3,242 cf, Depth= 3.17"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (sf)	CN	Description
12,284	98	Unconnected roofs, HSG B
12,284		100.00% Impervious Area
12,284		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, Min. Tc.**

Summary for Pond 1P: Ex. DMH

Inflow Area = 278,929 sf, 14.82% Impervious, Inflow Depth = 0.49" for 2-Year event
Inflow = 1.60 cfs @ 12.43 hrs, Volume= 11,368 cf
Outflow = 1.60 cfs @ 12.43 hrs, Volume= 11,368 cf, Atten= 0%, Lag= 0.0 min
Primary = 1.60 cfs @ 12.43 hrs, Volume= 11,368 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Peak Elev= 12.31' @ 12.43 hrs
Flood Elev= 20.98'

Device	Routing	Invert	Outlet Devices
#1	Primary	11.80'	**18.0" Round RCP_Round 18"** L= 32.0' RCP, groove end projecting, Ke= 0.200 Inlet / Outlet Invert= 11.80' / 9.80' S= 0.0625 '/' Cc= 0.900 n= 0.015 Concrete sewer w/manholes & inlets, Flow Area= 1.77 sf

Primary OutFlow Max=1.60 cfs @ 12.43 hrs HW=12.31' TW=0.00' (Dynamic Tailwater)
└─**1=RCP_Round 18"** (Inlet Controls 1.60 cfs @ 3.03 fps)

Summary for Pond 2P: Ex. DMH

Inflow Area = 132,543 sf, 34.94% Impervious, Inflow Depth = 1.11" for 2-Year event
Inflow = 3.71 cfs @ 12.10 hrs, Volume= 12,293 cf
Outflow = 3.71 cfs @ 12.10 hrs, Volume= 12,293 cf, Atten= 0%, Lag= 0.0 min
Primary = 3.71 cfs @ 12.10 hrs, Volume= 12,293 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs

Peak Elev= 19.41' @ 12.10 hrs
Flood Elev= 28.22'

Device	Routing	Invert	Outlet Devices
#1	Primary	18.60'	**18.0" Round RCP_Round 18"** L= 190.0' RCP, groove end projecting, Ke= 0.200 Inlet / Outlet Invert= 18.60' / 14.20' S= 0.0232 '/' Cc= 0.900 n= 0.015 Concrete sewer w/manholes & inlets, Flow Area= 1.77 sf

Primary OutFlow Max=3.71 cfs @ 12.10 hrs HW=19.41' TW=0.00' (Dynamic Tailwater)
└─**1=RCP_Round 18"** (Inlet Controls 3.71 cfs @ 3.82 fps)

Summary for Link SP-1: Study Point #1

Inflow Area = 291,273 sf, 18.43% Impervious, Inflow Depth = 0.60" for 2-Year event
Inflow = 1.87 cfs @ 12.40 hrs, Volume= 14,625 cf
Primary = 1.87 cfs @ 12.40 hrs, Volume= 14,625 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs

Summary for Link SP-2: Study Point #2

Inflow Area = 144,827 sf, 40.46% Impervious, Inflow Depth = 1.29" for 2-Year event
Inflow = 4.61 cfs @ 12.10 hrs, Volume= 15,534 cf
Primary = 4.61 cfs @ 12.10 hrs, Volume= 15,534 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs

Summary for Link SP-3: Study Point #3

Inflow Area = 89,191 sf, 4.43% Impervious, Inflow Depth = 0.70" for 2-Year event
Inflow = 1.04 cfs @ 12.24 hrs, Volume= 5,204 cf
Primary = 1.04 cfs @ 12.24 hrs, Volume= 5,204 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs

Time span=0.00-36.00 hrs, dt=0.05 hrs, 721 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment E-1: Watershed Runoff Area=278,929 sf 14.82% Impervious Runoff Depth=1.13"
Flow Length=842' Tc=22.3 min CN=60 Runoff=4.74 cfs 26,258 cf

Subcatchment E-2: Watershed Runoff Area=132,543 sf 34.94% Impervious Runoff Depth=2.05"
Flow Length=100' Tc=6.0 min CN=73 Runoff=7.10 cfs 22,618 cf

Subcatchment E-3: Watershed Runoff Area=89,191 sf 4.43% Impervious Runoff Depth=1.46"
Flow Length=316' Tc=14.4 min CN=65 Runoff=2.49 cfs 10,831 cf

Subcatchment R-1: Ex. Roof (left) Runoff Area=12,344 sf 100.00% Impervious Runoff Depth=4.46"
Tc=6.0 min CN=98 Runoff=1.27 cfs 4,592 cf

Subcatchment R-2: Ex. Roof (Right) Runoff Area=12,284 sf 100.00% Impervious Runoff Depth=4.46"
Tc=6.0 min CN=98 Runoff=1.27 cfs 4,569 cf

Pond 1P: Ex. DMH Peak Elev=12.73' Inflow=4.74 cfs 26,258 cf
18.0" Round Culvert n=0.015 L=32.0' S=0.0625 '/' Outflow=4.74 cfs 26,258 cf

Pond 2P: Ex. DMH Peak Elev=19.80' Inflow=7.10 cfs 22,618 cf
18.0" Round Culvert n=0.015 L=190.0' S=0.0232 '/' Outflow=7.10 cfs 22,618 cf

Link SP-1: Study Point #1 Inflow=5.18 cfs 30,850 cf
Primary=5.18 cfs 30,850 cf

Link SP-2: Study Point #2 Inflow=8.36 cfs 27,188 cf
Primary=8.36 cfs 27,188 cf

Link SP-3: Study Point #3 Inflow=2.49 cfs 10,831 cf
Primary=2.49 cfs 10,831 cf

Total Runoff Area = 525,291 sf Runoff Volume = 68,869 cf Average Runoff Depth = 1.57"
77.87% Pervious = 409,062 sf 22.13% Impervious = 116,229 sf

Summary for Subcatchment E-1: Watershed

Runoff = 4.74 cfs @ 12.36 hrs, Volume= 26,258 cf, Depth= 1.13"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.70"

Area (sf)	CN	Description
25,611	98	Paved parking, HSG A
15,727	98	Paved parking, HSG B
24,418	39	>75% Grass cover, Good, HSG A
111,979	61	>75% Grass cover, Good, HSG B
38,171	32	Woods/grass comb., Good, HSG A
63,023	58	Woods/grass comb., Good, HSG B
278,929	60	Weighted Average
237,591		85.18% Pervious Area
41,338		14.82% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.9	50	0.0260	0.17		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.40"
7.4	356	0.0130	0.80		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
6.1	207	0.0130	0.57		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
1.5	45	0.0050	0.49		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
2.3	119	0.0310	0.88		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
0.1	65	0.0630	12.93	22.85	**Pipe Channel, RCP_Round 18"** 18.0" Round Area= 1.8 sf Perim= 4.7' r= 0.38' n= 0.015 Concrete sewer w/manholes & inlets
22.3	842	Total			

Summary for Subcatchment E-2: Watershed

Runoff = 7.10 cfs @ 12.10 hrs, Volume= 22,618 cf, Depth= 2.05"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.70"

Area (sf)	CN	Description
46,311	98	Paved parking, HSG B
55,350	61	>75% Grass cover, Good, HSG B
30,882	58	Woods/grass comb., Good, HSG B
132,543	73	Weighted Average
86,232		65.06% Pervious Area
46,311		34.94% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	100		0.28		**Direct Entry, Min. Tc.**

Summary for Subcatchment E-3: Watershed

Runoff = 2.49 cfs @ 12.22 hrs, Volume= 10,831 cf, Depth= 1.46"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.70"

Area (sf)	CN	Description
1,396	98	Water Surface, 0% imp, HSG B
3,952	98	Paved parking, HSG B
31,835	61	>75% Grass cover, Good, HSG B
1,152	32	Woods/grass comb., Good, HSG A
34,494	58	Woods/grass comb., Good, HSG B
16,362	79	Woods/grass comb., Good, HSG D
89,191	65	Weighted Average
85,239		95.57% Pervious Area
3,952		4.43% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	50	0.0110	0.12		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.40"
4.4	132	0.0050	0.49		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
1.2	114	0.1030	1.60		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
1.9	20	0.0050	0.18		**Shallow Concentrated Flow,** Forest w/Heavy Litter Kv= 2.5 fps
14.4	316	Total			

Summary for Subcatchment R-1: Ex. Roof (left)

Runoff = 1.27 cfs @ 12.09 hrs, Volume= 4,592 cf, Depth= 4.46"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.70"

Area (sf)	CN	Description
1,647	98	Unconnected roofs, HSG A
10,697	98	Unconnected roofs, HSG B
12,344	98	Weighted Average
12,344		100.00% Impervious Area
12,344		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, Min. Tc.**

Summary for Subcatchment R-2: Ex. Roof (Right)

Runoff = 1.27 cfs @ 12.09 hrs, Volume= 4,569 cf, Depth= 4.46"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.70"

Area (sf)	CN	Description
12,284	98	Unconnected roofs, HSG B
12,284		100.00% Impervious Area
12,284		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, Min. Tc.**

Summary for Pond 1P: Ex. DMH

Inflow Area = 278,929 sf, 14.82% Impervious, Inflow Depth = 1.13" for 10-Year event
Inflow = 4.74 cfs @ 12.36 hrs, Volume= 26,258 cf
Outflow = 4.74 cfs @ 12.36 hrs, Volume= 26,258 cf, Atten= 0%, Lag= 0.0 min
Primary = 4.74 cfs @ 12.36 hrs, Volume= 26,258 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Peak Elev= 12.73' @ 12.36 hrs
Flood Elev= 20.98'

Device	Routing	Invert	Outlet Devices
#1	Primary	11.80'	**18.0" Round RCP_Round 18"** L= 32.0' RCP, groove end projecting, Ke= 0.200 Inlet / Outlet Invert= 11.80' / 9.80' S= 0.0625 '/' Cc= 0.900 n= 0.015 Concrete sewer w/manholes & inlets, Flow Area= 1.77 sf

Primary OutFlow Max=4.72 cfs @ 12.36 hrs HW=12.73' TW=0.00' (Dynamic Tailwater)
1=RCP_Round 18" (Inlet Controls 4.72 cfs @ 4.10 fps)

Summary for Pond 2P: Ex. DMH

Inflow Area = 132,543 sf, 34.94% Impervious, Inflow Depth = 2.05" for 10-Year event
Inflow = 7.10 cfs @ 12.10 hrs, Volume= 22,618 cf
Outflow = 7.10 cfs @ 12.10 hrs, Volume= 22,618 cf, Atten= 0%, Lag= 0.0 min
Primary = 7.10 cfs @ 12.10 hrs, Volume= 22,618 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs

Peak Elev= 19.80' @ 12.10 hrs
Flood Elev= 28.22'

Device	Routing	Invert	Outlet Devices
#1	Primary	18.60'	**18.0" Round RCP_Round 18"** L= 190.0' RCP, groove end projecting, Ke= 0.200 Inlet / Outlet Invert= 18.60' / 14.20' S= 0.0232 '/' Cc= 0.900 n= 0.015 Concrete sewer w/manholes & inlets, Flow Area= 1.77 sf

Primary OutFlow Max=7.02 cfs @ 12.10 hrs HW=19.79' TW=0.00' (Dynamic Tailwater)
1=RCP_Round 18" (Inlet Controls 7.02 cfs @ 4.65 fps)

Summary for Link SP-1: Study Point #1

Inflow Area = 291,273 sf, 18.43% Impervious, Inflow Depth = 1.27" for 10-Year event
Inflow = 5.18 cfs @ 12.35 hrs, Volume= 30,850 cf
Primary = 5.18 cfs @ 12.35 hrs, Volume= 30,850 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs

Summary for Link SP-2: Study Point #2

Inflow Area = 144,827 sf, 40.46% Impervious, Inflow Depth = 2.25" for 10-Year event
Inflow = 8.36 cfs @ 12.09 hrs, Volume= 27,188 cf
Primary = 8.36 cfs @ 12.09 hrs, Volume= 27,188 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs

Summary for Link SP-3: Study Point #3

Inflow Area = 89,191 sf, 4.43% Impervious, Inflow Depth = 1.46" for 10-Year event
Inflow = 2.49 cfs @ 12.22 hrs, Volume= 10,831 cf
Primary = 2.49 cfs @ 12.22 hrs, Volume= 10,831 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs

Time span=0.00-36.00 hrs, dt=0.05 hrs, 721 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment E-1: Watershed	Runoff Area=278,929 sf 14.82% Impervious Runoff Depth=2.60" Flow Length=842' Tc=22.3 min CN=60 Runoff=12.12 cfs 60,518 cf
Subcatchment E-2: Watershed	Runoff Area=132,543 sf 34.94% Impervious Runoff Depth=3.94" Flow Length=100' Tc=6.0 min CN=73 Runoff=13.76 cfs 43,466 cf
Subcatchment E-3: Watershed	Runoff Area=89,191 sf 4.43% Impervious Runoff Depth=3.10" Flow Length=316' Tc=14.4 min CN=65 Runoff=5.63 cfs 23,060 cf
Subcatchment R-1: Ex. Roof (left)	Runoff Area=12,344 sf 100.00% Impervious Runoff Depth=6.76" Tc=6.0 min CN=98 Runoff=1.90 cfs 6,955 cf
Subcatchment R-2: Ex. Roof (Right)	Runoff Area=12,284 sf 100.00% Impervious Runoff Depth=6.76" Tc=6.0 min CN=98 Runoff=1.89 cfs 6,921 cf
Pond 1P: Ex. DMH	Peak Elev=13.85' Inflow=12.12 cfs 60,518 cf 18.0" Round Culvert n=0.015 L=32.0' S=0.0625 '/' Outflow=12.12 cfs 60,518 cf
Pond 2P: Ex. DMH	Peak Elev=21.16' Inflow=13.76 cfs 43,466 cf 18.0" Round Culvert n=0.015 L=190.0' S=0.0232 '/' Outflow=13.76 cfs 43,466 cf
Link SP-1: Study Point #1	Inflow=12.85 cfs 67,473 cf Primary=12.85 cfs 67,473 cf
Link SP-2: Study Point #2	Inflow=15.65 cfs 50,387 cf Primary=15.65 cfs 50,387 cf
Link SP-3: Study Point #3	Inflow=5.63 cfs 23,060 cf Primary=5.63 cfs 23,060 cf

Total Runoff Area = 525,291 sf Runoff Volume = 140,920 cf Average Runoff Depth = 3.22"
77.87% Pervious = 409,062 sf 22.13% Impervious = 116,229 sf

Summary for Subcatchment E-1: Watershed

Runoff = 12.12 cfs @ 12.33 hrs, Volume= 60,518 cf, Depth= 2.60"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (sf)	CN	Description
25,611	98	Paved parking, HSG A
15,727	98	Paved parking, HSG B
24,418	39	>75% Grass cover, Good, HSG A
111,979	61	>75% Grass cover, Good, HSG B
38,171	32	Woods/grass comb., Good, HSG A
63,023	58	Woods/grass comb., Good, HSG B
278,929	60	Weighted Average
237,591		85.18% Pervious Area
41,338		14.82% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.9	50	0.0260	0.17		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.40"
7.4	356	0.0130	0.80		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
6.1	207	0.0130	0.57		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
1.5	45	0.0050	0.49		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
2.3	119	0.0310	0.88		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
0.1	65	0.0630	12.93	22.85	**Pipe Channel, RCP_Round 18"** 18.0" Round Area= 1.8 sf Perim= 4.7' r= 0.38' n= 0.015 Concrete sewer w/manholes & inlets
22.3	842	Total			

Summary for Subcatchment E-2: Watershed

Runoff = 13.76 cfs @ 12.09 hrs, Volume= 43,466 cf, Depth= 3.94"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (sf)	CN	Description
46,311	98	Paved parking, HSG B
55,350	61	>75% Grass cover, Good, HSG B
30,882	58	Woods/grass comb., Good, HSG B
132,543	73	Weighted Average
86,232		65.06% Pervious Area
46,311		34.94% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	100		0.28		**Direct Entry, Min. Tc.**

Summary for Subcatchment E-3: Watershed

Runoff = 5.63 cfs @ 12.21 hrs, Volume= 23,060 cf, Depth= 3.10"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (sf)	CN	Description
1,396	98	Water Surface, 0% imp, HSG B
3,952	98	Paved parking, HSG B
31,835	61	>75% Grass cover, Good, HSG B
1,152	32	Woods/grass comb., Good, HSG A
34,494	58	Woods/grass comb., Good, HSG B
16,362	79	Woods/grass comb., Good, HSG D
89,191	65	Weighted Average
85,239		95.57% Pervious Area
3,952		4.43% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	50	0.0110	0.12		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.40"
4.4	132	0.0050	0.49		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
1.2	114	0.1030	1.60		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
1.9	20	0.0050	0.18		**Shallow Concentrated Flow,** Forest w/Heavy Litter Kv= 2.5 fps
14.4	316	Total			

Summary for Subcatchment R-1: Ex. Roof (left)

Runoff = 1.90 cfs @ 12.09 hrs, Volume= 6,955 cf, Depth= 6.76"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (sf)	CN	Description
1,647	98	Unconnected roofs, HSG A
10,697	98	Unconnected roofs, HSG B
12,344	98	Weighted Average
12,344		100.00% Impervious Area
12,344		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, Min. Tc.**

Summary for Subcatchment R-2: Ex. Roof (Right)

Runoff = 1.89 cfs @ 12.09 hrs, Volume= 6,921 cf, Depth= 6.76"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (sf)	CN	Description
12,284	98	Unconnected roofs, HSG B
12,284		100.00% Impervious Area
12,284		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, Min. Tc.**

Summary for Pond 1P: Ex. DMH

Inflow Area = 278,929 sf, 14.82% Impervious, Inflow Depth = 2.60" for 100-Year event
Inflow = 12.12 cfs @ 12.33 hrs, Volume= 60,518 cf
Outflow = 12.12 cfs @ 12.33 hrs, Volume= 60,518 cf, Atten= 0%, Lag= 0.0 min
Primary = 12.12 cfs @ 12.33 hrs, Volume= 60,518 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Peak Elev= 13.85' @ 12.33 hrs
Flood Elev= 20.98'

Device	Routing	Invert	Outlet Devices
#1	Primary	11.80'	**18.0" Round RCP_Round 18"** L= 32.0' RCP, groove end projecting, Ke= 0.200 Inlet / Outlet Invert= 11.80' / 9.80' S= 0.0625 '/' Cc= 0.900 n= 0.015 Concrete sewer w/manholes & inlets, Flow Area= 1.77 sf

Primary OutFlow Max=12.05 cfs @ 12.33 hrs HW=13.83' TW=0.00' (Dynamic Tailwater)
└─**1=RCP_Round 18"** (Inlet Controls 12.05 cfs @ 6.82 fps)

Summary for Pond 2P: Ex. DMH

Inflow Area = 132,543 sf, 34.94% Impervious, Inflow Depth = 3.94" for 100-Year event
Inflow = 13.76 cfs @ 12.09 hrs, Volume= 43,466 cf
Outflow = 13.76 cfs @ 12.09 hrs, Volume= 43,466 cf, Atten= 0%, Lag= 0.0 min
Primary = 13.76 cfs @ 12.09 hrs, Volume= 43,466 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs

Peak Elev= 21.16' @ 12.09 hrs
Flood Elev= 28.22'

Device	Routing	Invert	Outlet Devices
#1	Primary	18.60'	**18.0" Round RCP_Round 18"** L= 190.0' RCP, groove end projecting, Ke= 0.200 Inlet / Outlet Invert= 18.60' / 14.20' S= 0.0232 '/' Cc= 0.900 n= 0.015 Concrete sewer w/manholes & inlets, Flow Area= 1.77 sf

Primary OutFlow Max=13.63 cfs @ 12.09 hrs HW=21.08' TW=0.00' (Dynamic Tailwater)
└─**1=RCP_Round 18"** (Barrel Controls 13.63 cfs @ 7.71 fps)

Summary for Link SP-1: Study Point #1

Inflow Area = 291,273 sf, 18.43% Impervious, Inflow Depth = 2.78" for 100-Year event
Inflow = 12.85 cfs @ 12.32 hrs, Volume= 67,473 cf
Primary = 12.85 cfs @ 12.32 hrs, Volume= 67,473 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs

Summary for Link SP-2: Study Point #2

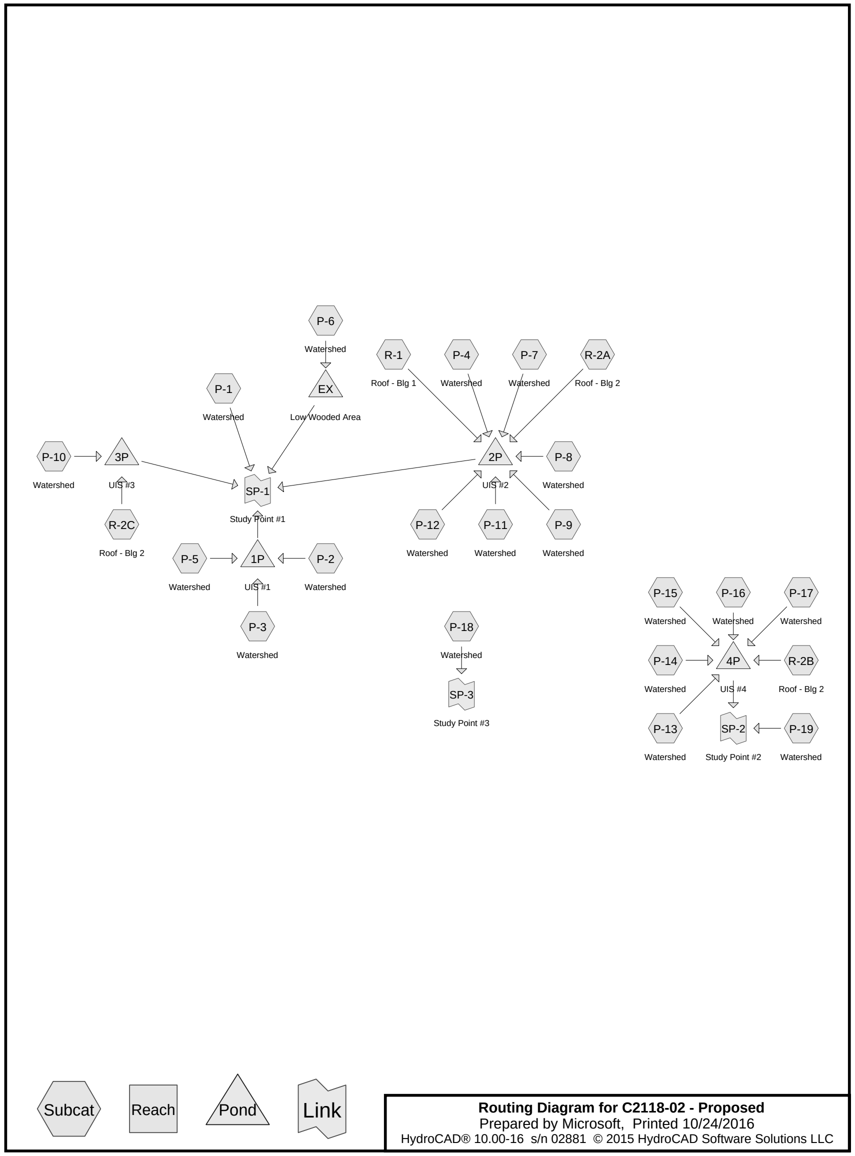
Inflow Area = 144,827 sf, 40.46% Impervious, Inflow Depth = 4.17" for 100-Year event
Inflow = 15.65 cfs @ 12.09 hrs, Volume= 50,387 cf
Primary = 15.65 cfs @ 12.09 hrs, Volume= 50,387 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs

Summary for Link SP-3: Study Point #3

Inflow Area = 89,191 sf, 4.43% Impervious, Inflow Depth = 3.10" for 100-Year event
Inflow = 5.63 cfs @ 12.21 hrs, Volume= 23,060 cf
Primary = 5.63 cfs @ 12.21 hrs, Volume= 23,060 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs



Time span=0.00-36.00 hrs, dt=0.05 hrs, 721 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment P-1: Watershed Runoff Area=19,602 sf 17.35% Impervious Runoff Depth=0.28"
Tc=6.0 min CN=54 Runoff=0.05 cfs 460 cf

Subcatchment P-10: Watershed Runoff Area=34,442 sf 31.42% Impervious Runoff Depth=0.53"
Flow Length=160' Tc=6.0 min CN=61 Runoff=0.33 cfs 1,517 cf

Subcatchment P-11: Watershed Runoff Area=21,449 sf 46.97% Impervious Runoff Depth=1.42"
Flow Length=160' Tc=6.0 min CN=78 Runoff=0.79 cfs 2,541 cf

Subcatchment P-12: Watershed Runoff Area=15,395 sf 57.91% Impervious Runoff Depth=1.70"
Flow Length=160' Tc=6.0 min CN=82 Runoff=0.69 cfs 2,181 cf

Subcatchment P-13: Watershed Runoff Area=4,800 sf 67.37% Impervious Runoff Depth=2.01"
Flow Length=160' Tc=6.0 min CN=86 Runoff=0.25 cfs 804 cf

Subcatchment P-14: Watershed Runoff Area=24,445 sf 51.05% Impervious Runoff Depth=1.56"
Flow Length=160' Tc=6.0 min CN=80 Runoff=1.00 cfs 3,173 cf

Subcatchment P-15: Watershed Runoff Area=16,750 sf 15.43% Impervious Runoff Depth=0.70"
Flow Length=160' Tc=6.0 min CN=65 Runoff=0.26 cfs 977 cf

Subcatchment P-16: Watershed Runoff Area=18,626 sf 52.06% Impervious Runoff Depth=1.56"
Flow Length=160' Tc=6.0 min CN=80 Runoff=0.76 cfs 2,417 cf

Subcatchment P-17: Watershed Runoff Area=23,626 sf 47.93% Impervious Runoff Depth=1.42"
Flow Length=160' Tc=6.0 min CN=78 Runoff=0.87 cfs 2,799 cf

Subcatchment P-18: Watershed Runoff Area=89,505 sf 4.55% Impervious Runoff Depth=0.66"
Flow Length=316' Tc=14.4 min CN=64 Runoff=0.94 cfs 4,887 cf

Subcatchment P-19: Watershed Runoff Area=33,178 sf 0.00% Impervious Runoff Depth=0.45"
Flow Length=160' Tc=6.0 min CN=59 Runoff=0.23 cfs 1,247 cf

Subcatchment P-2: Watershed Runoff Area=9,533 sf 73.47% Impervious Runoff Depth=2.18"
Flow Length=100' Tc=6.0 min CN=88 Runoff=0.54 cfs 1,730 cf

Subcatchment P-3: Watershed Runoff Area=25,878 sf 14.23% Impervious Runoff Depth=0.75"
Flow Length=160' Tc=6.0 min CN=66 Runoff=0.43 cfs 1,610 cf

Subcatchment P-4: Watershed Runoff Area=3,442 sf 100.00% Impervious Runoff Depth=3.17"
Tc=6.0 min CN=98 Runoff=0.26 cfs 908 cf

Subcatchment P-5: Watershed Runoff Area=26,819 sf 78.10% Impervious Runoff Depth=2.26"
Tc=6.0 min CN=89 Runoff=1.59 cfs 5,062 cf

Subcatchment P-6: Watershed Runoff Area=22,639 sf 1.29% Impervious Runoff Depth=0.01"
Tc=6.0 min CN=40 Runoff=0.00 cfs 20 cf

Subcatchment P-7: Watershed Runoff Area=13,890 sf 64.95% Impervious Runoff Depth=1.93"
Flow Length=160' Tc=6.0 min CN=85 Runoff=0.71 cfs 2,233 cf

Subcatchment P-8: Watershed Runoff Area=8,052 sf 79.77% Impervious Runoff Depth=2.45"
Flow Length=160' Tc=6.0 min CN=91 Runoff=0.51 cfs 1,642 cf

Subcatchment P-9: Watershed Runoff Area=12,329 sf 40.72% Impervious Runoff Depth=1.29"
Flow Length=160' Tc=6.0 min CN=76 Runoff=0.41 cfs 1,329 cf

Subcatchment R-1: Roof - Blg 1 Runoff Area=31,613 sf 100.00% Impervious Runoff Depth=3.17"
Tc=6.0 min CN=98 Runoff=2.34 cfs 8,343 cf

Subcatchment R-2A: Roof - Blg 2 Runoff Area=23,334 sf 100.00% Impervious Runoff Depth=3.17"
Tc=6.0 min CN=98 Runoff=1.73 cfs 6,158 cf

Subcatchment R-2B: Roof - Blg 2 Runoff Area=35,439 sf 100.00% Impervious Runoff Depth=3.17"
Tc=6.0 min CN=98 Runoff=2.63 cfs 9,352 cf

Subcatchment R-2C: Roof - Blg 2 Runoff Area=10,505 sf 100.00% Impervious Runoff Depth=3.17"
Tc=6.0 min CN=98 Runoff=0.78 cfs 2,772 cf

Pond 1P: UIS #1 Peak Elev=15.04' Storage=4,804 cf Inflow=2.56 cfs 8,402 cf
Outflow=0.24 cfs 4,266 cf

Pond 2P: UIS #2 Peak Elev=20.89' Storage=14,795 cf Inflow=7.43 cfs 25,335 cf
Outflow=0.81 cfs 16,615 cf

Pond 3P: UIS #3 Peak Elev=14.61' Storage=2,196 cf Inflow=1.10 cfs 4,289 cf
Outflow=0.21 cfs 2,418 cf

Pond 4P: UIS #4 Peak Elev=15.22' Storage=7,797 cf Inflow=5.76 cfs 19,523 cf
Outflow=2.91 cfs 14,205 cf

Pond EX: Low Wooded Area Peak Elev=16.26' Storage=20 cf Inflow=0.00 cfs 20 cf
Outflow=0.00 cfs 0 cf

Link SP-1: Study Point #1 Inflow=1.25 cfs 23,759 cf
Primary=1.25 cfs 23,759 cf

Link SP-2: Study Point #2 Inflow=3.10 cfs 15,452 cf
Primary=3.10 cfs 15,452 cf

Link SP-3: Study Point #3 Inflow=0.94 cfs 4,887 cf
Primary=0.94 cfs 4,887 cf

Total Runoff Area = 525,291 sf Runoff Volume = 64,163 cf Average Runoff Depth = 1.47"
55.58% Pervious = 291,972 sf 44.42% Impervious = 233,319 sf

Summary for Subcatchment P-1: Watershed

Runoff = 0.05 cfs @ 12.32 hrs, Volume= 460 cf, Depth= 0.28"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (sf)	CN	Description
100	98	Paved parking, HSG A
3,300	98	Paved parking, HSG B
2,671	39	>75% Grass cover, Good, HSG A
4,687	61	>75% Grass cover, Good, HSG B
6,509	32	Woods/grass comb., Good, HSG A
2,335	58	Woods/grass comb., Good, HSG B
19,602	54	Weighted Average
16,202		82.65% Pervious Area
3,400		17.35% Impervious Area

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

Summary for Subcatchment P-10: Watershed

Runoff = 0.33 cfs @ 12.12 hrs, Volume= 1,517 cf, Depth= 0.53"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (sf)	CN	Description
5,299	98	Paved parking, HSG A
5,521	98	Paved parking, HSG B
15,068	39	>75% Grass cover, Good, HSG A
6,581	61	>75% Grass cover, Good, HSG B
1,973	32	Woods/grass comb., Good, HSG A
34,442	61	Weighted Average
23,622		68.58% Pervious Area
10,820		31.42% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	160		0.44		**Direct Entry, Min. Tc.**

Summary for Subcatchment P-11: Watershed

Runoff = 0.79 cfs @ 12.10 hrs, Volume= 2,541 cf, Depth= 1.42"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (sf)	CN	Description
10,074	98	Paved parking, HSG B
11,375	61	>75% Grass cover, Good, HSG B
21,449	78	Weighted Average
11,375		53.03% Pervious Area
10,074		46.97% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	160		0.44		**Direct Entry, Min. Tc.**

Summary for Subcatchment P-12: Watershed

Runoff = 0.69 cfs @ 12.09 hrs, Volume= 2,181 cf, Depth= 1.70"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (sf)	CN	Description
8,915	98	Paved parking, HSG B
6,480	61	>75% Grass cover, Good, HSG B
15,395	82	Weighted Average
6,480		42.09% Pervious Area
8,915		57.91% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	160		0.44		**Direct Entry, Min. Tc.**

Summary for Subcatchment P-13: Watershed

Runoff = 0.25 cfs @ 12.09 hrs, Volume= 804 cf, Depth= 2.01"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (sf)	CN	Description
3,234	98	Paved parking, HSG B
1,566	61	>75% Grass cover, Good, HSG B
4,800	86	Weighted Average
1,566		32.62% Pervious Area
3,234		67.37% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	160		0.44		**Direct Entry, Min. Tc.**

Summary for Subcatchment P-14: Watershed

Runoff = 1.00 cfs @ 12.10 hrs, Volume= 3,173 cf, Depth= 1.56"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (sf)	CN	Description
12,480	98	Paved parking, HSG B
11,965	61	>75% Grass cover, Good, HSG B
24,445	80	Weighted Average
11,965		48.95% Pervious Area
12,480		51.05% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	160		0.44		**Direct Entry, Min. Tc.**

Summary for Subcatchment P-15: Watershed

Runoff = 0.26 cfs @ 12.11 hrs, Volume= 977 cf, Depth= 0.70"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (sf)	CN	Description
2,585	98	Paved parking, HSG B
6,512	61	>75% Grass cover, Good, HSG B
7,653	58	Woods/grass comb., Good, HSG B
16,750	65	Weighted Average
14,165		84.57% Pervious Area
2,585		15.43% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	160		0.44		**Direct Entry, Min. Tc.**

Summary for Subcatchment P-16: Watershed

Runoff = 0.76 cfs @ 12.10 hrs, Volume= 2,417 cf, Depth= 1.56"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

	Area (sf)	CN	Description
	9,697	98	Paved parking, HSG B
	8,929	61	>75% Grass cover, Good, HSG B
	18,626	80	Weighted Average
	8,929		47.94% Pervious Area
	9,697		52.06% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	160		0.44		**Direct Entry, Min. Tc.**

Summary for Subcatchment P-17: Watershed

Runoff = 0.87 cfs @ 12.10 hrs, Volume= 2,799 cf, Depth= 1.42"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

	Area (sf)	CN	Description
	11,323	98	Paved parking, HSG B
	11,510	61	>75% Grass cover, Good, HSG B
	793	39	>75% Grass cover, Good, HSG A
	23,626	78	Weighted Average
	12,303		52.07% Pervious Area
	11,323		47.93% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	160		0.44		**Direct Entry, Min. Tc.**

Summary for Subcatchment P-18: Watershed

Runoff = 0.94 cfs @ 12.25 hrs, Volume= 4,887 cf, Depth= 0.66"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

	Area (sf)	CN	Description
*	1,395	98	Water Surface, 0% imp, HSG B
	3,801	39	>75% Grass cover, Good, HSG A
	33,365	61	>75% Grass cover, Good, HSG B
	2,502	32	Woods/grass comb., Good, HSG A
	28,018	58	Woods/grass comb., Good, HSG B
	16,355	79	Woods/grass comb., Good, HSG D
	2,519	98	Paved parking, HSG B
	1,550	98	Paved parking, HSG A
	89,505	64	Weighted Average
	85,436		95.45% Pervious Area
	4,069		4.55% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	50	0.0110	0.12		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.40"
4.4	132	0.0050	0.49		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
1.2	114	0.1030	1.60		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
1.9	20	0.0050	0.18		**Shallow Concentrated Flow,** Forest w/Heavy Litter Kv= 2.5 fps
14.4	316	Total			

Summary for Subcatchment P-19: Watershed

Runoff = 0.23 cfs @ 12.14 hrs, Volume= 1,247 cf, Depth= 0.45"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (sf)	CN	Description
9,855	61	>75% Grass cover, Good, HSG B
23,323	58	Woods/grass comb., Good, HSG B
33,178	59	Weighted Average
33,178		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	160		0.44		**Direct Entry, Min. Tc.**

Summary for Subcatchment P-2: Watershed

Runoff = 0.54 cfs @ 12.09 hrs, Volume= 1,730 cf, Depth= 2.18"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (sf)	CN	Description
7,004	98	Paved parking, HSG B
2,529	61	>75% Grass cover, Good, HSG B
9,533	88	Weighted Average
2,529		26.53% Pervious Area
7,004		73.47% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	100		0.28		**Direct Entry, Min. Tc.**

Summary for Subcatchment P-3: Watershed

Runoff = 0.43 cfs @ 12.11 hrs, Volume= 1,610 cf, Depth= 0.75"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (sf)	CN	Description
3,683	98	Paved parking, HSG B
22,195	61	>75% Grass cover, Good, HSG B
25,878	66	Weighted Average
22,195		85.77% Pervious Area
3,683		14.23% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	160		0.44		**Direct Entry, Min. Tc.**

Summary for Subcatchment P-4: Watershed

Runoff = 0.26 cfs @ 12.09 hrs, Volume= 908 cf, Depth= 3.17"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (sf)	CN	Description
3,442	98	Paved parking, HSG B
3,442		100.00% Impervious Area

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

Summary for Subcatchment P-5: Watershed

Runoff = 1.59 cfs @ 12.09 hrs, Volume= 5,062 cf, Depth= 2.26"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (sf)	CN	Description
12,978	98	Paved parking, HSG A
7,967	98	Paved parking, HSG B
1,046	39	>75% Grass cover, Good, HSG A
4,828	61	>75% Grass cover, Good, HSG B
26,819	89	Weighted Average
5,874		21.90% Pervious Area
20,945		78.10% Impervious Area

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

Summary for Subcatchment P-6: Watershed

Runoff = 0.00 cfs @ 22.15 hrs, Volume= 20 cf, Depth= 0.01"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (sf)	CN	Description
293	98	Paved parking, HSG A
0	98	Paved parking, HSG B
10,175	39	>75% Grass cover, Good, HSG A
3,090	61	>75% Grass cover, Good, HSG B
9,081	32	Woods/grass comb., Good, HSG A
22,639	40	Weighted Average
22,346		98.71% Pervious Area
293		1.29% Impervious Area

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

Summary for Subcatchment P-7: Watershed

Runoff = 0.71 cfs @ 12.09 hrs, Volume= 2,233 cf, Depth= 1.93"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (sf)	CN	Description
9,021	98	Paved parking, HSG B
4,869	61	>75% Grass cover, Good, HSG B
13,890	85	Weighted Average
4,869		35.05% Pervious Area
9,021		64.95% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	160		0.44		**Direct Entry, Min. Tc.**

Summary for Subcatchment P-8: Watershed

Runoff = 0.51 cfs @ 12.09 hrs, Volume= 1,642 cf, Depth= 2.45"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (sf)	CN	Description
6,423	98	Paved parking, HSG B
1,629	61	>75% Grass cover, Good, HSG B
8,052	91	Weighted Average
1,629		20.23% Pervious Area
6,423		79.77% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	160		0.44		**Direct Entry, Min. Tc.**

Summary for Subcatchment P-9: Watershed

Runoff = 0.41 cfs @ 12.10 hrs, Volume= 1,329 cf, Depth= 1.29"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (sf)	CN	Description
5,020	98	Paved parking, HSG B
7,309	61	>75% Grass cover, Good, HSG B
12,329	76	Weighted Average
7,309		59.28% Pervious Area
5,020		40.72% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	160		0.44		**Direct Entry, Min. Tc.**

Summary for Subcatchment R-1: Roof - Blg 1

Runoff = 2.34 cfs @ 12.09 hrs, Volume= 8,343 cf, Depth= 3.17"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (sf)	CN	Description
7,300	98	Unconnected roofs, HSG A
24,313	98	Unconnected roofs, HSG B
31,613	98	Weighted Average
31,613		100.00% Impervious Area
31,613		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, Min. Tc.**

Summary for Subcatchment R-2A: Roof - Blg 2

Runoff = 1.73 cfs @ 12.09 hrs, Volume= 6,158 cf, Depth= 3.17"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (sf)	CN	Description
1,976	98	Unconnected roofs, HSG A
21,358	98	Unconnected roofs, HSG B
23,334	98	Weighted Average
23,334		100.00% Impervious Area
23,334		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, Min. Tc.**

Summary for Subcatchment R-2B: Roof - Blg 2

Runoff = 2.63 cfs @ 12.09 hrs, Volume= 9,352 cf, Depth= 3.17"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (sf)	CN	Description
8,577	98	Unconnected roofs, HSG A
26,862	98	Unconnected roofs, HSG B
35,439	98	Weighted Average
35,439		100.00% Impervious Area
35,439		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, Min. Tc.**

Summary for Subcatchment R-2C: Roof - Blg 2

Runoff = 0.78 cfs @ 12.09 hrs, Volume= 2,772 cf, Depth= 3.17"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (sf)	CN	Description
4,367	98	Unconnected roofs, HSG A
6,138	98	Unconnected roofs, HSG B
10,505	98	Weighted Average
10,505		100.00% Impervious Area
10,505		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, Min. Tc.**

Summary for Pond 1P: UIS #1

Inflow Area = 62,230 sf, 50.83% Impervious, Inflow Depth = 1.62" for 2-Year event
Inflow = 2.56 cfs @ 12.09 hrs, Volume= 8,402 cf
Outflow = 0.24 cfs @ 13.12 hrs, Volume= 4,266 cf, Atten= 90%, Lag= 61.6 min
Primary = 0.24 cfs @ 13.12 hrs, Volume= 4,266 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Peak Elev= 15.04' @ 13.12 hrs Surf.Area= 3,067 sf Storage= 4,804 cf
Flood Elev= 14.75' Surf.Area= 3,067 sf Storage= 4,099 cf

Plug-Flow detention time= 304.6 min calculated for 4,260 cf (51% of inflow)
Center-of-Mass det. time= 186.3 min (1,010.5 - 824.2)

Volume	Invert	Avail.Storage	Storage Description
#1A	12.75'	4,336 cf	**22.75'W x 134.83'L x 5.50'H Field A** 16,870 cf Overall - 6,031 cf Embedded = 10,839 cf x 40.0% Voids
#2A	13.50'	6,031 cf	**ADS_StormTech MC-3500 c +Cap** x 54 Inside #1 Effective Size= 70.4"W x 45.0"H => 15.33 sf x 7.17'L = 110.0 cf Overall Size= 77.0"W x 45.0"H x 7.50'L with 0.33' Overlap 3 Rows of 18 Chambers Cap Storage= +15.6 cf x 2 x 3 rows = 93.6 cf
		10,367 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	14.75'	**12.0" Round Culvert** L= 80.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 14.75' / 13.95' S= 0.0100 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.79 sf
#2	Device 1	14.75'	**7.0" Vert. Orifice/Grate** C= 0.600
#3	Device 1	17.90'	**4.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32
#4	Device 1	16.50'	**6.0" Vert. Orifice/Grate** C= 0.600

Primary OutFlow Max=0.24 cfs @ 13.12 hrs HW=15.04' TW=0.00' (Dynamic Tailwater)
└─**1=Culvert** (Passes 0.24 cfs of 0.27 cfs potential flow)
  ├─**2=Orifice/Grate** (Orifice Controls 0.24 cfs @ 1.83 fps)
  ├─**3=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)
  └─**4=Orifice/Grate** (Controls 0.00 cfs)

Summary for Pond 2P: UIS #2

Inflow Area = 129,504 sf, 75.55% Impervious, Inflow Depth = 2.35" for 2-Year event
Inflow = 7.43 cfs @ 12.09 hrs, Volume= 25,335 cf
Outflow = 0.81 cfs @ 12.85 hrs, Volume= 16,615 cf, Atten= 89%, Lag= 45.8 min
Primary = 0.81 cfs @ 12.85 hrs, Volume= 16,615 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Peak Elev= 20.89' @ 12.85 hrs Surf.Area= 7,935 sf Storage= 14,795 cf
Flood Elev= 19.90' Surf.Area= 7,935 sf Storage= 8,460 cf

Plug-Flow detention time= 308.8 min calculated for 16,615 cf (66% of inflow)
Center-of-Mass det. time= 205.5 min (990.5 - 785.0)

Volume	Invert	Avail.Storage	Storage Description
#1A	18.25'	10,983 cf	**65.75'W x 120.49'L x 5.50'H Field A** 43,571 cf Overall - 16,114 cf Embedded = 27,457 cf x 40.0% Voids
#2A	19.00'	16,114 cf	**ADS_StormTech MC-3500 c +Cap** x 144 Inside #1 Effective Size= 70.4"W x 45.0"H => 15.33 sf x 7.17'L = 110.0 cf Overall Size= 77.0"W x 45.0"H x 7.50'L with 0.33' Overlap 9 Rows of 16 Chambers Cap Storage= +15.6 cf x 2 x 9 rows = 280.8 cf
#3	19.00'	92 cf	**4.00'D x 7.30'H Vertical Cone/Cylinder**
		27,188 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	19.90'	**15.0" Round Culvert** L= 52.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 19.90' / 19.38' S= 0.0100 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 1.23 sf
#2	Device 1	19.90'	**6.0" Vert. Orifice/Grate** C= 0.600
#3	Device 1	21.30'	**12.0" Vert. Orifice/Grate** C= 0.600
#4	Device 1	23.00'	**6.0" Vert. Orifice/Grate** C= 0.600
#5	Device 1	24.00'	**4.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Primary OutFlow Max=0.81 cfs @ 12.85 hrs HW=20.89' TW=0.00' (Dynamic Tailwater)
└─**1=Culvert** (Passes 0.81 cfs of 2.80 cfs potential flow)
  ├─**2=Orifice/Grate** (Orifice Controls 0.81 cfs @ 4.15 fps)
  ├─**3=Orifice/Grate** (Controls 0.00 cfs)
  ├─**4=Orifice/Grate** (Controls 0.00 cfs)
  └─**5=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Pond 3P: UIS #3

Inflow Area = 44,947 sf, 47.44% Impervious, Inflow Depth = 1.15" for 2-Year event
Inflow = 1.10 cfs @ 12.10 hrs, Volume= 4,289 cf
Outflow = 0.21 cfs @ 12.59 hrs, Volume= 2,418 cf, Atten= 81%, Lag= 29.8 min
Primary = 0.21 cfs @ 12.59 hrs, Volume= 2,418 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Peak Elev= 14.61' @ 12.59 hrs Surf.Area= 1,612 sf Storage= 2,196 cf
Flood Elev= 14.35' Surf.Area= 1,612 sf Storage= 1,860 cf

Plug-Flow detention time= 296.2 min calculated for 2,414 cf (56% of inflow)
Center-of-Mass det. time= 164.8 min (973.7 - 809.0)

Volume	Invert	Avail.Storage	Storage Description
#1A	12.55'	2,293 cf	**22.75'W x 70.30'L x 5.50'H Field A** 8,796 cf Overall - 3,062 cf Embedded = 5,734 cf x 40.0% Voids
#2A	13.30'	3,062 cf	**ADS_StormTech MC-3500 c +Cap** x 27 Inside #1 Effective Size= 70.4"W x 45.0"H => 15.33 sf x 7.17'L = 110.0 cf Overall Size= 77.0"W x 45.0"H x 7.50'L with 0.33' Overlap 3 Rows of 9 Chambers Cap Storage= +15.6 cf x 2 x 3 rows = 93.6 cf
#3	14.35'	107 cf	**4.00'D x 8.55'H Vertical Cone/Cylinder**
		5,463 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	14.35'	**12.0" Round Culvert** L= 24.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 14.35' / 14.11' S= 0.0100 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.79 sf
#2	Device 1	14.35'	**6.0" W x 3.0" H Vert. Orifice/Grate** C= 0.600
#3	Device 1	18.05'	**4.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Primary OutFlow Max=0.21 cfs @ 12.59 hrs HW=14.61' TW=0.00' (Dynamic Tailwater)
└─**1=Culvert** (Passes 0.21 cfs of 0.23 cfs potential flow)
  ├─**2=Orifice/Grate** (Orifice Controls 0.21 cfs @ 1.70 fps)
  └─**3=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Pond 4P: UIS #4

Inflow Area = 123,686 sf, 60.44% Impervious, Inflow Depth = 1.89" for 2-Year event
Inflow = 5.76 cfs @ 12.09 hrs, Volume= 19,523 cf
Outflow = 2.91 cfs @ 12.26 hrs, Volume= 14,205 cf, Atten= 49%, Lag= 10.2 min
Primary = 2.91 cfs @ 12.26 hrs, Volume= 14,205 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Peak Elev= 15.22' @ 12.26 hrs Surf.Area= 3,624 sf Storage= 7,797 cf
Flood Elev= 14.30' Surf.Area= 3,624 sf Storage= 5,276 cf

Plug-Flow detention time= 193.1 min calculated for 14,186 cf (73% of inflow)
Center-of-Mass det. time= 99.5 min (901.3 - 801.8)

Volume	Invert	Avail.Storage	Storage Description
#1A	12.15'	5,090 cf	**51.42'W x 70.23'L x 5.50'H Field A** 19,860 cf Overall - 7,136 cf Embedded = 12,725 cf x 40.0% Voids
#2A	12.90'	7,136 cf	**ADS_StormTech MC-3500 d +Cap** x 63 Inside #1 Effective Size= 70.4"W x 45.0"H => 15.33 sf x 7.17'L = 110.0 cf Overall Size= 77.0"W x 45.0"H x 7.50'L with 0.33' Overlap 7 Rows of 9 Chambers Cap Storage= +14.9 cf x 2 x 7 rows = 208.6 cf
#3	13.70'	82 cf	**4.00'D x 6.50'H Vertical Cone/Cylinder**
		12,307 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	14.30'	**18.0" Round Culvert** L= 70.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 14.30' / 13.60' S= 0.0100 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 1.77 sf
#2	Device 1	14.30'	**15.0" Vert. Orifice/Grate** C= 0.600
#3	Device 1	17.65'	**4.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Primary OutFlow Max=2.89 cfs @ 12.26 hrs HW=15.21' TW=0.00' (Dynamic Tailwater)
└─**1=Culvert** (Inlet Controls 2.89 cfs @ 2.57 fps)
  ├─**2=Orifice/Grate** (Passes 2.89 cfs of 3.13 cfs potential flow)
  └─**3=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Pond EX: Low Wooded Area

Inflow Area = 22,639 sf, 1.29% Impervious, Inflow Depth = 0.01" for 2-Year event
Inflow = 0.00 cfs @ 22.15 hrs, Volume= 20 cf
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0 cf, Atten= 100%, Lag= 0.0 min
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs

Peak Elev= 16.26' @ 24.40 hrs Surf.Area= 13 sf Storage= 20 cf

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

Volume	Invert	Avail.Storage	Storage Description
#1	14.70'	55 cf	**4.00'D x 4.35'H Vertical Cone/Cylinder**
#2	18.05'	2,768 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)
		2,823 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
18.05	4	0	0
18.50	593	134	134
19.00	1,448	510	645
19.50	2,349	949	1,594
20.00	2,349	1,175	2,768

Device	Routing	Invert	Outlet Devices
#1	Primary	19.49'	**2.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=14.70' TW=0.00' (Dynamic Tailwater)
└─**1=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Link SP-1: Study Point #1

Inflow Area = 278,922 sf, 55.39% Impervious, Inflow Depth > 1.02" for 2-Year event
Inflow = 1.25 cfs @ 12.90 hrs, Volume= 23,759 cf
Primary = 1.25 cfs @ 12.90 hrs, Volume= 23,759 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs

Summary for Link SP-2: Study Point #2

Inflow Area = 156,864 sf, 47.66% Impervious, Inflow Depth > 1.18" for 2-Year event
Inflow = 3.10 cfs @ 12.26 hrs, Volume= 15,452 cf
Primary = 3.10 cfs @ 12.26 hrs, Volume= 15,452 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs

Summary for Link SP-3: Study Point #3

Inflow Area = 89,505 sf, 4.55% Impervious, Inflow Depth = 0.66" for 2-Year event
Inflow = 0.94 cfs @ 12.25 hrs, Volume= 4,887 cf
Primary = 0.94 cfs @ 12.25 hrs, Volume= 4,887 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs

Time span=0.00-36.00 hrs, dt=0.05 hrs, 721 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment P-1: Watershed Runoff Area=19,602 sf 17.35% Impervious Runoff Depth=0.78"
Tc=6.0 min CN=54 Runoff=0.29 cfs 1,274 cf

Subcatchment P-10: Watershed Runoff Area=34,442 sf 31.42% Impervious Runoff Depth=1.19"
Flow Length=160' Tc=6.0 min CN=61 Runoff=0.97 cfs 3,423 cf

Subcatchment P-11: Watershed Runoff Area=21,449 sf 46.97% Impervious Runoff Depth=2.46"
Flow Length=160' Tc=6.0 min CN=78 Runoff=1.39 cfs 4,395 cf

Subcatchment P-12: Watershed Runoff Area=15,395 sf 57.91% Impervious Runoff Depth=2.81"
Flow Length=160' Tc=6.0 min CN=82 Runoff=1.14 cfs 3,608 cf

Subcatchment P-13: Watershed Runoff Area=4,800 sf 67.37% Impervious Runoff Depth=3.19"
Flow Length=160' Tc=6.0 min CN=86 Runoff=0.40 cfs 1,275 cf

Subcatchment P-14: Watershed Runoff Area=24,445 sf 51.05% Impervious Runoff Depth=2.63"
Flow Length=160' Tc=6.0 min CN=80 Runoff=1.70 cfs 5,363 cf

Subcatchment P-15: Watershed Runoff Area=16,750 sf 15.43% Impervious Runoff Depth=1.46"
Flow Length=160' Tc=6.0 min CN=65 Runoff=0.61 cfs 2,034 cf

Subcatchment P-16: Watershed Runoff Area=18,626 sf 52.06% Impervious Runoff Depth=2.63"
Flow Length=160' Tc=6.0 min CN=80 Runoff=1.29 cfs 4,087 cf

Subcatchment P-17: Watershed Runoff Area=23,626 sf 47.93% Impervious Runoff Depth=2.46"
Flow Length=160' Tc=6.0 min CN=78 Runoff=1.53 cfs 4,841 cf

Subcatchment P-18: Watershed Runoff Area=89,505 sf 4.55% Impervious Runoff Depth=1.39"
Flow Length=316' Tc=14.4 min CN=64 Runoff=2.36 cfs 10,362 cf

Subcatchment P-19: Watershed Runoff Area=33,178 sf 0.00% Impervious Runoff Depth=1.07"
Flow Length=160' Tc=6.0 min CN=59 Runoff=0.80 cfs 2,953 cf

Subcatchment P-2: Watershed Runoff Area=9,533 sf 73.47% Impervious Runoff Depth=3.38"
Flow Length=100' Tc=6.0 min CN=88 Runoff=0.83 cfs 2,689 cf

Subcatchment P-3: Watershed Runoff Area=25,878 sf 14.23% Impervious Runoff Depth=1.53"
Flow Length=160' Tc=6.0 min CN=66 Runoff=0.99 cfs 3,292 cf

Subcatchment P-4: Watershed Runoff Area=3,442 sf 100.00% Impervious Runoff Depth=4.46"
Tc=6.0 min CN=98 Runoff=0.35 cfs 1,280 cf

Subcatchment P-5: Watershed Runoff Area=26,819 sf 78.10% Impervious Runoff Depth=3.49"
Tc=6.0 min CN=89 Runoff=2.40 cfs 7,790 cf

Subcatchment P-6: Watershed Runoff Area=22,639 sf 1.29% Impervious Runoff Depth=0.17"
Tc=6.0 min CN=40 Runoff=0.01 cfs 326 cf

Subcatchment P-7: Watershed Runoff Area=13,890 sf 64.95% Impervious Runoff Depth=3.09"
Flow Length=160' Tc=6.0 min CN=85 Runoff=1.12 cfs 3,579 cf

Subcatchment P-8: Watershed Runoff Area=8,052 sf 79.77% Impervious Runoff Depth=3.69"
Flow Length=160' Tc=6.0 min CN=91 Runoff=0.75 cfs 2,477 cf

Subcatchment P-9: Watershed Runoff Area=12,329 sf 40.72% Impervious Runoff Depth=2.29"
Flow Length=160' Tc=6.0 min CN=76 Runoff=0.74 cfs 2,353 cf

Subcatchment R-1: Roof - Blg 1 Runoff Area=31,613 sf 100.00% Impervious Runoff Depth=4.46"
Tc=6.0 min CN=98 Runoff=3.26 cfs 11,759 cf

Subcatchment R-2A: Roof - Blg 2 Runoff Area=23,334 sf 100.00% Impervious Runoff Depth=4.46"
Tc=6.0 min CN=98 Runoff=2.40 cfs 8,680 cf

Subcatchment R-2B: Roof - Blg 2 Runoff Area=35,439 sf 100.00% Impervious Runoff Depth=4.46"
Tc=6.0 min CN=98 Runoff=3.65 cfs 13,182 cf

Subcatchment R-2C: Roof - Blg 2 Runoff Area=10,505 sf 100.00% Impervious Runoff Depth=4.46"
Tc=6.0 min CN=98 Runoff=1.08 cfs 3,908 cf

Pond 1P: UIS #1 Peak Elev=15.75' Storage=6,438 cf Inflow=4.22 cfs 13,771 cf
Outflow=1.08 cfs 9,634 cf

Pond 2P: UIS #2 Peak Elev=21.91' Storage=20,539 cf Inflow=11.16 cfs 38,131 cf
Outflow=2.59 cfs 29,399 cf

Pond 3P: UIS #3 Peak Elev=15.39' Storage=3,154 cf Inflow=2.04 cfs 7,331 cf
Outflow=0.58 cfs 5,459 cf

Pond 4P: UIS #4 Peak Elev=15.97' Storage=9,620 cf Inflow=9.17 cfs 30,783 cf
Outflow=6.05 cfs 25,465 cf

Pond EX: Low Wooded Area Peak Elev=18.69' Storage=326 cf Inflow=0.01 cfs 326 cf
Outflow=0.00 cfs 0 cf

Link SP-1: Study Point #1 Inflow=4.38 cfs 45,765 cf
Primary=4.38 cfs 45,765 cf

Link SP-2: Study Point #2 Inflow=6.71 cfs 28,418 cf
Primary=6.71 cfs 28,418 cf

Link SP-3: Study Point #3 Inflow=2.36 cfs 10,362 cf
Primary=2.36 cfs 10,362 cf

Total Runoff Area = 525,291 sf Runoff Volume = 104,930 cf Average Runoff Depth = 2.40"
55.58% Pervious = 291,972 sf 44.42% Impervious = 233,319 sf

Summary for Subcatchment P-1: Watershed

Runoff = 0.29 cfs @ 12.12 hrs, Volume= 1,274 cf, Depth= 0.78"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.70"

Area (sf)	CN	Description
100	98	Paved parking, HSG A
3,300	98	Paved parking, HSG B
2,671	39	>75% Grass cover, Good, HSG A
4,687	61	>75% Grass cover, Good, HSG B
6,509	32	Woods/grass comb., Good, HSG A
2,335	58	Woods/grass comb., Good, HSG B
19,602	54	Weighted Average
16,202		82.65% Pervious Area
3,400		17.35% Impervious Area

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

Summary for Subcatchment P-10: Watershed

Runoff = 0.97 cfs @ 12.10 hrs, Volume= 3,423 cf, Depth= 1.19"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.70"

Area (sf)	CN	Description
5,299	98	Paved parking, HSG A
5,521	98	Paved parking, HSG B
15,068	39	>75% Grass cover, Good, HSG A
6,581	61	>75% Grass cover, Good, HSG B
1,973	32	Woods/grass comb., Good, HSG A
34,442	61	Weighted Average
23,622		68.58% Pervious Area
10,820		31.42% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	160		0.44		**Direct Entry, Min. Tc.**

Summary for Subcatchment P-11: Watershed

Runoff = 1.39 cfs @ 12.09 hrs, Volume= 4,395 cf, Depth= 2.46"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.70"

Area (sf)	CN	Description
10,074	98	Paved parking, HSG B
11,375	61	>75% Grass cover, Good, HSG B
21,449	78	Weighted Average
11,375		53.03% Pervious Area
10,074		46.97% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	160		0.44		**Direct Entry, Min. Tc.**

Summary for Subcatchment P-12: Watershed

Runoff = 1.14 cfs @ 12.09 hrs, Volume= 3,608 cf, Depth= 2.81"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.70"

Area (sf)	CN	Description
8,915	98	Paved parking, HSG B
6,480	61	>75% Grass cover, Good, HSG B
15,395	82	Weighted Average
6,480		42.09% Pervious Area
8,915		57.91% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	160		0.44		**Direct Entry, Min. Tc.**

Summary for Subcatchment P-13: Watershed

Runoff = 0.40 cfs @ 12.09 hrs, Volume= 1,275 cf, Depth= 3.19"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.70"

Area (sf)	CN	Description
3,234	98	Paved parking, HSG B
1,566	61	>75% Grass cover, Good, HSG B
4,800	86	Weighted Average
1,566		32.62% Pervious Area
3,234		67.37% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	160		0.44		**Direct Entry, Min. Tc.**

Summary for Subcatchment P-14: Watershed

Runoff = 1.70 cfs @ 12.09 hrs, Volume= 5,363 cf, Depth= 2.63"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.70"

Area (sf)	CN	Description
12,480	98	Paved parking, HSG B
11,965	61	>75% Grass cover, Good, HSG B
24,445	80	Weighted Average
11,965		48.95% Pervious Area
12,480		51.05% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	160		0.44		**Direct Entry, Min. Tc.**

Summary for Subcatchment P-15: Watershed

Runoff = 0.61 cfs @ 12.10 hrs, Volume= 2,034 cf, Depth= 1.46"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.70"

Area (sf)	CN	Description
2,585	98	Paved parking, HSG B
6,512	61	>75% Grass cover, Good, HSG B
7,653	58	Woods/grass comb., Good, HSG B
16,750	65	Weighted Average
14,165		84.57% Pervious Area
2,585		15.43% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	160		0.44		**Direct Entry, Min. Tc.**

Summary for Subcatchment P-16: Watershed

Runoff = 1.29 cfs @ 12.09 hrs, Volume= 4,087 cf, Depth= 2.63"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.70"

Area (sf)	CN	Description
9,697	98	Paved parking, HSG B
8,929	61	>75% Grass cover, Good, HSG B
18,626	80	Weighted Average
8,929		47.94% Pervious Area
9,697		52.06% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	160		0.44		**Direct Entry, Min. Tc.**

Summary for Subcatchment P-17: Watershed

Runoff = 1.53 cfs @ 12.09 hrs, Volume= 4,841 cf, Depth= 2.46"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.70"

Area (sf)	CN	Description
11,323	98	Paved parking, HSG B
11,510	61	>75% Grass cover, Good, HSG B
793	39	>75% Grass cover, Good, HSG A
23,626	78	Weighted Average
12,303		52.07% Pervious Area
11,323		47.93% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	160		0.44		**Direct Entry, Min. Tc.**

Summary for Subcatchment P-18: Watershed

Runoff = 2.36 cfs @ 12.22 hrs, Volume= 10,362 cf, Depth= 1.39"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.70"

	Area (sf)	CN	Description
*	1,395	98	Water Surface, 0% imp, HSG B
	3,801	39	>75% Grass cover, Good, HSG A
	33,365	61	>75% Grass cover, Good, HSG B
	2,502	32	Woods/grass comb., Good, HSG A
	28,018	58	Woods/grass comb., Good, HSG B
	16,355	79	Woods/grass comb., Good, HSG D
	2,519	98	Paved parking, HSG B
	1,550	98	Paved parking, HSG A
	89,505	64	Weighted Average
	85,436		95.45% Pervious Area
	4,069		4.55% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	50	0.0110	0.12		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.40"
4.4	132	0.0050	0.49		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
1.2	114	0.1030	1.60		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
1.9	20	0.0050	0.18		**Shallow Concentrated Flow,** Forest w/Heavy Litter Kv= 2.5 fps
14.4	316	Total			

Summary for Subcatchment P-19: Watershed

Runoff = 0.80 cfs @ 12.11 hrs, Volume= 2,953 cf, Depth= 1.07"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.70"

Area (sf)	CN	Description
9,855	61	>75% Grass cover, Good, HSG B
23,323	58	Woods/grass comb., Good, HSG B
33,178	59	Weighted Average
33,178		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	160		0.44		**Direct Entry, Min. Tc.**

Summary for Subcatchment P-2: Watershed

Runoff = 0.83 cfs @ 12.09 hrs, Volume= 2,689 cf, Depth= 3.38"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.70"

Area (sf)	CN	Description
7,004	98	Paved parking, HSG B
2,529	61	>75% Grass cover, Good, HSG B
9,533	88	Weighted Average
2,529		26.53% Pervious Area
7,004		73.47% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	100		0.28		**Direct Entry, Min. Tc.**

Summary for Subcatchment P-3: Watershed

Runoff = 0.99 cfs @ 12.10 hrs, Volume= 3,292 cf, Depth= 1.53"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.70"

Area (sf)	CN	Description
3,683	98	Paved parking, HSG B
22,195	61	>75% Grass cover, Good, HSG B
25,878	66	Weighted Average
22,195		85.77% Pervious Area
3,683		14.23% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	160		0.44		**Direct Entry, Min. Tc.**

Summary for Subcatchment P-4: Watershed

Runoff = 0.35 cfs @ 12.09 hrs, Volume= 1,280 cf, Depth= 4.46"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.70"

Area (sf)	CN	Description
3,442	98	Paved parking, HSG B
3,442		100.00% Impervious Area

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

Summary for Subcatchment P-5: Watershed

Runoff = 2.40 cfs @ 12.09 hrs, Volume= 7,790 cf, Depth= 3.49"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.70"

Area (sf)	CN	Description
12,978	98	Paved parking, HSG A
7,967	98	Paved parking, HSG B
1,046	39	>75% Grass cover, Good, HSG A
4,828	61	>75% Grass cover, Good, HSG B
26,819	89	Weighted Average
5,874		21.90% Pervious Area
20,945		78.10% Impervious Area

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

Summary for Subcatchment P-6: Watershed

Runoff = 0.01 cfs @ 12.50 hrs, Volume= 326 cf, Depth= 0.17"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.70"

Area (sf)	CN	Description
293	98	Paved parking, HSG A
0	98	Paved parking, HSG B
10,175	39	>75% Grass cover, Good, HSG A
3,090	61	>75% Grass cover, Good, HSG B
9,081	32	Woods/grass comb., Good, HSG A
22,639	40	Weighted Average
22,346		98.71% Pervious Area
293		1.29% Impervious Area

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

Summary for Subcatchment P-7: Watershed

Runoff = 1.12 cfs @ 12.09 hrs, Volume= 3,579 cf, Depth= 3.09"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.70"

Area (sf)	CN	Description
9,021	98	Paved parking, HSG B
4,869	61	>75% Grass cover, Good, HSG B
13,890	85	Weighted Average
4,869		35.05% Pervious Area
9,021		64.95% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	160		0.44		**Direct Entry, Min. Tc.**

Summary for Subcatchment P-8: Watershed

Runoff = 0.75 cfs @ 12.09 hrs, Volume= 2,477 cf, Depth= 3.69"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.70"

Area (sf)	CN	Description
6,423	98	Paved parking, HSG B
1,629	61	>75% Grass cover, Good, HSG B
8,052	91	Weighted Average
1,629		20.23% Pervious Area
6,423		79.77% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	160		0.44		**Direct Entry, Min. Tc.**

Summary for Subcatchment P-9: Watershed

Runoff = 0.74 cfs @ 12.09 hrs, Volume= 2,353 cf, Depth= 2.29"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.70"

Area (sf)	CN	Description
5,020	98	Paved parking, HSG B
7,309	61	>75% Grass cover, Good, HSG B
12,329	76	Weighted Average
7,309		59.28% Pervious Area
5,020		40.72% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	160		0.44		**Direct Entry, Min. Tc.**

Summary for Subcatchment R-1: Roof - Blg 1

Runoff = 3.26 cfs @ 12.09 hrs, Volume= 11,759 cf, Depth= 4.46"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.70"

Area (sf)	CN	Description
7,300	98	Unconnected roofs, HSG A
24,313	98	Unconnected roofs, HSG B
31,613	98	Weighted Average
31,613		100.00% Impervious Area
31,613		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, Min. Tc.**

Summary for Subcatchment R-2A: Roof - Blg 2

Runoff = 2.40 cfs @ 12.09 hrs, Volume= 8,680 cf, Depth= 4.46"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.70"

Area (sf)	CN	Description
1,976	98	Unconnected roofs, HSG A
21,358	98	Unconnected roofs, HSG B
23,334	98	Weighted Average
23,334		100.00% Impervious Area
23,334		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, Min. Tc.**

Summary for Subcatchment R-2B: Roof - Blg 2

Runoff = 3.65 cfs @ 12.09 hrs, Volume= 13,182 cf, Depth= 4.46"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.70"

Area (sf)	CN	Description
8,577	98	Unconnected roofs, HSG A
26,862	98	Unconnected roofs, HSG B
35,439	98	Weighted Average
35,439		100.00% Impervious Area
35,439		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, Min. Tc.**

Summary for Subcatchment R-2C: Roof - Blg 2

Runoff = 1.08 cfs @ 12.09 hrs, Volume= 3,908 cf, Depth= 4.46"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.70"

Area (sf)	CN	Description
4,367	98	Unconnected roofs, HSG A
6,138	98	Unconnected roofs, HSG B
10,505	98	Weighted Average
10,505		100.00% Impervious Area
10,505		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, Min. Tc.**

Summary for Pond 1P: UIS #1

Inflow Area = 62,230 sf, 50.83% Impervious, Inflow Depth = 2.66" for 10-Year event
Inflow = 4.22 cfs @ 12.09 hrs, Volume= 13,771 cf
Outflow = 1.08 cfs @ 12.48 hrs, Volume= 9,634 cf, Atten= 74%, Lag= 23.5 min
Primary = 1.08 cfs @ 12.48 hrs, Volume= 9,634 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Peak Elev= 15.75' @ 12.48 hrs Surf.Area= 3,067 sf Storage= 6,438 cf
Flood Elev= 14.75' Surf.Area= 3,067 sf Storage= 4,099 cf

Plug-Flow detention time= 206.2 min calculated for 9,634 cf (70% of inflow)
Center-of-Mass det. time= 109.5 min (922.4 - 812.9)

Volume	Invert	Avail.Storage	Storage Description
#1A	12.75'	4,336 cf	**22.75'W x 134.83'L x 5.50'H Field A** 16,870 cf Overall - 6,031 cf Embedded = 10,839 cf x 40.0% Voids
#2A	13.50'	6,031 cf	**ADS_StormTech MC-3500 c +Cap** x 54 Inside #1 Effective Size= 70.4"W x 45.0"H => 15.33 sf x 7.17'L = 110.0 cf Overall Size= 77.0"W x 45.0"H x 7.50'L with 0.33' Overlap 3 Rows of 18 Chambers Cap Storage= +15.6 cf x 2 x 3 rows = 93.6 cf
		10,367 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	14.75'	**12.0" Round Culvert** L= 80.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 14.75' / 13.95' S= 0.0100 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.79 sf
#2	Device 1	14.75'	**7.0" Vert. Orifice/Grate** C= 0.600
#3	Device 1	17.90'	**4.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32
#4	Device 1	16.50'	**6.0" Vert. Orifice/Grate** C= 0.600

Primary OutFlow Max=1.08 cfs @ 12.48 hrs HW=15.74' TW=0.00' (Dynamic Tailwater)
└─**1=Culvert** (Passes 1.08 cfs of 2.10 cfs potential flow)
  ├─**2=Orifice/Grate** (Orifice Controls 1.08 cfs @ 4.04 fps)
  ├─**3=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)
  └─**4=Orifice/Grate** (Controls 0.00 cfs)

Summary for Pond 2P: UIS #2

Inflow Area = 129,504 sf, 75.55% Impervious, Inflow Depth = 3.53" for 10-Year event
Inflow = 11.16 cfs @ 12.09 hrs, Volume= 38,131 cf
Outflow = 2.59 cfs @ 12.49 hrs, Volume= 29,399 cf, Atten= 77%, Lag= 24.2 min
Primary = 2.59 cfs @ 12.49 hrs, Volume= 29,399 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Peak Elev= 21.91' @ 12.49 hrs Surf.Area= 7,935 sf Storage= 20,539 cf
Flood Elev= 19.90' Surf.Area= 7,935 sf Storage= 8,460 cf

Plug-Flow detention time= 260.6 min calculated for 29,358 cf (77% of inflow)
Center-of-Mass det. time= 178.3 min (956.9 - 778.6)

Volume	Invert	Avail.Storage	Storage Description
#1A	18.25'	10,983 cf	**65.75'W x 120.49'L x 5.50'H Field A** 43,571 cf Overall - 16,114 cf Embedded = 27,457 cf x 40.0% Voids
#2A	19.00'	16,114 cf	**ADS_StormTech MC-3500 c +Cap** x 144 Inside #1 Effective Size= 70.4"W x 45.0"H => 15.33 sf x 7.17'L = 110.0 cf Overall Size= 77.0"W x 45.0"H x 7.50'L with 0.33' Overlap 9 Rows of 16 Chambers Cap Storage= +15.6 cf x 2 x 9 rows = 280.8 cf
#3	19.00'	92 cf	**4.00'D x 7.30'H Vertical Cone/Cylinder**
		27,188 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	19.90'	**15.0" Round Culvert** L= 52.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 19.90' / 19.38' S= 0.0100 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 1.23 sf
#2	Device 1	19.90'	**6.0" Vert. Orifice/Grate** C= 0.600
#3	Device 1	21.30'	**12.0" Vert. Orifice/Grate** C= 0.600
#4	Device 1	23.00'	**6.0" Vert. Orifice/Grate** C= 0.600
#5	Device 1	24.00'	**4.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Primary OutFlow Max=2.59 cfs @ 12.49 hrs HW=21.91' TW=0.00' (Dynamic Tailwater)
1=Culvert (Passes 2.59 cfs of 5.49 cfs potential flow)
2=Orifice/Grate (Orifice Controls 1.25 cfs @ 6.39 fps)
3=Orifice/Grate (Orifice Controls 1.33 cfs @ 2.66 fps)
4=Orifice/Grate (Controls 0.00 cfs)
5=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

Summary for Pond 3P: UIS #3

Inflow Area = 44,947 sf, 47.44% Impervious, Inflow Depth = 1.96" for 10-Year event
Inflow = 2.04 cfs @ 12.10 hrs, Volume= 7,331 cf
Outflow = 0.58 cfs @ 12.48 hrs, Volume= 5,459 cf, Atten= 72%, Lag= 23.2 min
Primary = 0.58 cfs @ 12.48 hrs, Volume= 5,459 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Peak Elev= 15.39' @ 12.48 hrs Surf.Area= 1,612 sf Storage= 3,154 cf
Flood Elev= 14.35' Surf.Area= 1,612 sf Storage= 1,860 cf

Plug-Flow detention time= 199.8 min calculated for 5,451 cf (74% of inflow)
Center-of-Mass det. time= 104.2 min (912.9 - 808.8)

Volume	Invert	Avail.Storage	Storage Description
#1A	12.55'	2,293 cf	**22.75'W x 70.30'L x 5.50'H Field A** 8,796 cf Overall - 3,062 cf Embedded = 5,734 cf x 40.0% Voids
#2A	13.30'	3,062 cf	**ADS_StormTech MC-3500 c +Cap** x 27 Inside #1 Effective Size= 70.4"W x 45.0"H => 15.33 sf x 7.17'L = 110.0 cf Overall Size= 77.0"W x 45.0"H x 7.50'L with 0.33' Overlap 3 Rows of 9 Chambers Cap Storage= +15.6 cf x 2 x 3 rows = 93.6 cf
#3	14.35'	107 cf	**4.00'D x 8.55'H Vertical Cone/Cylinder**
		5,463 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	14.35'	**12.0" Round Culvert** L= 24.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 14.35' / 14.11' S= 0.0100 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.79 sf
#2	Device 1	14.35'	**6.0" W x 3.0" H Vert. Orifice/Grate** C= 0.600
#3	Device 1	18.05'	**4.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Primary OutFlow Max=0.58 cfs @ 12.48 hrs HW=15.39' TW=0.00' (Dynamic Tailwater)
1=Culvert (Passes 0.58 cfs of 2.19 cfs potential flow)
2=Orifice/Grate (Orifice Controls 0.58 cfs @ 4.60 fps)
3=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

Summary for Pond 4P: UIS #4

Inflow Area = 123,686 sf, 60.44% Impervious, Inflow Depth = 2.99" for 10-Year event
Inflow = 9.17 cfs @ 12.09 hrs, Volume= 30,783 cf
Outflow = 6.05 cfs @ 12.19 hrs, Volume= 25,465 cf, Atten= 34%, Lag= 6.0 min
Primary = 6.05 cfs @ 12.19 hrs, Volume= 25,465 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Peak Elev= 15.97' @ 12.19 hrs Surf.Area= 3,624 sf Storage= 9,620 cf
Flood Elev= 14.30' Surf.Area= 3,624 sf Storage= 5,276 cf

Plug-Flow detention time= 144.7 min calculated for 25,465 cf (83% of inflow)
Center-of-Mass det. time= 72.7 min (867.6 - 795.0)

Volume	Invert	Avail.Storage	Storage Description
#1A	12.15'	5,090 cf	**51.42'W x 70.23'L x 5.50'H Field A** 19,860 cf Overall - 7,136 cf Embedded = 12,725 cf x 40.0% Voids
#2A	12.90'	7,136 cf	**ADS_StormTech MC-3500 d +Cap** x 63 Inside #1 Effective Size= 70.4"W x 45.0"H => 15.33 sf x 7.17'L = 110.0 cf Overall Size= 77.0"W x 45.0"H x 7.50'L with 0.33' Overlap 7 Rows of 9 Chambers Cap Storage= +14.9 cf x 2 x 7 rows = 208.6 cf
#3	13.70'	82 cf	**4.00'D x 6.50'H Vertical Cone/Cylinder**
		12,307 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	14.30'	**18.0" Round Culvert** L= 70.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 14.30' / 13.60' S= 0.0100 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 1.77 sf
#2	Device 1	14.30'	**15.0" Vert. Orifice/Grate** C= 0.600
#3	Device 1	17.65'	**4.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Primary OutFlow Max=6.03 cfs @ 12.19 hrs HW=15.97' TW=0.00' (Dynamic Tailwater)
1=Culvert (Passes 6.03 cfs of 6.43 cfs potential flow)
2=Orifice/Grate (Orifice Controls 6.03 cfs @ 4.91 fps)
3=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

Summary for Pond EX: Low Wooded Area

Inflow Area = 22,639 sf, 1.29% Impervious, Inflow Depth = 0.17" for 10-Year event
Inflow = 0.01 cfs @ 12.50 hrs, Volume= 326 cf
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0 cf, Atten= 100%, Lag= 0.0 min
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs

Peak Elev= 18.69' @ 24.40 hrs Surf.Area= 928 sf Storage= 326 cf

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

Volume	Invert	Avail.Storage	Storage Description
#1	14.70'	55 cf	**4.00'D x 4.35'H Vertical Cone/Cylinder**
#2	18.05'	2,768 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)
		2,823 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
18.05	4	0	0
18.50	593	134	134
19.00	1,448	510	645
19.50	2,349	949	1,594
20.00	2,349	1,175	2,768

Device	Routing	Invert	Outlet Devices
#1	Primary	19.49'	**2.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=14.70' TW=0.00' (Dynamic Tailwater)
└─**1=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Link SP-1: Study Point #1

Inflow Area =	278,922 sf, 55.39% Impervious, Inflow Depth > 1.97"	for 10-Year event
Inflow =	4.38 cfs @ 12.48 hrs, Volume=	45,765 cf
Primary =	4.38 cfs @ 12.48 hrs, Volume=	45,765 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs

Summary for Link SP-2: Study Point #2

Inflow Area =	156,864 sf, 47.66% Impervious, Inflow Depth > 2.17"	for 10-Year event
Inflow =	6.71 cfs @ 12.17 hrs, Volume=	28,418 cf
Primary =	6.71 cfs @ 12.17 hrs, Volume=	28,418 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs

Summary for Link SP-3: Study Point #3

Inflow Area =	89,505 sf, 4.55% Impervious, Inflow Depth = 1.39"	for 10-Year event
Inflow =	2.36 cfs @ 12.22 hrs, Volume=	10,362 cf
Primary =	2.36 cfs @ 12.22 hrs, Volume=	10,362 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs

Time span=0.00-36.00 hrs, dt=0.05 hrs, 721 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment P-1: Watershed	Runoff Area=19,602 sf 17.35% Impervious Runoff Depth=2.03" Tc=6.0 min CN=54 Runoff=0.98 cfs 3,317 cf
Subcatchment P-10: Watershed	Runoff Area=34,442 sf 31.42% Impervious Runoff Depth=2.70" Flow Length=160' Tc=6.0 min CN=61 Runoff=2.40 cfs 7,755 cf
Subcatchment P-11: Watershed	Runoff Area=21,449 sf 46.97% Impervious Runoff Depth=4.47" Flow Length=160' Tc=6.0 min CN=78 Runoff=2.52 cfs 7,998 cf
Subcatchment P-12: Watershed	Runoff Area=15,395 sf 57.91% Impervious Runoff Depth=4.92" Flow Length=160' Tc=6.0 min CN=82 Runoff=1.96 cfs 6,307 cf
Subcatchment P-13: Watershed	Runoff Area=4,800 sf 67.37% Impervious Runoff Depth=5.37" Flow Length=160' Tc=6.0 min CN=86 Runoff=0.66 cfs 2,146 cf
Subcatchment P-14: Watershed	Runoff Area=24,445 sf 51.05% Impervious Runoff Depth=4.69" Flow Length=160' Tc=6.0 min CN=80 Runoff=2.99 cfs 9,563 cf
Subcatchment P-15: Watershed	Runoff Area=16,750 sf 15.43% Impervious Runoff Depth=3.10" Flow Length=160' Tc=6.0 min CN=65 Runoff=1.36 cfs 4,331 cf
Subcatchment P-16: Watershed	Runoff Area=18,626 sf 52.06% Impervious Runoff Depth=4.69" Flow Length=160' Tc=6.0 min CN=80 Runoff=2.28 cfs 7,287 cf
Subcatchment P-17: Watershed	Runoff Area=23,626 sf 47.93% Impervious Runoff Depth=4.47" Flow Length=160' Tc=6.0 min CN=78 Runoff=2.77 cfs 8,810 cf
Subcatchment P-18: Watershed	Runoff Area=89,505 sf 4.55% Impervious Runoff Depth=3.00" Flow Length=316' Tc=14.4 min CN=64 Runoff=5.44 cfs 22,386 cf
Subcatchment P-19: Watershed	Runoff Area=33,178 sf 0.00% Impervious Runoff Depth=2.51" Flow Length=160' Tc=6.0 min CN=59 Runoff=2.12 cfs 6,929 cf
Subcatchment P-2: Watershed	Runoff Area=9,533 sf 73.47% Impervious Runoff Depth=5.59" Flow Length=100' Tc=6.0 min CN=88 Runoff=1.34 cfs 4,444 cf
Subcatchment P-3: Watershed	Runoff Area=25,878 sf 14.23% Impervious Runoff Depth=3.20" Flow Length=160' Tc=6.0 min CN=66 Runoff=2.18 cfs 6,910 cf
Subcatchment P-4: Watershed	Runoff Area=3,442 sf 100.00% Impervious Runoff Depth=6.76" Tc=6.0 min CN=98 Runoff=0.53 cfs 1,939 cf
Subcatchment P-5: Watershed	Runoff Area=26,819 sf 78.10% Impervious Runoff Depth=5.71" Tc=6.0 min CN=89 Runoff=3.83 cfs 12,757 cf
Subcatchment P-6: Watershed	Runoff Area=22,639 sf 1.29% Impervious Runoff Depth=0.84" Tc=6.0 min CN=40 Runoff=0.27 cfs 1,589 cf

Subcatchment P-7: Watershed Runoff Area=13,890 sf 64.95% Impervious Runoff Depth=5.25"
Flow Length=160' Tc=6.0 min CN=85 Runoff=1.87 cfs 6,080 cf

Subcatchment P-8: Watershed Runoff Area=8,052 sf 79.77% Impervious Runoff Depth=5.94"
Flow Length=160' Tc=6.0 min CN=91 Runoff=1.18 cfs 3,985 cf

Subcatchment P-9: Watershed Runoff Area=12,329 sf 40.72% Impervious Runoff Depth=4.26"
Flow Length=160' Tc=6.0 min CN=76 Runoff=1.38 cfs 4,374 cf

Subcatchment R-1: Roof - Blg 1 Runoff Area=31,613 sf 100.00% Impervious Runoff Depth=6.76"
Tc=6.0 min CN=98 Runoff=4.87 cfs 17,811 cf

Subcatchment R-2A: Roof - Blg 2 Runoff Area=23,334 sf 100.00% Impervious Runoff Depth=6.76"
Tc=6.0 min CN=98 Runoff=3.59 cfs 13,147 cf

Subcatchment R-2B: Roof - Blg 2 Runoff Area=35,439 sf 100.00% Impervious Runoff Depth=6.76"
Tc=6.0 min CN=98 Runoff=5.46 cfs 19,967 cf

Subcatchment R-2C: Roof - Blg 2 Runoff Area=10,505 sf 100.00% Impervious Runoff Depth=6.76"
Tc=6.0 min CN=98 Runoff=1.62 cfs 5,919 cf

Pond 1P: UIS #1 Peak Elev=17.68' Storage=9,671 cf Inflow=7.34 cfs 24,111 cf
Outflow=3.00 cfs 19,973 cf

Pond 2P: UIS #2 Peak Elev=23.68' Storage=26,934 cf Inflow=17.89 cfs 61,641 cf
Outflow=7.58 cfs 52,896 cf

Pond 3P: UIS #3 Peak Elev=18.14' Storage=5,403 cf Inflow=4.01 cfs 13,674 cf
Outflow=1.47 cfs 11,802 cf

Pond 4P: UIS #4 Peak Elev=17.87' Storage=12,278 cf Inflow=15.51 cfs 52,103 cf
Outflow=11.03 cfs 46,784 cf

Pond EX: Low Wooded Area Peak Elev=19.47' Storage=1,589 cf Inflow=0.27 cfs 1,589 cf
Outflow=0.00 cfs 0 cf

Link SP-1: Study Point #1 Inflow=12.19 cfs 87,988 cf
Primary=12.19 cfs 87,988 cf

Link SP-2: Study Point #2 Inflow=12.51 cfs 53,713 cf
Primary=12.51 cfs 53,713 cf

Link SP-3: Study Point #3 Inflow=5.44 cfs 22,386 cf
Primary=5.44 cfs 22,386 cf

Total Runoff Area = 525,291 sf Runoff Volume = 185,750 cf Average Runoff Depth = 4.24"
55.58% Pervious = 291,972 sf 44.42% Impervious = 233,319 sf

Summary for Subcatchment P-1: Watershed

Runoff = 0.98 cfs @ 12.10 hrs, Volume= 3,317 cf, Depth= 2.03"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (sf)	CN	Description
100	98	Paved parking, HSG A
3,300	98	Paved parking, HSG B
2,671	39	>75% Grass cover, Good, HSG A
4,687	61	>75% Grass cover, Good, HSG B
6,509	32	Woods/grass comb., Good, HSG A
2,335	58	Woods/grass comb., Good, HSG B
19,602	54	Weighted Average
16,202		82.65% Pervious Area
3,400		17.35% Impervious Area

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

Summary for Subcatchment P-10: Watershed

Runoff = 2.40 cfs @ 12.10 hrs, Volume= 7,755 cf, Depth= 2.70"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (sf)	CN	Description
5,299	98	Paved parking, HSG A
5,521	98	Paved parking, HSG B
15,068	39	>75% Grass cover, Good, HSG A
6,581	61	>75% Grass cover, Good, HSG B
1,973	32	Woods/grass comb., Good, HSG A
34,442	61	Weighted Average
23,622		68.58% Pervious Area
10,820		31.42% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	160		0.44		**Direct Entry, Min. Tc.**

Summary for Subcatchment P-11: Watershed

Runoff = 2.52 cfs @ 12.09 hrs, Volume= 7,998 cf, Depth= 4.47"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (sf)	CN	Description
10,074	98	Paved parking, HSG B
11,375	61	>75% Grass cover, Good, HSG B
21,449	78	Weighted Average
11,375		53.03% Pervious Area
10,074		46.97% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	160		0.44		**Direct Entry, Min. Tc.**

Summary for Subcatchment P-12: Watershed

Runoff = 1.96 cfs @ 12.09 hrs, Volume= 6,307 cf, Depth= 4.92"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (sf)	CN	Description
8,915	98	Paved parking, HSG B
6,480	61	>75% Grass cover, Good, HSG B
15,395	82	Weighted Average
6,480		42.09% Pervious Area
8,915		57.91% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	160		0.44		**Direct Entry, Min. Tc.**

Summary for Subcatchment P-13: Watershed

Runoff = 0.66 cfs @ 12.09 hrs, Volume= 2,146 cf, Depth= 5.37"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (sf)	CN	Description
3,234	98	Paved parking, HSG B
1,566	61	>75% Grass cover, Good, HSG B
4,800	86	Weighted Average
1,566		32.62% Pervious Area
3,234		67.37% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	160		0.44		**Direct Entry, Min. Tc.**

Summary for Subcatchment P-14: Watershed

Runoff = 2.99 cfs @ 12.09 hrs, Volume= 9,563 cf, Depth= 4.69"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (sf)	CN	Description
12,480	98	Paved parking, HSG B
11,965	61	>75% Grass cover, Good, HSG B
24,445	80	Weighted Average
11,965		48.95% Pervious Area
12,480		51.05% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	160		0.44		**Direct Entry, Min. Tc.**

Summary for Subcatchment P-15: Watershed

Runoff = 1.36 cfs @ 12.10 hrs, Volume= 4,331 cf, Depth= 3.10"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (sf)	CN	Description
2,585	98	Paved parking, HSG B
6,512	61	>75% Grass cover, Good, HSG B
7,653	58	Woods/grass comb., Good, HSG B
16,750	65	Weighted Average
14,165		84.57% Pervious Area
2,585		15.43% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	160		0.44		**Direct Entry, Min. Tc.**

Summary for Subcatchment P-16: Watershed

Runoff = 2.28 cfs @ 12.09 hrs, Volume= 7,287 cf, Depth= 4.69"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (sf)	CN	Description
9,697	98	Paved parking, HSG B
8,929	61	>75% Grass cover, Good, HSG B
18,626	80	Weighted Average
8,929		47.94% Pervious Area
9,697		52.06% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	160		0.44		**Direct Entry, Min. Tc.**

Summary for Subcatchment P-17: Watershed

Runoff = 2.77 cfs @ 12.09 hrs, Volume= 8,810 cf, Depth= 4.47"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (sf)	CN	Description
11,323	98	Paved parking, HSG B
11,510	61	>75% Grass cover, Good, HSG B
793	39	>75% Grass cover, Good, HSG A
23,626	78	Weighted Average
12,303		52.07% Pervious Area
11,323		47.93% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	160		0.44		**Direct Entry, Min. Tc.**

Summary for Subcatchment P-18: Watershed

Runoff = 5.44 cfs @ 12.21 hrs, Volume= 22,386 cf, Depth= 3.00"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

	Area (sf)	CN	Description
*	1,395	98	Water Surface, 0% imp, HSG B
	3,801	39	>75% Grass cover, Good, HSG A
	33,365	61	>75% Grass cover, Good, HSG B
	2,502	32	Woods/grass comb., Good, HSG A
	28,018	58	Woods/grass comb., Good, HSG B
	16,355	79	Woods/grass comb., Good, HSG D
	2,519	98	Paved parking, HSG B
	1,550	98	Paved parking, HSG A
	89,505	64	Weighted Average
	85,436		95.45% Pervious Area
	4,069		4.55% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	50	0.0110	0.12		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.40"
4.4	132	0.0050	0.49		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
1.2	114	0.1030	1.60		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
1.9	20	0.0050	0.18		**Shallow Concentrated Flow,** Forest w/Heavy Litter Kv= 2.5 fps
14.4	316	Total			

Summary for Subcatchment P-19: Watershed

Runoff = 2.12 cfs @ 12.10 hrs, Volume= 6,929 cf, Depth= 2.51"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (sf)	CN	Description
9,855	61	>75% Grass cover, Good, HSG B
23,323	58	Woods/grass comb., Good, HSG B
33,178	59	Weighted Average
33,178		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	160		0.44		**Direct Entry, Min. Tc.**

Summary for Subcatchment P-2: Watershed

Runoff = 1.34 cfs @ 12.09 hrs, Volume= 4,444 cf, Depth= 5.59"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (sf)	CN	Description
7,004	98	Paved parking, HSG B
2,529	61	>75% Grass cover, Good, HSG B
9,533	88	Weighted Average
2,529		26.53% Pervious Area
7,004		73.47% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	100		0.28		**Direct Entry, Min. Tc.**

Summary for Subcatchment P-3: Watershed

Runoff = 2.18 cfs @ 12.10 hrs, Volume= 6,910 cf, Depth= 3.20"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (sf)	CN	Description
3,683	98	Paved parking, HSG B
22,195	61	>75% Grass cover, Good, HSG B
25,878	66	Weighted Average
22,195		85.77% Pervious Area
3,683		14.23% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	160		0.44		**Direct Entry, Min. Tc.**

Summary for Subcatchment P-4: Watershed

Runoff = 0.53 cfs @ 12.09 hrs, Volume= 1,939 cf, Depth= 6.76"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (sf)	CN	Description
3,442	98	Paved parking, HSG B
3,442		100.00% Impervious Area

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

Summary for Subcatchment P-5: Watershed

Runoff = 3.83 cfs @ 12.09 hrs, Volume= 12,757 cf, Depth= 5.71"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (sf)	CN	Description
12,978	98	Paved parking, HSG A
7,967	98	Paved parking, HSG B
1,046	39	>75% Grass cover, Good, HSG A
4,828	61	>75% Grass cover, Good, HSG B
26,819	89	Weighted Average
5,874		21.90% Pervious Area
20,945		78.10% Impervious Area

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

Summary for Subcatchment P-6: Watershed

Runoff = 0.27 cfs @ 12.15 hrs, Volume= 1,589 cf, Depth= 0.84"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (sf)	CN	Description
293	98	Paved parking, HSG A
0	98	Paved parking, HSG B
10,175	39	>75% Grass cover, Good, HSG A
3,090	61	>75% Grass cover, Good, HSG B
9,081	32	Woods/grass comb., Good, HSG A
22,639	40	Weighted Average
22,346		98.71% Pervious Area
293		1.29% Impervious Area

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

Summary for Subcatchment P-7: Watershed

Runoff = 1.87 cfs @ 12.09 hrs, Volume= 6,080 cf, Depth= 5.25"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (sf)	CN	Description
9,021	98	Paved parking, HSG B
4,869	61	>75% Grass cover, Good, HSG B
13,890	85	Weighted Average
4,869		35.05% Pervious Area
9,021		64.95% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	160		0.44		**Direct Entry, Min. Tc.**

Summary for Subcatchment P-8: Watershed

Runoff = 1.18 cfs @ 12.09 hrs, Volume= 3,985 cf, Depth= 5.94"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (sf)	CN	Description
6,423	98	Paved parking, HSG B
1,629	61	>75% Grass cover, Good, HSG B
8,052	91	Weighted Average
1,629		20.23% Pervious Area
6,423		79.77% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	160		0.44		**Direct Entry, Min. Tc.**

Summary for Subcatchment P-9: Watershed

Runoff = 1.38 cfs @ 12.09 hrs, Volume= 4,374 cf, Depth= 4.26"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (sf)	CN	Description
5,020	98	Paved parking, HSG B
7,309	61	>75% Grass cover, Good, HSG B
12,329	76	Weighted Average
7,309		59.28% Pervious Area
5,020		40.72% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0	160		0.44		**Direct Entry, Min. Tc.**

Summary for Subcatchment R-1: Roof - Blg 1

Runoff = 4.87 cfs @ 12.09 hrs, Volume= 17,811 cf, Depth= 6.76"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (sf)	CN	Description
7,300	98	Unconnected roofs, HSG A
24,313	98	Unconnected roofs, HSG B
31,613	98	Weighted Average
31,613		100.00% Impervious Area
31,613		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, Min. Tc.**

Summary for Subcatchment R-2A: Roof - Blg 2

Runoff = 3.59 cfs @ 12.09 hrs, Volume= 13,147 cf, Depth= 6.76"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (sf)	CN	Description
1,976	98	Unconnected roofs, HSG A
21,358	98	Unconnected roofs, HSG B
23,334	98	Weighted Average
23,334		100.00% Impervious Area
23,334		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, Min. Tc.**

Summary for Subcatchment R-2B: Roof - Blg 2

Runoff = 5.46 cfs @ 12.09 hrs, Volume= 19,967 cf, Depth= 6.76"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (sf)	CN	Description
8,577	98	Unconnected roofs, HSG A
26,862	98	Unconnected roofs, HSG B
35,439	98	Weighted Average
35,439		100.00% Impervious Area
35,439		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, Min. Tc.**

Summary for Subcatchment R-2C: Roof - Blg 2

Runoff = 1.62 cfs @ 12.09 hrs, Volume= 5,919 cf, Depth= 6.76"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (sf)	CN	Description
4,367	98	Unconnected roofs, HSG A
6,138	98	Unconnected roofs, HSG B
10,505	98	Weighted Average
10,505		100.00% Impervious Area
10,505		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, Min. Tc.**

Summary for Pond 1P: UIS #1

Inflow Area = 62,230 sf, 50.83% Impervious, Inflow Depth = 4.65" for 100-Year event
Inflow = 7.34 cfs @ 12.09 hrs, Volume= 24,111 cf
Outflow = 3.00 cfs @ 12.32 hrs, Volume= 19,973 cf, Atten= 59%, Lag= 13.8 min
Primary = 3.00 cfs @ 12.32 hrs, Volume= 19,973 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Peak Elev= 17.68' @ 12.32 hrs Surf.Area= 3,067 sf Storage= 9,671 cf
Flood Elev= 14.75' Surf.Area= 3,067 sf Storage= 4,099 cf

Plug-Flow detention time= 150.1 min calculated for 19,945 cf (83% of inflow)
Center-of-Mass det. time= 81.1 min (881.0 - 800.0)

Volume	Invert	Avail.Storage	Storage Description
#1A	12.75'	4,336 cf	**22.75'W x 134.83'L x 5.50'H Field A** 16,870 cf Overall - 6,031 cf Embedded = 10,839 cf x 40.0% Voids
#2A	13.50'	6,031 cf	**ADS_StormTech MC-3500 c +Cap** x 54 Inside #1 Effective Size= 70.4"W x 45.0"H => 15.33 sf x 7.17'L = 110.0 cf Overall Size= 77.0"W x 45.0"H x 7.50'L with 0.33' Overlap 3 Rows of 18 Chambers Cap Storage= +15.6 cf x 2 x 3 rows = 93.6 cf
		10,367 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	14.75'	**12.0" Round Culvert** L= 80.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 14.75' / 13.95' S= 0.0100 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.79 sf
#2	Device 1	14.75'	**7.0" Vert. Orifice/Grate** C= 0.600
#3	Device 1	17.90'	**4.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32
#4	Device 1	16.50'	**6.0" Vert. Orifice/Grate** C= 0.600

Primary OutFlow Max=3.00 cfs @ 12.32 hrs HW=17.67' TW=0.00' (Dynamic Tailwater)
└─**1=Culvert** (Passes 3.00 cfs of 4.65 cfs potential flow)
  ├─**2=Orifice/Grate** (Orifice Controls 2.09 cfs @ 7.81 fps)
  ├─**3=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)
  └─**4=Orifice/Grate** (Orifice Controls 0.91 cfs @ 4.63 fps)

Summary for Pond 2P: UIS #2

Inflow Area = 129,504 sf, 75.55% Impervious, Inflow Depth = 5.71" for 100-Year event
Inflow = 17.89 cfs @ 12.09 hrs, Volume= 61,641 cf
Outflow = 7.58 cfs @ 12.30 hrs, Volume= 52,896 cf, Atten= 58%, Lag= 12.5 min
Primary = 7.58 cfs @ 12.30 hrs, Volume= 52,896 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Peak Elev= 23.68' @ 12.30 hrs Surf.Area= 7,935 sf Storage= 26,934 cf
Flood Elev= 19.90' Surf.Area= 7,935 sf Storage= 8,460 cf

Plug-Flow detention time= 200.5 min calculated for 52,896 cf (86% of inflow)
Center-of-Mass det. time= 137.8 min (908.5 - 770.7)

Volume	Invert	Avail.Storage	Storage Description
#1A	18.25'	10,983 cf	**65.75'W x 120.49'L x 5.50'H Field A** 43,571 cf Overall - 16,114 cf Embedded = 27,457 cf x 40.0% Voids
#2A	19.00'	16,114 cf	**ADS_StormTech MC-3500 c +Cap** x 144 Inside #1 Effective Size= 70.4"W x 45.0"H => 15.33 sf x 7.17'L = 110.0 cf Overall Size= 77.0"W x 45.0"H x 7.50'L with 0.33' Overlap 9 Rows of 16 Chambers Cap Storage= +15.6 cf x 2 x 9 rows = 280.8 cf
#3	19.00'	92 cf	**4.00'D x 7.30'H Vertical Cone/Cylinder**
		27,188 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	19.90'	**15.0" Round Culvert** L= 52.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 19.90' / 19.38' S= 0.0100 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 1.23 sf
#2	Device 1	19.90'	**6.0" Vert. Orifice/Grate** C= 0.600
#3	Device 1	21.30'	**12.0" Vert. Orifice/Grate** C= 0.600
#4	Device 1	23.00'	**6.0" Vert. Orifice/Grate** C= 0.600
#5	Device 1	24.00'	**4.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Primary OutFlow Max=7.58 cfs @ 12.30 hrs HW=23.68' TW=0.00' (Dynamic Tailwater)
└**1=Culvert** (Passes 7.58 cfs of 8.28 cfs potential flow)
  ├**2=Orifice/Grate** (Orifice Controls 1.78 cfs @ 9.04 fps)
  ├**3=Orifice/Grate** (Orifice Controls 5.18 cfs @ 6.60 fps)
  ├**4=Orifice/Grate** (Orifice Controls 0.62 cfs @ 3.15 fps)
  └**5=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Pond 3P: UIS #3

Inflow Area = 44,947 sf, 47.44% Impervious, Inflow Depth = 3.65" for 100-Year event
Inflow = 4.01 cfs @ 12.09 hrs, Volume= 13,674 cf
Outflow = 1.47 cfs @ 12.40 hrs, Volume= 11,802 cf, Atten= 63%, Lag= 18.5 min
Primary = 1.47 cfs @ 12.40 hrs, Volume= 11,802 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Peak Elev= 18.14' @ 12.41 hrs Surf.Area= 1,612 sf Storage= 5,403 cf
Flood Elev= 14.35' Surf.Area= 1,612 sf Storage= 1,860 cf

Plug-Flow detention time= 145.1 min calculated for 11,785 cf (86% of inflow)
Center-of-Mass det. time= 82.8 min (887.1 - 804.3)

Volume	Invert	Avail.Storage	Storage Description
#1A	12.55'	2,293 cf	**22.75'W x 70.30'L x 5.50'H Field A** 8,796 cf Overall - 3,062 cf Embedded = 5,734 cf x 40.0% Voids
#2A	13.30'	3,062 cf	**ADS_StormTech MC-3500 c +Cap** x 27 Inside #1 Effective Size= 70.4"W x 45.0"H => 15.33 sf x 7.17'L = 110.0 cf Overall Size= 77.0"W x 45.0"H x 7.50'L with 0.33' Overlap 3 Rows of 9 Chambers Cap Storage= +15.6 cf x 2 x 3 rows = 93.6 cf
#3	14.35'	107 cf	**4.00'D x 8.55'H Vertical Cone/Cylinder**
		5,463 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	14.35'	**12.0" Round Culvert** L= 24.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 14.35' / 14.11' S= 0.0100 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.79 sf
#2	Device 1	14.35'	**6.0" W x 3.0" H Vert. Orifice/Grate** C= 0.600
#3	Device 1	18.05'	**4.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Primary OutFlow Max=1.46 cfs @ 12.40 hrs HW=18.14' TW=0.00' (Dynamic Tailwater)
└**1=Culvert** (Passes 1.46 cfs of 5.42 cfs potential flow)
  ├**2=Orifice/Grate** (Orifice Controls 1.15 cfs @ 9.22 fps)
  └**3=Broad-Crested Rectangular Weir** (Weir Controls 0.30 cfs @ 0.84 fps)

Summary for Pond 4P: UIS #4

Inflow Area = 123,686 sf, 60.44% Impervious, Inflow Depth = 5.06" for 100-Year event
Inflow = 15.51 cfs @ 12.09 hrs, Volume= 52,103 cf
Outflow = 11.03 cfs @ 12.19 hrs, Volume= 46,784 cf, Atten= 29%, Lag= 5.7 min
Primary = 11.03 cfs @ 12.19 hrs, Volume= 46,784 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Peak Elev= 17.87' @ 12.18 hrs Surf.Area= 3,624 sf Storage= 12,278 cf
Flood Elev= 14.30' Surf.Area= 3,624 sf Storage= 5,276 cf

Plug-Flow detention time= 104.6 min calculated for 46,719 cf (90% of inflow)
Center-of-Mass det. time= 55.5 min (841.6 - 786.1)

Volume	Invert	Avail.Storage	Storage Description
#1A	12.15'	5,090 cf	**51.42'W x 70.23'L x 5.50'H Field A** 19,860 cf Overall - 7,136 cf Embedded = 12,725 cf x 40.0% Voids
#2A	12.90'	7,136 cf	**ADS_StormTech MC-3500 d +Cap** x 63 Inside #1 Effective Size= 70.4"W x 45.0"H => 15.33 sf x 7.17'L = 110.0 cf Overall Size= 77.0"W x 45.0"H x 7.50'L with 0.33' Overlap 7 Rows of 9 Chambers Cap Storage= +14.9 cf x 2 x 7 rows = 208.6 cf
#3	13.70'	82 cf	**4.00'D x 6.50'H Vertical Cone/Cylinder**
		12,307 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	14.30'	**18.0" Round Culvert** L= 70.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 14.30' / 13.60' S= 0.0100 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 1.77 sf
#2	Device 1	14.30'	**15.0" Vert. Orifice/Grate** C= 0.600
#3	Device 1	17.65'	**4.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Primary OutFlow Max=10.82 cfs @ 12.19 hrs HW=17.82' TW=0.00' (Dynamic Tailwater)
└**1=Culvert** (Passes 10.82 cfs of 11.18 cfs potential flow)
  ├**2=Orifice/Grate** (Orifice Controls 10.05 cfs @ 8.19 fps)
  └**3=Broad-Crested Rectangular Weir** (Weir Controls 0.77 cfs @ 1.15 fps)

Summary for Pond EX: Low Wooded Area

Inflow Area = 22,639 sf, 1.29% Impervious, Inflow Depth = 0.84" for 100-Year event
Inflow = 0.27 cfs @ 12.15 hrs, Volume= 1,589 cf
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0 cf, Atten= 100%, Lag= 0.0 min
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs

Peak Elev= 19.47' @ 24.40 hrs Surf.Area= 2,315 sf Storage= 1,589 cf

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

Volume	Invert	Avail.Storage	Storage Description
#1	14.70'	55 cf	**4.00'D x 4.35'H Vertical Cone/Cylinder**
#2	18.05'	2,768 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)
		2,823 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
18.05	4	0	0
18.50	593	134	134
19.00	1,448	510	645
19.50	2,349	949	1,594
20.00	2,349	1,175	2,768

Device	Routing	Invert	Outlet Devices
#1	Primary	19.49'	**2.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=14.70' TW=0.00' (Dynamic Tailwater)
└─**1=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Link SP-1: Study Point #1

Inflow Area = 278,922 sf, 55.39% Impervious, Inflow Depth > 3.79" for 100-Year event
Inflow = 12.19 cfs @ 12.30 hrs, Volume= 87,988 cf
Primary = 12.19 cfs @ 12.30 hrs, Volume= 87,988 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs

Summary for Link SP-2: Study Point #2

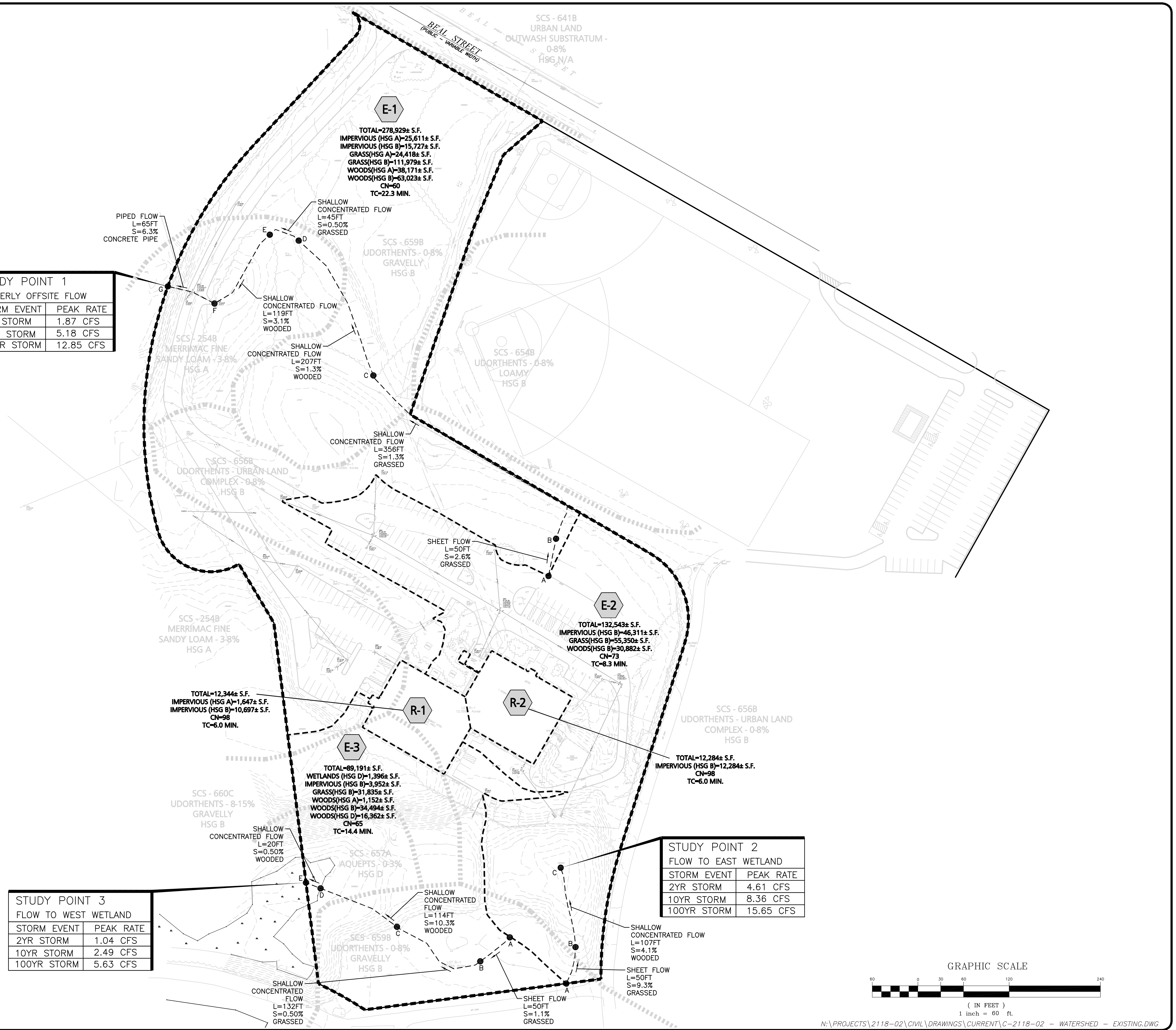
Inflow Area = 156,864 sf, 47.66% Impervious, Inflow Depth = 4.11" for 100-Year event
Inflow = 12.51 cfs @ 12.17 hrs, Volume= 53,713 cf
Primary = 12.51 cfs @ 12.17 hrs, Volume= 53,713 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs

Summary for Link SP-3: Study Point #3

Inflow Area = 89,505 sf, 4.55% Impervious, Inflow Depth = 3.00" for 100-Year event
Inflow = 5.44 cfs @ 12.21 hrs, Volume= 22,386 cf
Primary = 5.44 cfs @ 12.21 hrs, Volume= 22,386 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs



STUDY POINT 1

WESTERLY OFFSITE FLOW

STORM EVENT	PEAK RATE
2YR STORM	1.87 CFS
10YR STORM	5.18 CFS
100YR STORM	12.85 CFS

STUDY POINT 2

FLOW TO EAST WETLAND

STORM EVENT	PEAK RATE
2YR STORM	4.61 CFS
10YR STORM	8.36 CFS
100YR STORM	15.65 CFS

STUDY POINT 3

FLOW TO WEST WETLAND

STORM EVENT	PEAK RATE
2YR STORM	1.04 CFS
10YR STORM	2.49 CFS
100YR STORM	5.63 CFS

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N:\PROJECTS\2118-02\CIVIL\DRAWINGS\CURRENT\C-2118-02 - WATERSHED - EXISTING.DWG

ISSUED FOR DRAINAGE REPORT
OCTOBER 25, 2016

PROFESSIONAL ENGINEER FOR
ALLEN & MAJOR ASSOCIATES, INC.

REV	DATE	DESCRIPTION
1.	10/25/2016	REVISED PER TOWN COMMENTS

APPLICANT\OWNER:
BROADSTONE BARE COVE ALLIANCE, LLC. C/O
ALLIANCE RESIDENTIAL COMPANY
184 HIGH STREET, SUITE 401
BOSTON, MA 02110

PROJECT:
BROADSTONE BARE COVE
230 BEAL STREET
HINGHAM, MA

PROJECT NO.	2118-02	DATE:	08-12-2016
SCALE:	1" = 40'	DWG. NAME:	C2118-02
DESIGNED BY:	SJL	CHECKED BY:	CMQ

PREPARED BY:

ALLEN & MAJOR ASSOCIATES, INC.
civil & structural engineering ◆ land surveying
environmental consulting ◆ landscape architecture
www.allenmajor.com
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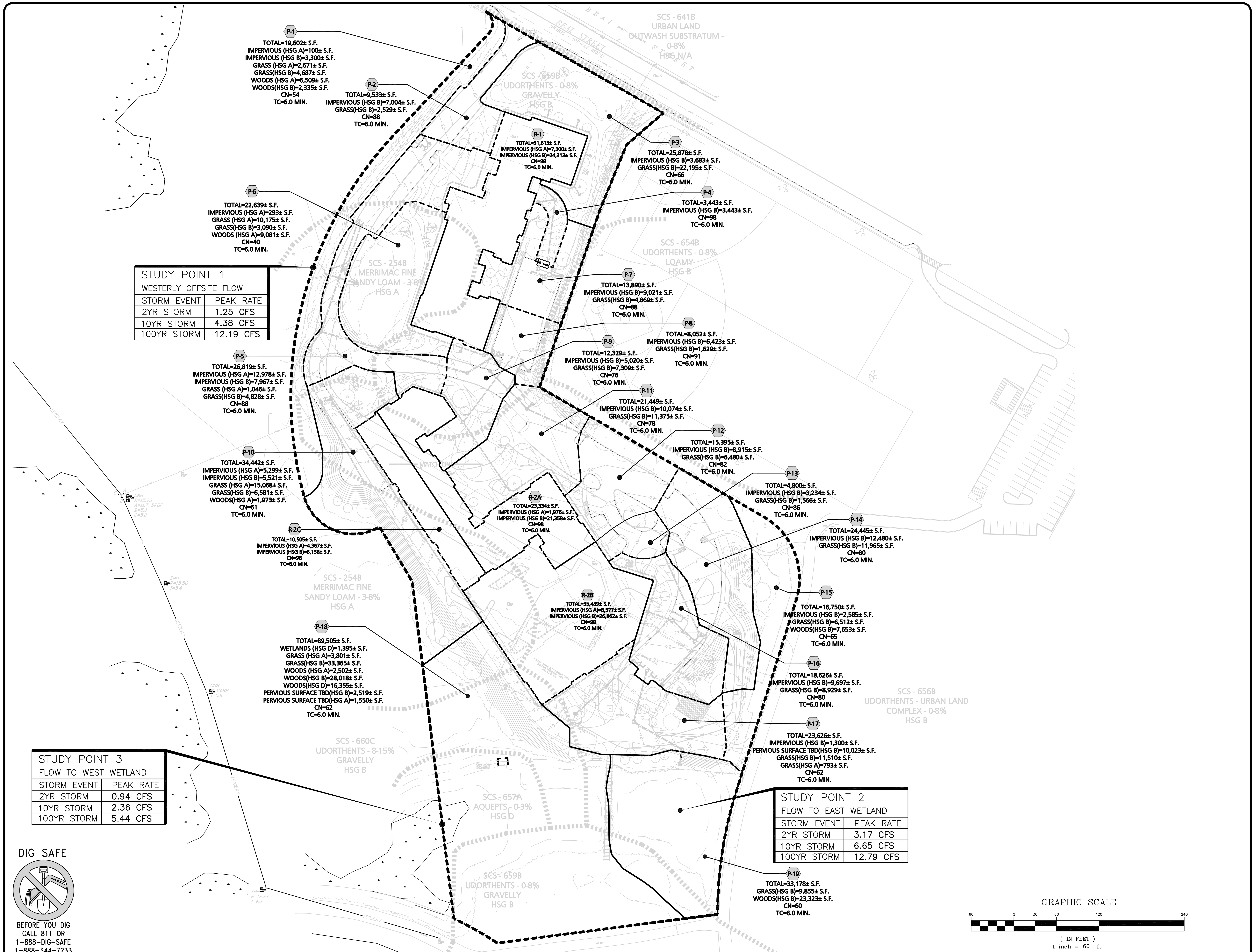
P.O. BOX 2118
WOBURN MA 01888-0118
TEL: (781) 935-6889
FAX: (781) 935-2896
WOBURN, MA ◆ LAKEVILLE, MA ◆ MANCHESTER, NH

DRAWING TITLE: EXISTING WATERSHED PLAN

SHEET No. EWP



STUDY POINT 1
WESTERLY OFFSITE FLOW

STORM EVENT	PEAK RATE
2YR STORM	1.25 CFS
10YR STORM	4.38 CFS
100YR STORM	12.19 CFS

STUDY POINT 2
FLOW TO EAST WETLAND

STORM EVENT	PEAK RATE
2YR STORM	3.17 CFS
10YR STORM	6.65 CFS
100YR STORM	12.79 CFS

STUDY POINT 3
FLOW TO WEST WETLAND

STORM EVENT	PEAK RATE
2YR STORM	0.94 CFS
10YR STORM	2.36 CFS
100YR STORM	5.44 CFS

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1-888-344-7233

N:\PROJECTS\2118-02\CIVIL\DRAWINGS\CURRENT\C-2118-02 - WATERSHED - AM.DWG

ISSUED FOR DRAINAGE REPORT
OCTOBER 25, 2016

PROFESSIONAL ENGINEER FOR
ALLEN & MAJOR ASSOCIATES, INC.

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PREPARED BY:
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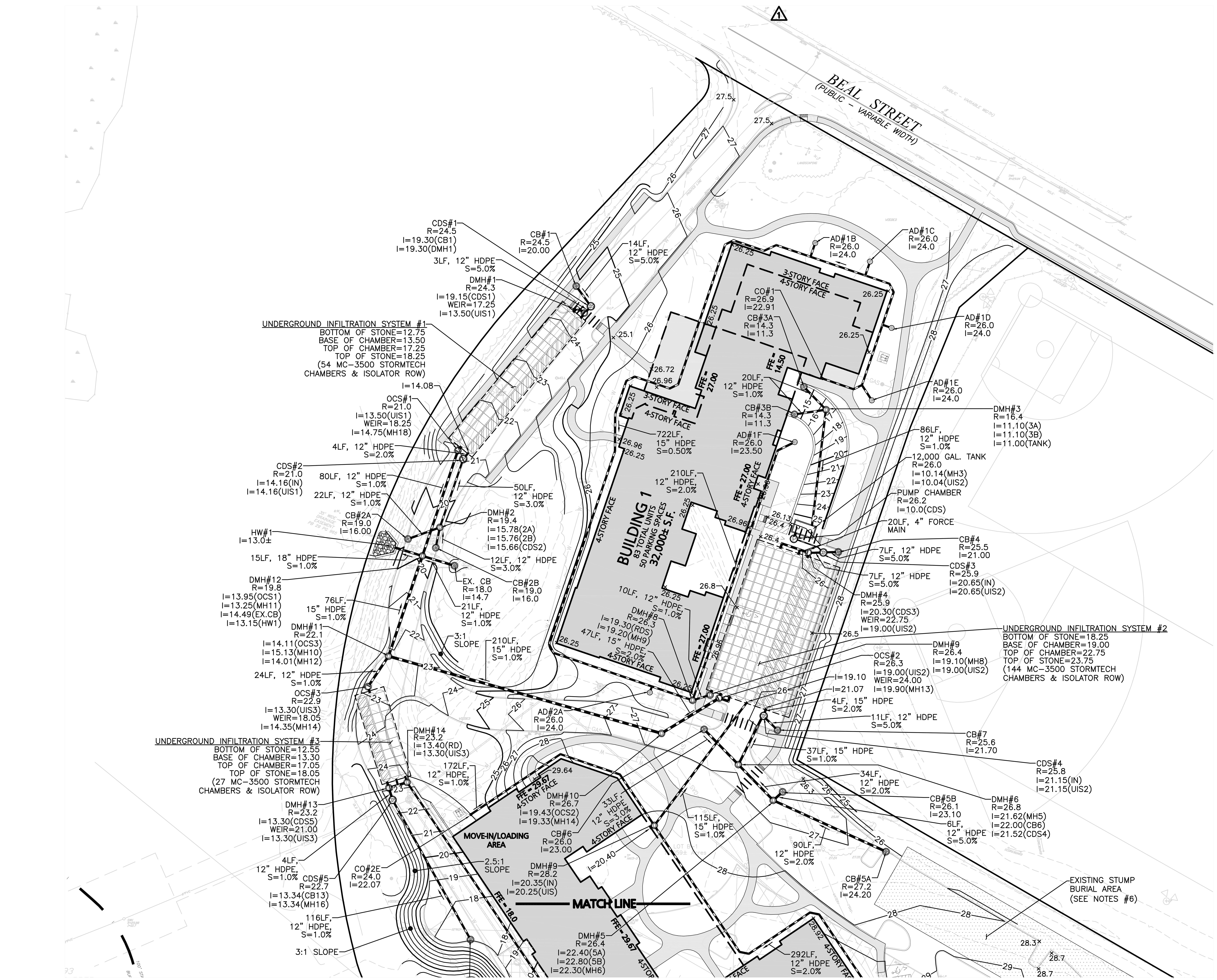
FAX: (781) 935-2896
WOBURN, MA ◆ LAKEVILLE, MA ◆ MANCHESTER, NH

DRAWING TITLE: PROPOSED WATERSHED PLAN
SHEET No. PWP



LEGEND:

DRAIN MANHOLE (DMH)	
OUTLET CONTROL STRUCTURE (OCS)	
CONTECH CDS UNIT (CDS)	
STORAGE TANK	
PUMP CHAMBER	
CATCH BASIN (CB)	
AREA DRAIN (AD)	
CLEAN OUT (CO)	
FLARED END SECTION (FES)	
DRAIN LINE	
RIPRAP OUTFALL	
HEADWALL	
5' CONTOUR	30
1' CONTOUR	31
SPOT GRADE	×128
LIMIT OF INFILTRATION STONE	
INFILTRATION CHAMBERS	
ISOLATOR ROW	

NOTES:

1. THE LOCATIONS OF EXISTING UNDERGROUND UTILITIES ARE SHOWN IN AN APPROXIMATE WAY ONLY AND HAVE NOT BEEN INDEPENDENTLY VERIFIED BY THE OWNER OR IT'S REPRESENTATIVE. THE CONTRACTOR SHALL DETERMINE THE EXACT LOCATION OF ALL EXISTING UTILITIES BEFORE COMMENCING WORK, AND AGREES TO BE FULLY RESPONSIBLE FOR ANY AND ALL DAMAGES WHICH MIGHT BE OCCASIONED BY THE CONTRACTOR'S FAILURE TO EXACTLY LOCATE AND PRESERVE ANY AND ALL UNDERGROUND UTILITIES.
2. THE INFORMATION SHOWN ON THIS PLAN IS THE SOLE PROPERTY OF ALLEN & MAJOR ASSOCIATES, INC. IT'S INTENDED USE IS TO PROVIDE INFORMATION. ANY ALTERATION, MISUSE, OR RECALCULATION OF INFORMATION OR DATA WITHOUT THE EXPRESSED, WRITTEN CONSENT OF ALLEN & MAJOR ASSOCIATES, INC. IS STRICTLY PROHIBITED.
3. PIPE DIMENSIONS ARE MEASURED FROM THE INSIDE FACE OF THE STRUCTURE.
4. THE SIZE AND LOCATION OF EXISTING ROOF LEADERS SHALL BE CONFIRMED BY THE CONTRACTOR IN THE FIELD.
5. THE ELEVATIONS ON THIS PLAN ARE BASED ON THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88). SEE EXISTING CONDITIONS PLANS.
6. THE CONTRACTOR SHALL CONTACT "DIGSAFE" AND THE AT LEAST 72 HOURS PRIOR TO ANY EXCAVATION WORK TO REQUEST THE LOCATION OF THE EXISTING UTILITIES. DIGSAFE: 1-888-344-7233.
7. THE CONTRACTOR SHALL REVIEW THE RECORD PLAN ENTITLED "BUILDING DEMOLITION AND DEBRIS DISPOSAL AREA PLAN" OF 1988 AND VERIFY, IN THE FIELD, THE ELEVATION AND LOCATION OF THE DEBRIS AND STUMP BURIAL AREA. SPECIAL PRECAUTIONS SHALL BE TAKEN TO ENSURE THIS AREA IS NOT DISTURBED DURING CONSTRUCTION.

BENCHMARK SUMMARY

TBM #	DESCRIPTION	ELEV.
1	X CUT IN HYDRANT SPINDLE	29.57

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1-888-344-7233

GRAPHIC SCALE

40 0 20 40 80 160

(IN FEET)
1 inch = 40 ft.

N:\PROJECTS\2118-02\CIVIL\DRAWINGS\CURRENT\C-2118-02 - GRADING & DRAINAGE.DWG

ISSUED FOR DRAINAGE REPORT
OCTOBER 25, 2016

PROFESSIONAL ENGINEER FOR
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230 BEAL STREET
HINGHAM, MA

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DESIGNED BY:	SJL	CHECKED BY:	CMQ

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FAX: (781) 935-2896
WOBURN, MA ◆ LAKEVILLE, MA ◆ MANCHESTER, NH

DRAWING TITLE:
GRADING & DRAINAGE PLAN

SHEET No.
C-3A

LEGEND:

- DRAIN MANHOLE (DMH)
- OUTLET CONTROL STRUCTURE (OCS)
- CONTECH CDS UNIT (CDS)
- STORAGE TANK
- PUMP CHAMBER
- CATCH BASIN (CB)
- AREA DRAIN (AD)
- CLEAN OUT (CO)
- FLARED END SECTION (FES)
- DRAIN LINE
- RIPRAP OUTFALL
- HEADWALL
- 5' CONTOUR —30—
- 1' CONTOUR —31—
- SPOT GRADE ×128
- LIMIT OF INFILTRATION STONE
- INFILTRATION CHAMBERS
- ISOLATOR ROW

NOTES:

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GRAPHIC SCALE
(IN FEET)
1 inch = 40 ft.

N:\PROJECTS\2118-02\CIVIL\DRAWINGS\CURRENT\C-2118-02 - GRADING & DRAINAGE.DWG

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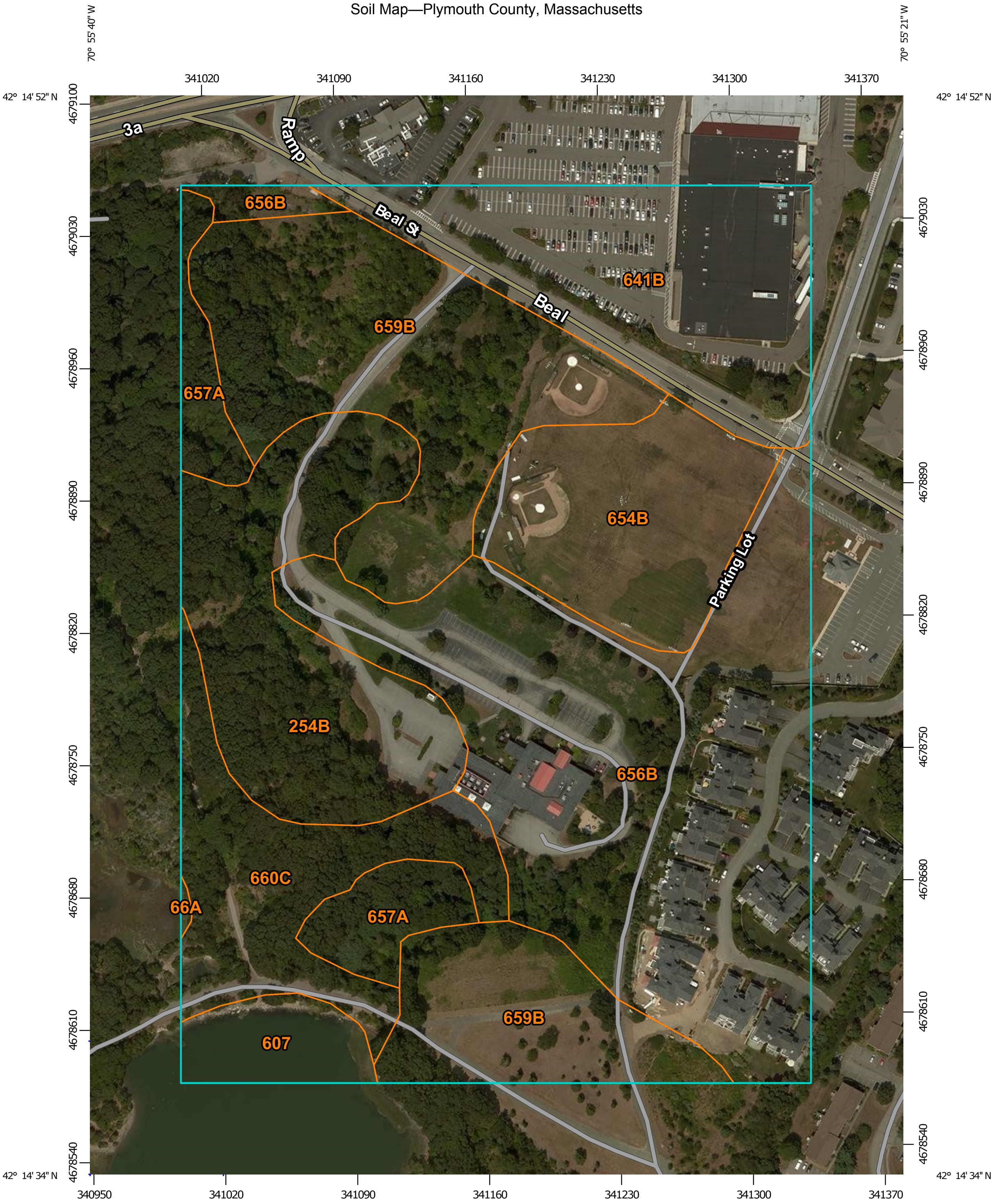
DRAWING TITLE: GRADING & DRAINAGE PLAN
SHEET No. C-3B



Map Scale: 1:2,780 if printed on A portrait (8.5" x 11") sheet.

N

Meters: 0, 40, 80, 160, 240

Feet: 0, 100, 200, 400, 600

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 19N 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 1:12,000.

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: http://websoilsurvey.nrcs.usda.gov
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: Plymouth County, Massachusetts
Survey Area Data: Version 8, Sep 28, 2015

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

Date(s) aerial images were photographed: Aug 10, 2014—Aug 25, 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

Plymouth County, Massachusetts (MA023)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
66A	Ipswich - Pawcatuck - Matunuck complex, 0 to 2 percent slopes, very frequently flooded	0.0	0.1%
254B	Merrimac fine sandy loam, 3 to 8 percent slopes	4.9	12.4%
607	Water, saline	1.0	2.6%
641B	Urban land, outwash substratum, 0 to 8 percent slopes	5.0	12.7%
654B	Udorthents, loamy, 0 to 8 percent slopes	3.5	8.8%
656B	Udorthents - Urban land complex, 0 to 8 percent slopes	11.3	28.7%
657A	Aquepts, 0 to 3 percent slopes	1.6	4.1%
659B	Udorthents, 0 to 8 percent slopes, gravelly	8.7	22.1%
660C	Udorthents, 8 to 15 percent slopes, gravelly	3.3	8.5%
Totals for Area of Interest		**39.4**	**100.0%**

HALEY & ALDRICH, INC.
465 Medford St.
Suite 2200
Boston, MA 02129
617.886.7400

5 February 2016
File No. 42837-004

Alliance Residential Company New England
One International Place, Suite 1400
Boston, MA 02110

Attention: Michael Boujoulian

Subject: Preliminary Geotechnical Investigation
230 Beal Street
Hingham, Massachusetts

Ladies and Gentlemen:

This report summarizes the results of a preliminary geotechnical investigation of a proposed development site located at 230 Beal Street in Hingham, Massachusetts. The investigation was conducted in accordance with our 18 December 2015 proposal, and your authorization.

The scope of the evaluation included the following:

- Discuss the project and scope of the geotechnical investigation with you;
- Review information on the proposed development provided by you;
- Gather and review readily-available information on subsurface soil and water conditions in the site vicinity from geologic maps and Haley & Aldrich files;
- Conduct a limited subsurface investigation program to obtain site-specific data on soil conditions and groundwater levels;
- Make preliminary evaluations of the collected information to identify probable building foundation requirements, and geotechnical design and construction issues that could result in significant premium cost, construction schedule implications, or similar impacts to the proposed development; and
- Prepare this report summarizing the results of the preliminary investigation.

SITE CONDITIONS AND PROPOSED CONSTRUCTION

Alliance Residential Company New England is considering acquisition of the property located at 230 Beal Street in Hingham, Massachusetts for development of a multi-family residential facility. Our understanding of the proposed development configuration is based on the concept site plan dated 28 January 2016. The general location of the site is shown on Figure 1, Project Locus.

The approximately 12-acre site is currently occupied by an approximately 24,000 square foot, 2-story office building, bituminous-paved parking areas and drive lanes, and landscaped areas, configured as shown on Figure 2 – Site and Subsurface Exploration Location Plan. The site is bordered by Beal Street to the north, a baseball field and residential subdivision to the north and east, and heavily wooded areas to the west and south. Site grades typically range from about El. 25 to El. 33[1], with the exception of the parking lot area southeast of the existing building which is at about El. 19.

Current planning for the development includes two 5-story residential structures referred to as "Building 1" and "Building 2", a 3 to 4-level parking garage, bituminous-paved parking areas, utilities and other infrastructure. No below-grade space is planned. Proposed site grading has not been finalized at this time.

SUBSURFACE SOIL CONDITIONS

Information on site subsurface conditions is available from three historic test borings performed by others and six test borings (HA16-1 through HA16-6) conducted by Haley & Aldrich during 8 to 13 January 2016 in connection with this investigation. Locations of the explorations are indicated on Figure 2 and logs are provided in Appendix A.

The subsurface explorations encountered the following sequence of subsurface units:

Subsurface Unit	Top of Stratum (NAVD88)	Range in Thickness (ft)
Topsoil Fill/ Miscellaneous Fill	El. 20 to El. 31 (Ground Surface)	1 to 7.5
Glacial Deposits	El. 25 to El. 13	29 (See Note 1)
Marine Deposits	Below El. -7	Not determined

Note:
1. Where fully penetrated in HA16-1.

A generalized description of the soil units is provided below.

- *Topsoil Fill* was encountered at three of the six boring locations (HA16-1, HA16-3, and HA16-6); the topsoil Fill extended to a depth of up to 1 ft below ground surface and consisted of a loamy, silty SAND

- *Miscellaneous Fill* was encountered at all test boring locations at ground surface or directly beneath bituminous pavement or topsoil fill. The Miscellaneous Fill thickness typically ranged from 2 to 7 ft, with the greater thicknesses of fill encountered towards the southern and eastern limits of the site. The Miscellaneous Fill was typically described as a medium dense to dense to

[1] Elevations are in feet and reference the North American Vertical Datum of 1988 (NAVD88)

very dense silty SAND with gravel or a medium dense poorly graded SAND with gravel. One test boring, HA16-3, encountered trace plastic debris in the upper portion of the layer.

- *Glacial Deposits* were encountered beneath the Fill at depths ranging from 1 to 7.5 ft below existing grades. The Glacial Deposits were generally described as medium dense poorly graded SAND or sandy SILT. The Glacial Deposits were penetrated at one boring location, HA16-1; the thickness of the Glacial Deposits at this location was 29 ft.

- *Marine Deposits* were encountered at one boring location, HA16-1, which penetrated the overlying Glacial Deposits. The Marine Deposits were encountered at a depth of 32 ft below existing grades and consisted of a stiff lean CLAY with sand.

GROUNDWATER

Groundwater observation wells were installed in the three recently-completed test boreholes. Water was detected in the observation wells at about 24 to 31 ft below existing site grades, corresponding to approximately El. 6.5 to El. -1. Water levels should be expected to vary with location, season, recent precipitation, snowmelt, nearby construction activities, tides and other factors.

GEOTECHNICAL CONSIDERATIONS

Based on the available information, the following preliminary conclusions and comments are provided, assuming project design will be performed in accordance with the current Massachusetts State Building Code (8th Edition [2]):

Design

- The pavements, Topsoil Fill, and Miscellaneous Fill materials are considered unsuitable for building foundation support in their current state. The naturally-deposited Glacial Deposits is the uppermost suitable foundation bearing stratum.

- We anticipate that proposed Buildings and Parking Garage can be supported on conventional reinforced concrete spread footing foundations bearing at “normal” depths. Design footing bearing pressures are likely to be within a normal range ; 4.0 kips per sq. ft may be assumed for early pricing purposes. The unsuitable materials noted above, where present beneath footing bearing levels, would have to be removed within the zone of influence beneath new foundations and be replaced with compacted structural fill[3].

[2] Massachusetts is planning to issue the 9th Edition of the Building Code in 2016. We anticipate that the 9th Edition will not significantly affect design and construction of the type of buildings proposed for the subject site.
[3] Due to their limited thickness, excavation/replacement of the unsuitable soils is expected to be the more cost-effective approach to enable footing foundations compared with ground improvement techniques such as aggregate piers.

- Conventional soil-supported concrete slab-on-grade construction is expected to be feasible for the new lowest building floors, with suitable subgrade preparation and possibly removal of selected materials determined to be unsuitable for slab support during geotechnical design investigations. We anticipate it will likely be determined that some or all of the existing Miscellaneous Fill could be left in place beneath new slabs if the risk of minor slab settlements is tolerable.

- Seismic Site Class C or D is likely to be applicable to the site. Accordingly, premium costs associated with structure seismic design are not anticipated. Site soils are unlikely to be subject to liquefaction.

- The test borings indicated that site subsurface soil conditions are generally suitable for stormwater infiltration, depending on final site grades and required infiltration rates.

- Site utilities, lighting, signage, pavements and similar site improvements can likely be designed and installed using normal methods.

- We anticipate that other geotechnical design parameters would be within normal ranges for the proposed type of building development.

Construction

- At the test borings, suitable bearing strata were present at or very close to "normal" spread footing bearing levels (i.e., within approximately 4 ft below current site grades) over most of the proposed building footprints. Unsuitable soils may be present and require over-excavation and replacement locally to a depth of a few feet below footing bearing levels.

- Significant dewatering is not anticipated to install foundations and utilities, based on water levels in the observation wells.

- Any existing utilities located within future building footprints will need to be decommissioned and removed where beneath new foundations or in conflict with new construction.

- We recommend that it be assumed that the existing Miscellaneous Fill is not suitable for re-use as fill or backfill beneath building foundations or floor slabs. More detailed determinations of the potential for Fill re-use within the building areas should be made based on final design investigations. Excavated inorganic fill materials that can be readily compacted can be re-used as Common Fill outside the buildings, subject to oversize debris removal and any special backfill requirements beneath structures, utilities, pavements, landscaping, etc.

- It is anticipated that on-site excavated Glacial Deposits would likely be suitable for reuse as Granular Fill subject to additional gradation and moisture-density relationship (Modified Proctor) analyses and review by the Geotechnical Engineer.

- Historical records indicate that building demolition debris was buried at the site to the north of the existing parking lot area. Current project planning does not require excavation within the reported debris area.

- No other site subsurface conditions have been identified that would be expected to result in significant premium geotechnical construction costs.

CONCLUDING COMMENTS

This report provides preliminary information and comments on geotechnical aspects of development of the subject site for low-rise residential buildings, based on available information. The comments provided herein are not suitable for final design of any structure. Additional subsurface explorations and engineering evaluations will be needed to better define subsurface conditions and for final design and construction of the subject buildings.

Haley & Aldrich has performed a companion Phase I environmental site assessment and limited environmental testing of soil and groundwater, the results of which are reported under separate cover.

Thank you for the opportunity to assist Alliance Residential Company New England on this matter. We trust the information provided herein is helpful to your current planning, and we look forward to assisting you with future phases of the project. Please do not hesitate to contact us if you wish to discuss the contents of this report.

Sincerely yours,
HALEY & ALDRICH, INC.

Lee S. Vanzler, P.E.
Project Manager

Steven R. Kraemer, P.E.
Senior Vice President

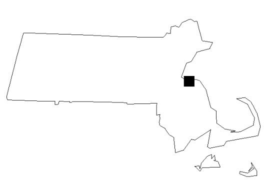
Attachments:

Figure 1	Project Locus
Figure 2	Site and Subsurface Exploration Location Plan
Appendix A	Logs of Recent and Historic Test Borings

G:\42837\004 - GT Evaluation\2016-0205-HAI-230Beal Geotech Eval-F.docx

MAP SOURCE: ESRI

SITE COORDINATES: 42°14'43"N, 70°55'28"W



HALEY ALDRICH

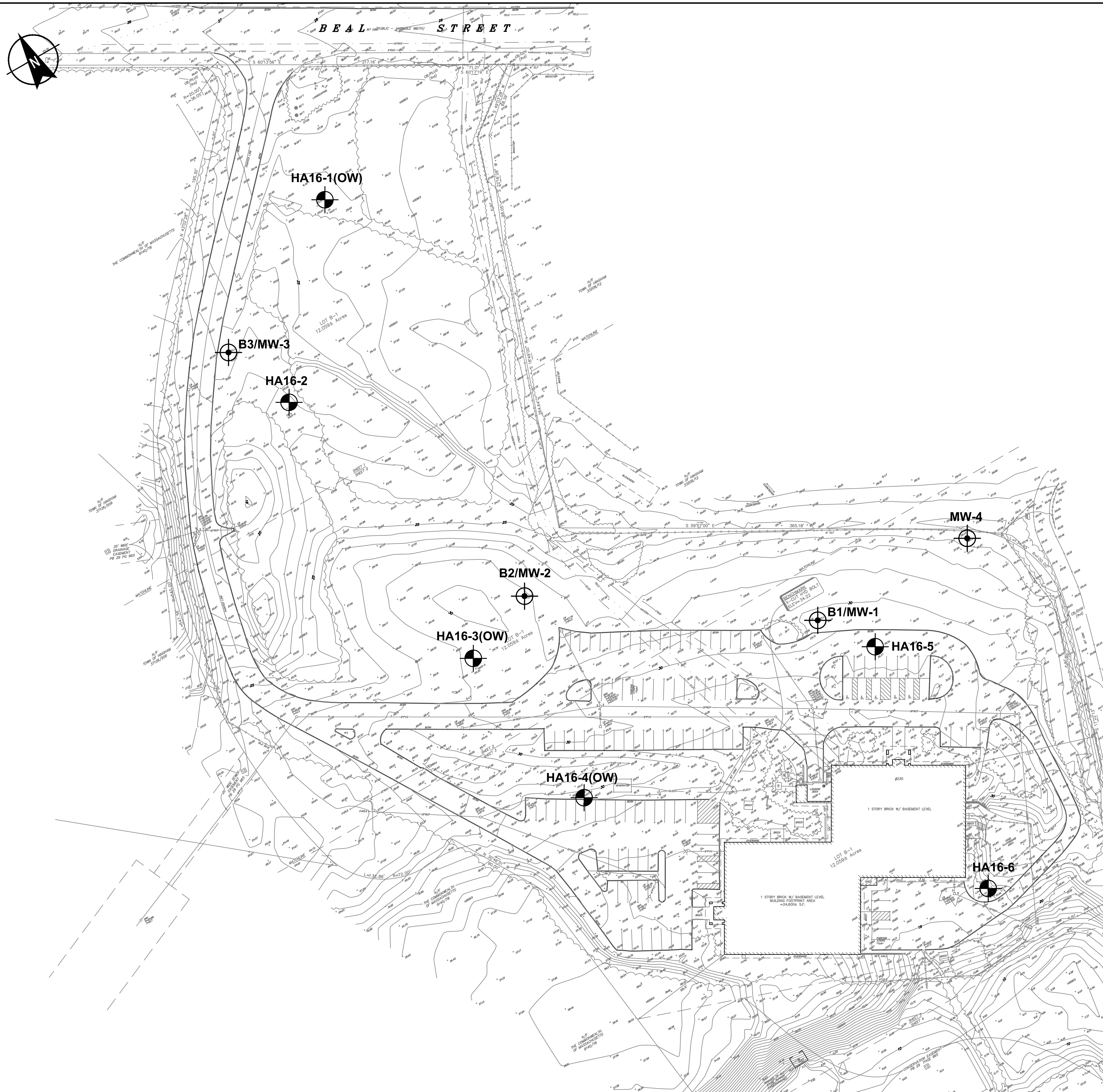
230 BEAL STREET
HINGHAM, MASSACHUSETTS

PROJECT LOCUS

APPROXIMATE SCALE: 1 IN = 2000 FT
FEBRUARY 2016

FIGURE 1

42837-004_1_LOCUS.PDF



LEGEND

HA16-2 — DESIGNATION AND APPROXIMATE LOCATION OF TEST BORING COMPLETED BY NORTHERN DRILL SERVICE, INC. AND MONITORED BY HALEY & ALDRICH, INC. BETWEEN 8 AND 13 JANUARY 2016

B1/MW-1 — DESIGNATION AND REPORTED LOCATION OF TEST BORING COMPLETED BY GEOSEARCH AND MONITORED BY ROUX ASSOCIATES, INC. BETWEEN 5 AND 26 MAY 2010

(OW) — INDICATES OBSERVATION WELL INSTALLED IN COMPLETED BOREHOLE

NOTES

1. BASEPLAN TAKEN FROM PLAN TITLED “EXISTING CONDITIONS PLAN IN HINGHAM, MA (PLYMOUTH COUNTY),” PREPARED BY PRECISION LAND SURVEYING, INC. DATED 6 JANUARY 2016.
2. ELEVATIONS SHOWN ARE IN FEET AND REFERENCE THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88).

0 100 200
SCALE IN FEET

HALEY ALDRICH

230 BEAL STREET
HINGHAM, MASSACHUESTTS

SITE AND SUBSURFACE
EXPLORATION LOCATION PLAN

SCALE: AS SHOWN
FEBRUARY 2016

FIGURE 2

ERVIN, DAYNA Printed: 2/3/2016 9:49 AM Layout: B001
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APPENDIX A

Logs of Recent and Historic Test Borings

Client:	Day Pitney	Drilling Co.:	Geosearch	Boring Diameter:	5"
Site Name:	Hingham Mutual	Drill Method:	Hollow Stem Auger	Total Depth of Boring:	37'
Address:	230 Beal Street	Sampler Type:	Split Spoon	Well Diam./Material:	n/a
City, State:	Hingham MA	Logged By:	Michael Hodess	Depth of Well:	n/a
Start Date:	5/5/10	Checked By:	Mitch Wiest	Screened Interval:	n/a
End Date:	5/5/10	Draft/Final:	Final	Screen Slot Size:	n/a

Boring/Well ID: B1

Initial Water Depth:	n/a
Static Water Depth:	n/a
Measuring Point Elev.:	n/a
Ground Surface Elev.:	n/a
Stick-up/Flush-mount:	n/a

Soil Description

Color PRIMARY UNIT, % Minor Unit(s); Inclusions (coal ash, bedrock frags., organics, etc.); Misc. Features (layers, seams, parting); Environmental observations (staining, odor, etc.); Moisture.

Relative Percentages
"and" = 35 to 50%
"some" = 12 to 35%
"little" = 5 to 12%
"trace" = 0 to 5%

Roll Test for fine grained soils:
- If sample breaks easily it contains little clay (=SILT)
- If it can be rolled into a thread of 1/8" in diameter without breaking, it contains clay (=SILT/CLAY)
- If the thread can be rolled and re-rolled it likely contains mostly clay (=CLAY).

[additional comments in brackets: e.g. driller's comments, sample ID, perched water table, etc]

Depth (feet)	Sample Interval	Blow Counts	Recovery Length (feet)	OVM/PID (ppm)	Soil Description	USCS Classification	Boring/Well Completion Details
0–2		Hand-Dug	n/a	4.2	Light Brown MEDIUM TO COARSE SAND, little gravel; Dry (0–12)	SP	
2–4		12, 8, 7, 16	1	0.7			
4–6		3, 4, 12, 21	1.5	0.9			
6–8		31, 20, 13, 13	1.5	0.7			
8–10		3, 4, 6, 5	1.75	0			
10–12		3, 4, 4, 5	1.7	4.4			
12–14		8, 6, 7, 12	1.5	5.8	Light Brown FINE TO MEDIUM SAND; Dry (12–14.5)	SP	
14–16		5, 7, 9, 10	1.5	0.9	Dark Brown FINE TO MEDIUM SAND; Dry (14.5–15); Light Brown VERY FINE TO FINE SAND, Little silt; 2-4" layering; Dry (15–20)	SP; SM	
16–18		14, 12, 15, 15	1.5	0.9			
18–20		7, 9, 9, 10	1.5	1.6			

Notes:

Well Construction Details

Casing | Sand Pack | Grout | Native Fill | Screen | Bentonite | Concrete | Bedrock

Client: Day Pitney | Site Name: Hingham Mutual | City, State: Hingham MA | **Boring/Well ID: B1**

Soil Description

Color PRIMARY UNIT, % Minor Unit(s); Inclusions (coal ash, bedrock frags., organics, etc.); Misc. Features (layers, seams, parting); Environmental observations (staining, odor, etc.); Moisture.

Relative Percentages
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[additional comments in brackets: e.g. driller's comments, sample ID, perched water table, etc]

Depth (feet)	Sample Interval (feet)	Blow Counts	Recovery Length (feet)	OVM/PID (ppm)	Soil Description	USCS Classification	Boring/Well Completion Details	Depth (feet)
20		6, 8, 7, 8	1.5	0.7	Light Brown VERY FINE TO FINE SAND, Little silt; 2-4" layering; Dry	SM		20
21					Light Brown VERY FINE SAND,; Dry	SP		21
					Light Brown VERY FINE SAND, Some silt;; Dry	SP		
22					No Sample Collected. Auger Only.			22
25		5, 10, 23, 15	1.5	0.5	Light Brown FINE TO MEDIUM SAND, Little silt and clay; Damp	SP		25
27					No Sample Collected. Auger Only.			27
30		4, 4, 7, 8	1.5	0.7	Light Brown FINE TO MEDIUM SAND; Moist	SP		30
32					No Sample Collected. Auger Only.			32
35		5, 7, 8, 8	1.5	0.5	Light Brown FINE TO MEDIUM SAND; Saturated	SP		35
37								37
40								40

Notes:

Well Construction Details

Casing | Sand Pack | Grout | Native Fill
Screen | Bentonite | Concrete | Bedrock

ROUX ASSOCIATES, INC. **BORING/ WELL LOG**

Client:	Day Pitney	Drilling Co.:	Geosearch	Boring Diameter:	5"
Site Name:	Hingham Mutual	Drill Method:	Hollow Stem Auger	Total Depth of Boring:	42'
Address:	230 Beal Street	Sampler Type:	Split Spoon	Well Diam./Material:	n/a
City, State:	Hingham MA	Logged By:	Michael Hodess	Depth of Well:	n/a
Start Date:	5/5/10	Checked By:	Mitch Wiest	Screened Interval:	n/a
End Date:	5/5/10	Draft/Final:	Final	Screen Slot Size:	n/a

Boring/Well ID: B2

Initial Water Depth:	n/a
Static Water Depth:	n/a
Measuring Point Elev.:	n/a
Ground Surface Elev.:	n/a
Stick-up/Flush-mount:	n/a

Soil Description

Color PRIMARY UNIT, % Minor Unit(s); Inclusions (coal ash, bedrock frags., organics, etc.); Misc. Features (layers, seams, parting); Environmental observations (staining, odor, etc.); Moisture.

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[additional comments in brackets: e.g. driller's comments, sample ID, perched water table, etc]

Depth (feet)	Sample Interval	Blow Counts	Recovery Length (feet)	OVM/PID (ppm)	Soil Description	USCS Classification	Boring/Well Completion Details
0-2		Hand-Dug	n/a	--	Light Brown MEDIUM TO COARSE SAND, some gravel; dry (0-11)	SP	
2-4		6, 7, 5, 5	1.5	0.4			
4-6		2, 3, 8, 8	1.5	0.3			
6-8		8, 9, 9, 13	1.75	--			
8-10		4, 5, 6, 8	1.5	0.4			
10-12		4, 5, 7, 13	1.25	0.4	Light Brown FINE SAND, some Silt, little clay; dry (11-14.5)	SP	
12-14		15, 13, 10, 10	1.5	0.8			
14-16		5, 6, 8, 9	1.5	1.7	Light Brown FINE TO MEDIUM SAND; dry (14.5-16.25)	SP	
16-18		7, 11, 10, 10	1.5	1.4	Light Brown FINE SAND, some Silt, 2"-4" Layering; damp (16.25-20)	SM	
18-20		3, 4, 8, 6	1.5	0.8			

Notes:

Well Construction Details

Casing, Sand Pack, Grout, Native Fill, Screen, Bentonite, Concrete, Bedrock

Client: Day Pitney | Site Name: Hingham Mutual | City, State: Hingham MA | **Boring/Well ID: B2**

Soil Description

Color PRIMARY UNIT, % Minor Unit(s); Inclusions (coal ash, bedrock frags., organics, etc.); Misc. Features (layers, seams, parting); Environmental observations (staining, odor, etc.); Moisture.

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[additional comments in brackets: e.g. driller's comments, sample ID, perched water table, etc]

Depth (feet)	Sample Interval (feet)	Blow Counts	Recovery Length (feet)	OVM/PID (ppm)	Soil Description	USCS Classification	Boring/Well Completion Details	Depth (feet)
20		3, 4, 9, 9	2	0.8	Light Brown FINE SAND, some Silt, 2"-4" Layering; damp	SM		20
21					Light Brown SILT and CLAY; damp	SM		21
					Light Brown FINE SAND, little Silt; damp	SP		
22		3, 4, 9, 9	2	1.1	Light Brown FINE SAND and SILT; Moist	SM		22
24					No Sample Collected. Auger Only.			24
25		4, 7, 8, 9	1.75	1.3	Light Brown FINE TO MEDIUM SAND; Moist	SP		25
27					No Sample Collected. Auger Only.			27
30		1, 2, 2, 5	1.5		Light Brown FINE SAND; Moist	SP		30
32					No Sample Collected. Auger Only.			32
35		1, 2, 2, 5	2	0.6	Light Brown VERY FINE SAND, some Clay and Silt; Saturated	SP		35
37					No Sample Collected. Auger Only.			37
40								40

Notes:

Well Construction Details

Casing | Sand Pack | Grout | Native Fill
Screen | Bentonite | Concrete | Bedrock

Client:	Day Pitney	Site Name:	Hingham Mutual	City, State:	Hingham MA	Boring/Well ID:	B2

Soil Description

Color PRIMARY UNIT, Minor Unit(s); Inclusions (coal ash, bedrock frags., organics, etc.); Misc. Features (layers, seams, parting); Environmental Observations (staining, odor, etc.); Moisture.

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- If the thread can be rolled and re-rolled it likely co

[additional comments in brackets: e.g. driller's comments, sample ID, perched water table, etc]

Depth (feet)	Sample Interval (feet)	Blow Counts	Recovery Length (feet)	OVM/PID (ppm)	Soil Description	USCS Classification	Boring/Well Completion Details	Depth (feet)
40–42		1 5 10 8	1	--	MEDIUM TO COARSE SAND AND GRAVEL; Saturated	SP		40–42
42–60								42–60

Notes:
Boriung advanced additional depth below water table due to slow ground water recharge in 35' to 37' interval.

Well Construction Details: Casing, Sand Pack, Grout, Native Fill, Screen, Bentonite, Concrete, Bedrock

Client:	Day Pitney	Drilling Co.:	Geosearch	Boring Diameter:	5"
Site Name:	Hingham Mutual	Drill Method:	Hollow Stem Auger	Total Depth of Boring:	24'
Address:	230 Beal Street	Sampler Type:	Split Spoon	Well Diam./Material:	n/a
City, State:	Hingham MA	Logged By:	Michael Hodess	Depth of Well:	n/a
Start Date:	5/6/10	Checked By:	Mitch Wiest	Screened Interval:	n/a
End Date:	5/6/10	Draft/Final:	Final	Screen Slot Size:	n/a

Boring/Well ID:	B3
Initial Water Depth:	n/a
Static Water Depth:	n/a
Measuring Point Elev.:	n/a
Ground Surface Elev.:	n/a
Stick-up/Flush-mount:	n/a

Soil Description

Color PRIMARY UNIT, % Minor Unit(s); Inclusions (coal ash, bedrock frags., organics, etc.); Misc. Features (layers, seams, parting); Environmental observations (staining, odor, etc.); Moisture.

Relative Percentages
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- If the thread can be rolled and re-rolled it likely contains mostly clay (=CLAY).

[additional comments in brackets: e.g. driller's comments, sample ID, perched water table, etc]

Depth (feet)	Sample Interval	Blow Counts	Recovery Length (feet)	OVM/PID (ppm)	Soil Description	USCS Classification	Boring/Well Completion Details	Depth (feet)
0–2		Hand-Dug	n/a	--	Light Brown MEDIUM TO COARSE SAND, some gravel; dry	SP		
2–4		6, 10, 12, 10	1.5	0.4				
4–6		2, 3, 2, 2	1.5	0.3				
6–8		2, 3, 4, 5	1.5	--				
8–10		3, 5, 2, 1	1.75	0.4				
10–12		2, 1, 1, 5	1.5	0.4				
12–14		5, 10, 10, 7	1.5	0.8				
14–16		1, 3, 3, 4	1.25	1.7	Light Brown MEDIUM TO COARSE SAND, some gravel; damp	SP		
16–18		6, 6, 10, 10	2	1.4	Light Brown MEDIUM TO COARSE SAND, some gravel; wet	SP		
18–20		2, 5, 5, 3	1.5	0.8				

Notes:

Well Construction Details

Casing | Sand Pack | Grout | Native Fill | Screen | Bentonite | Concrete | Bedrock

Client: Day Pitney | Site Name: Hingham Mutual | City, State: Hingham MA | **Boring/Well ID: B3**

Depth (feet)	Sample Interval (feet)	Blow Counts	Recovery Length (feet)	OVM/PID (ppm)	Soil Description	USCS Classification	Boring/Well Completion Details	Depth (feet)
20–22		3, 2, 2, 1	1.5	0.8	Light Brown MEDIUM TO COARSE SAND, some gravel; wet	SP		20–22
22–24		2, 6, 5, 4	2	1.1	Light Brown MEDIUM TO COARSE SAND, some gravel; wet	SP		22–24

Soil Description: Color PRIMARY UNIT, % Minor Unit(s); Inclusions (coal ash, bedrock frags., organics, etc.); Misc. Features (layers, seams, parting); Environmental observations (staining, odor, etc.); Moisture.

Relative Percentages
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- If the thread can be rolled and re-rolled it likely contains mostly clay (=CLAY).

[additional comments in brackets: e.g. driller's comments, sample ID, perched water table. etc]

Notes:

Well Construction Details

Casing | Sand Pack | Grout | Native Fill | Screen | Bentonite | Concrete | Bedrock

ROUX
ROUX ASSOCIATES, INC.
Environmental Consulting & Management

67 South Bedford Street
Suite 101 W
Burlington, MA 01803
Telephone: (781) 270-6600
Fax: (781) 270-9066

WELL CONSTRUCTION LOG

WELL NO.	NORTHING	EASTING
MW-1	Not Measured	Not Measured

PROJECT NO./NAME	LOCATION
1959.001M00 / Hingham Fire Insurance	230 Beal Street Hingham, MA

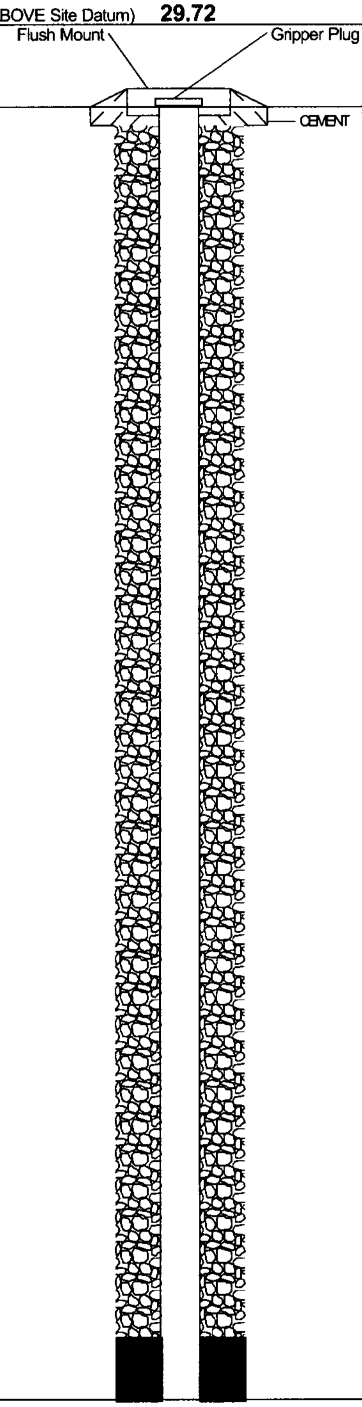
APPROVED BY	LOGGED BY
M. Wiest	M. Hodess

DRILLING CONTRACTOR/DRILLER	GEOGRAPHIC AREA
Geosearch / Geosearch	

DRILL BIT DIAMETER/TYPE	BOREHOLE DIAMETER	DRILLING EQUIPMENT/METHOD	SAMPLING METHOD	START-FINISH DATE
5-in. / Auger	5-inches	CME-75 / HSA	2" Split Spoon	5/26/10-5/26/10

CASING MAT./DIA.	SCREEN: TYPE	MAT.	TOTAL LENGTH	DIA.	SLOT SIZE
PVC / 2-inch	Slotted	PVC	10.0ft	2-inch	10-Slot

ELEVATION OF: (Feet ABOVE Site Datum)	GROUND SURFACE	TOP OF WELL CASING	TOP & BOTTOM SCREEN	SAND PACK SIZES
	29.72	29.72	0.9 / -9.1	--



Depth, feet	Graphic Log	Visual Description	Blow Counts per 6"	PID Values (ppm)	REMARKS
0				0	
5					
10					
15					
20					
25					

ROUX

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& Management

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Suite 101 W
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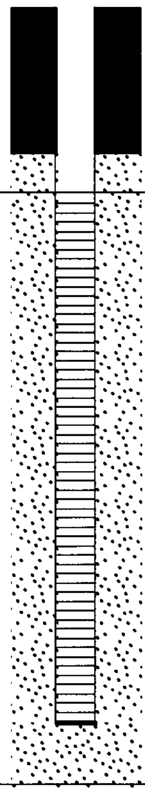
Fax: (781) 270-9066

WELL CONSTRUCTION LOG

WELL NO.	NORTHING	EASTING
MW-1	**Not Measured**	**Not Measured**
PROJECT NO./NAME **1959.001M00 / Hingham Fire Insurance**		LOCATION **230 Beal Street** **Hingham, MA**
APPROVED BY **M. Wiest**	LOGGED BY **M. Hodess**	

Depth, feet		Graphic Log	Visual Description (continued)	Blow Counts per 6"	PID Values (ppm)	REMARKS	
30							30
35							35
40							40



BORING/FEET 230 BEAL ST.GPJ ROUX.GDT 7/20/10

ROUX
ROUX ASSOCIATES, INC.
Environmental Consulting & Management

67 South Bedford Street
Suite 101 W
Burlington, MA 01803
Telephone: (781) 270-6600
Fax: (781) 270-9066

WELL CONSTRUCTION LOG

WELL NO. MW-2	NORTHING Not Measured	EASTING Not Measured		
PROJECT NO./NAME 1959.001M00 / Hingham Fire Insurance		LOCATION 230 Beal Street Hingham, MA		
APPROVED BY M. Wiest	LOGGED BY M. Hodess			
DRILLING CONTRACTOR/DRILLER Geosearch / Geosearch		GEOGRAPHIC AREA		
DRILL BIT DIAMETER/TYPE 5-in. / Auger	BOREHOLE DIAMETER 5-inches	DRILLING EQUIPMENT/METHOD CME-75 / HSA	SAMPLING METHOD 2" Split Spoon	START-FINISH DATE 5/26/10-5/27/10
CASING MAT./DIA. PVC / 2-inch	SCREEN: TYPE Slotted	MAT. PVC	TOTAL LENGTH 10.0ft DIA. 2-inch	SLOT SIZE 10-Slot
ELEVATION OF: (Feet ABOVE Site Datum)	GROUND SURFACE 29.43	TOP OF WELL CASING 29.43	TOP & BOTTOM SCREEN 0.6 / -9.4	SAND PACK SIZES --

Flush Mount | Gripper Plug | CEMENT

Depth, feet	Graphic Log	Visual Description	Blow Counts per 6"	PID Values (ppm)	REMARKS
0				0	
5					
10					
15					
20					
25					

BORING/FEET 230 BEAL ST.GPJ ROUX.GDT 7/20/10

ROUX

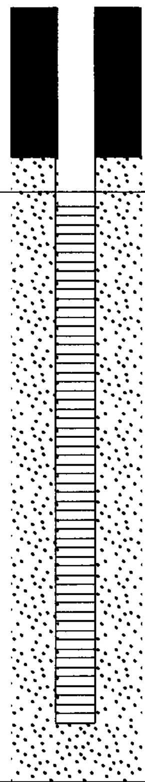
ROUX ASSOCIATES, INC.
Environmental Consulting
& Management

67 South Bedford Street
Suite 101 W
Burlington, MA 01803
Telephone: (781) 270-6600
Fax: (781) 270-9066

WELL CONSTRUCTION LOG

WELL NO.	NORTHING	EASTING
MW-2	**Not Measured**	**Not Measured**
PROJECT NO./NAME **1959.001M00 / Hingham Fire Insurance**		LOCATION **230 Beal Street**
APPROVED BY **M. Wiest**	LOGGED BY **M. Hodess**	**Hingham, MA**

Depth, feet		Graphic Log	Visual Description (continued)	Blow Counts per 6"	PID Values (ppm)	REMARKS
30						
35						
40						



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WELL CONSTRUCTION LOG

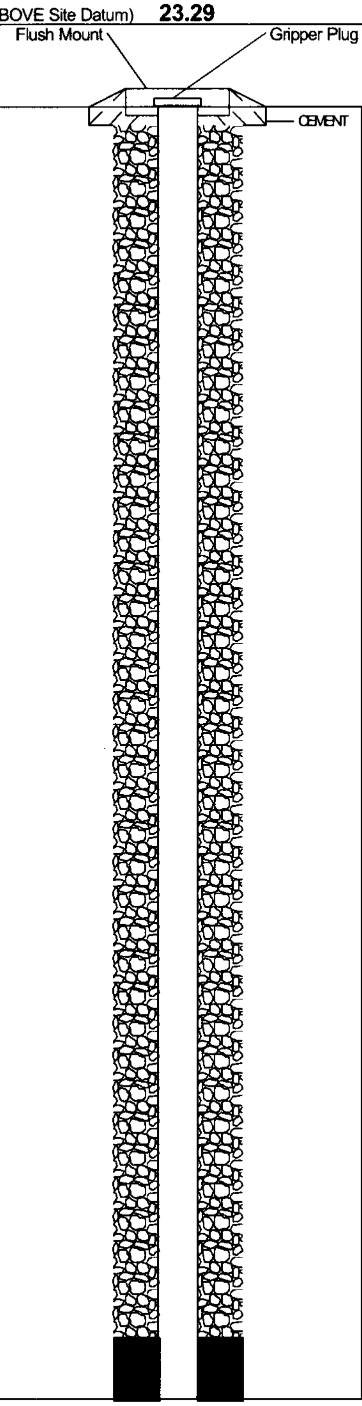
WELL NO. **MW-3**	NORTHING **Not Measured**	EASTING **Not Measured**
PROJECT NO./NAME **1959.001M00 / Hingham Fire Insurance**		LOCATION **230 Beal Street** **Hingham, MA**
APPROVED BY **M. Wiest**	LOGGED BY **M. Hodess**	
DRILLING CONTRACTOR/DRILLER **Geosearch / Geosearch**		GEOGRAPHIC AREA

DRILL BIT DIAMETER/TYPE	BOREHOLE DIAMETER	DRILLING EQUIPMENT/METHOD	SAMPLING METHOD	START-FINISH DATE
5-in. / Auger	**5-inches**	**CME-75 / HSA**	**2" Split Spoon**	**5/27/10-5/27/10**

CASING MAT./DIA. **PVC / 2-inch**
SCREEN: TYPE **Slotted** MAT. **PVC** TOTAL LENGTH **10.0**ft DIA. **2-inch** SLOT SIZE **10-Slot**

ELEVATION OF: (Feet ABOVE Site Datum)	GROUND SURFACE	TOP OF WELL CASING	TOP & BOTTOM SCREEN	SAND PACK SIZES
	23.29	**23.29**	**-5.5 / -15.5**	**--**

Depth, feet	Graphic Log	Visual Description	Blow Counts per 6"	PID Values (ppm)	REMARKS
				0	
5					
10					
15					
20					
25					



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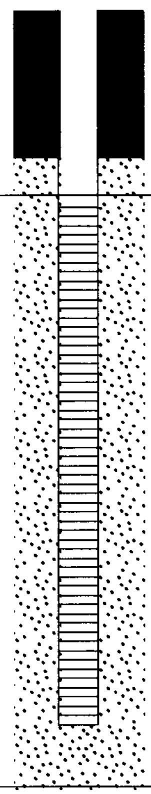
WELL CONSTRUCTION LOG

WELL NO.	NORTHING	EASTING
MW-3	**Not Measured**	**Not Measured**
PROJECT NO./NAME **1959.001M00 / Hingham Fire Insurance**		LOCATION **230 Beal Street**
APPROVED BY **M. Wiest**	LOGGED BY **M. Hodess**	**Hingham, MA**

Depth, feet		Graphic Log	Visual Description (continued)	Blow Counts per 6"	PID Values (ppm)	REMARKS
30						
35						
40						



BORING/FEET 230 BEAL ST.GPJ ROUX.GDT 7/20/10

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WELL CONSTRUCTION LOG

WELL NO.	NORTHING	EASTING
MW-4	Not Measured	Not Measured

PROJECT NO./NAME	LOCATION
1959.001M00 / Hingham Fire Insurance	230 Beal Street Hingham, MA

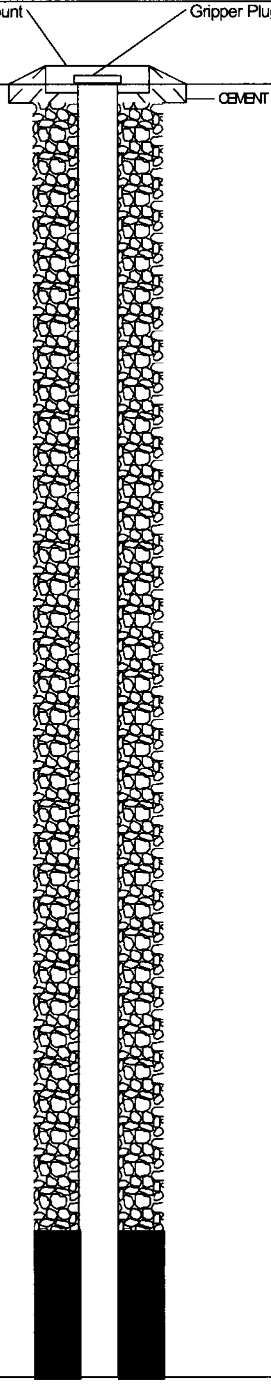
APPROVED BY	LOGGED BY
M. Wiest	M. Hodess

DRILLING CONTRACTOR/DRILLER	GEOGRAPHIC AREA
Geosearch / Geosearch	

DRILL BIT DIAMETER/TYPE	BOREHOLE DIAMETER	DRILLING EQUIPMENT/METHOD	SAMPLING METHOD	START-FINISH DATE
5-in. / Auger	5-inches	CME-75 / HSA	2" Split Spoon	5/26/10-5/26/10

CASING MAT./DIA.: PVC / 2-inch
SCREEN: TYPE Slotted MAT. PVC TOTAL LENGTH 10.0ft DIA. 2-inch SLOT SIZE 10-Slot

ELEVATION OF: (Feet ABOVE Site Datum)	GROUND SURFACE	TOP OF WELL CASING	TOP & BOTTOM SCREEN	SAND PACK SIZES
	26.04	26.04	-1.1 / -11.1	--



Depth, feet | Graphic Log | Visual Description | Blow Counts per 6" | PID Values (ppm) | REMARKS

Visual Description

- light brown MEDIUM SAND; dry
- light brown FINE TO MEDIUM SAND, some gravel; dry
- light brown FINE TO MEDIUM SAND, little silt; dry
- light brown FINE TO MEDIUM SAND, some silt; dry
- light brown FINE SAND; dry
- light brown FINE SAND, some silt; dry
- light brown FINE TO MEDIUM SAND, some gravel; dry
- light brown FINE SAND AND SILT; dry
- light brown SILT, some sand; dry
- light brown FINE TO MEDIUM SAND; dry

Blow Counts per 6"	PID Values (ppm)
5, 8, 6, 8	.1
3, 2, 3, 4	0
5, 7, 6, 7	0
2, 6, 9, 7	0
2, 4, 5, 6	0
14, 8, 4, 6	0
10, 15, 13, 12	0
19, 18, 21, 19	0
9, 14, 13, 17	0
15, 13, 12, 17	0

Depth scale: 5, 10, 15, 20, 25

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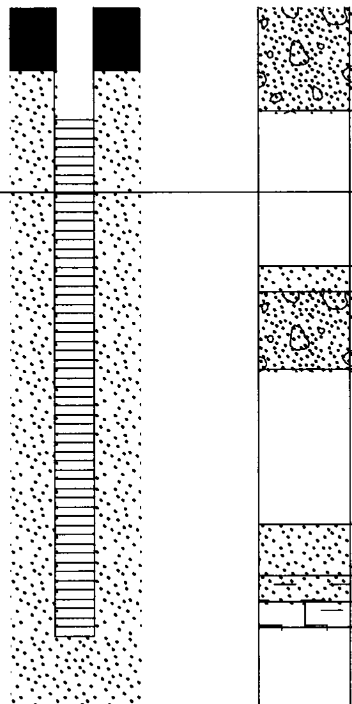
WELL CONSTRUCTION LOG

WELL NO.	NORTHING	EASTING
MW-4	**Not Measured**	**Not Measured**
PROJECT NO./NAME **1959.001M00 / Hingham Fire Insurance**		LOCATION **230 Beal Street**
APPROVED BY **M. Wiest**	LOGGED BY **M. Hodess**	**Hingham, MA**



Depth, feet	Visual Description (continued)	Blow Counts per 6"	PID Values (ppm)	REMARKS
	light brown FINE TO COARSE SAND AND GRAVEL; damp	10 18 28 20	0	
30	light brown MEDIUM TO COARSE SAND; damp light brown COARSE SAND AND GRAVEL; moist	6 15 33 50	0	
35	light brown FINE TO MEDIUM SAND; wet light brown FINE SAND AND SILT; wet light brown COARSE GRAVEL, little silt; wet	1 5 22 26	0	
40				

HALEY ALDRICH — TEST BORING REPORT

Boring No. HA16-1 (OW)

Project	230 BEAL STREET, HINGHAM, MA	File No.	42837-003
Client	ALLIANCE RESIDENTIAL COMPANY NEW ENGLAND	Sheet No.	1 of 2
Contractor	NORTHERN DRILL SERVICE, INC.	Start	12 January 2016
		Finish	13 January 2016
		Driller	C. Beirholm
		H&A Rep.	S. Shay
		Elevation	25.0 (est.)
		Datum	NAVD 88
		Location	See Plan

	Casing	Sampler	Barrel	Drilling Equipment and Procedures
Type	HW	S	-	Rig Make & Model: Mobile Drill B-59 on Truck
Inside Diameter (in.)	4	1 3/8	-	Bit Type: Roller Bit; Drill Mud: None
Hammer Weight (lb)	300	140	-	Casing: HW Driven 34.0'
Hammer Fall (in.)	24	30	-	Hoist/Hammer: Cat-Head Automatic Hammer; PID Make & Model: MiniRAE 2000 10.6 eV

Depth (ft)	Sampler Blows per 6 in.	Sample No. & Rec. (in.)	Sample Depth (ft)	PID Readings (ppm) (sample/bkgd)	USCS Symbol	Well Diagram	Stratum Change Elev/Depth (ft)	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Density/consistency, color, GROUP NAME, max. particle size†, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines
0					SM		24.0 1.0	Dark brown silty SAND (SM) Note: Push 3-in. spoon to 1.0 ft to prepare borehole for environmental composite. -TOPSOIL/FILL-					70	30
	20 19 10 6	S1* 10	1.0 3.0	-	SP		22.0 3.0	Dense brown poorly graded SAND (SP), mps 5 cm, no structure, no odor, dry Note: * denotes 3-in. spoon. -FILL-	5	5	15	15	60	
	4 6 7 10	S2 16	3.0 5.0	0.0	SP			Medium dense olive brown poorly graded SAND (SP), mps 3 mm, weak stratification, no odor, moist			10	40	55	5
5								-GLACIOFLUVIAL DEPOSITS-						
10	6 6 8 13	S3 14	9.0 11.0	0.0	SP			Medium dense olive brown poorly graded SAND (SP), mps 8 mm, weak stratification, no odor, moist		5	15	40	40	
15	6 7 10 11	S4 15	14.0 16.0	0.0	SP		7.0 18.0	Similar to above		5	15	45	35	
20	5 4	S5 1	19.0 21.0	0.0	GW			Loose olive brown well-graded GRAVEL (GW) Note: Poor recovery.	50	50				

Water Level Data

Date	Time	Elapsed Time (hr.)	Depth (ft) to: Bottom of Casing	Bottom of Hole	Water
1/13/16	1115	none	34.0	36.0	25.2

Sample ID
- O - Open End Rod
- T - Thin Wall Tube
- U - Undisturbed Sample
- S - Split Spoon Sample

Well Diagram
- Riser Pipe
- Screen
- Filter Sand
- Cuttings
- Grout
- Concrete
- Bentonite Seal

Summary

Overburden (ft)	36.0
Rock Cored (ft)	-
Samples	8S

Boring No. HA16-1 (OW)

Field Tests: **Dilatancy**: R - Rapid S - Slow N - None **Toughness**: L - Low M - Medium H - High **Plasticity**: N - Nonplastic L - Low M - Medium H - High **Dry Strength**: N - None L - Low M - Medium H - High V - Very High

†Note: Maximum particle size is determined by direct observation within the limitations of sampler size.

Note: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

TEST BORING REPORT

HALEY ALDRICH

Boring No. HA16-1 (OW)
File No. 42837-003

Depth (ft)	Sampler Blows per 6 in.	Sample No. & Rec. (in.)	Sample Depth (ft)	PID Readings (ppm) (sample/bkgd)	USCS Symbol	Well Diagram	Stratum Change Elev/Depth (ft)	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Density/consistency, color, GROUP NAME, max. particle size†, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines
20	5 5													
							3.0 22.0							
25	3 5 11 10	S6 15	24.0 26.0	0.2	SM/ ML			Medium dense olive brown silty SAND and sandy SILT (SM/ML), mps 4 mm, interbedded, no odor, wet			10	15	20	55
								-GLACIOFLUVIAL DEPOSITS-						
30	7 13 15 12	S7 12	29.0 31.0	0.3	SP			Medium dense olive brown poorly graded SAND (SP), mps 4 mm, single-grain structure, no odor, wet Note: No recovery first attempt. Recovery from 3-in. spoon sample 29 to 31 ft.			10	45	45	
							-7.0 32.0	-MARINE DEPOSITS-						
35	6 7 6 8	S8 20	34.0 36.0	0.0	CL			Stiff olive gray lean CLAY with sand (CL), mps < 0.5 mm, frequent partings, no odor, wet					20	80
							-11.0 36.0	BOTTOM OF EXPLORATION 36.0 FT						

NOTE: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

TEST BORING REPORT

HALEY ALDRICH

Boring No. HA16-2

Project	230 BEAL STREET, HINGHAM, MA	File No.	42837-003
Client	ALLIANCE RESIDENTIAL COMPANY NEW ENGLAND	Sheet No.	1 of 1
Contractor	NORTHERN DRILL SERVICE, INC.	Start	13 January 2016
		Finish	13 January 2016
		Driller	C. Beirholm
		H&A Rep.	S. Shay
		Elevation	22.0 (est.)
		Datum	NAVD 88
		Location	See Plan

	Casing	Sampler	Barrel
Type	HW	S	-
Inside Diameter (in.)	4	1 3/8	-
Hammer Weight (lb)	300	140	-
Hammer Fall (in.)	24	30	-

Drilling Equipment and Procedures

Rig Make & Model: Mobile Drill B-59 on Truck
Bit Type: Roller Bit
Drill Mud: None
Casing: HW Driven 14.0'
Hoist/Hammer: Cat-Head Automatic Hammer
PID Make & Model: MiniRAE 2000 10.6 eV

Depth (ft)	Sampler Blows per 6 in.	Sample No. & Rec. (in.)	Sample Depth (ft)	PID Readings (ppm) (sample/bkgd)	USCS Symbol	Stratum Change Elev/Depth (ft)	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Density/consistency, color, GROUP NAME, max. particle size†, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines
0	6 7	S1 10	0.0 1.0	0.9	SM		S1: Medium dense dark brown silty SAND with gravel (SM), mps 2.8 cm, no structure, no odor, moist	5	10	10	10	30	35
						21.0 1.0	-FILL-						
	8 12	S1A 10	1.0 2.0	0.2	SP		S1A: Medium dense olive brown poorly graded SAND (SP), mps 6 mm as trace gravel, weak stratification, no structure, no odor, moist			15	15	65	5
5	3 5 6 7	S2 14	4.0 6.0	0.0	SW		Medium dense olive brown well-graded SAND (SW), mps 0.9 cm, single-grain structure, no odor, moist		5	30	30	35	
							-GLACIOFLUVIAL DEPOSITS-						
10	4 5 6 10	S3 9	9.0 11.0	0.0	SP		Similar to above, except mps 1.5 cm		5	30	30	35	
15	4 5 6 6	S4 10	14.0 16.0	0.0	SP		Similar to above		5	30	30	35	
						6.0 16.0	BOTTOM OF EXPLORATION 16.0 FT						

Water Level Data

Date	Time	Elapsed Time (hr.)	Depth (ft) to: Bottom of Casing	Bottom of Hole	Water
1/13/16	1400	none*	14.0	16.0	No water
		*Upon completion			

Sample ID
O - Open End Rod
T - Thin Wall Tube
U - Undisturbed Sample
S - Split Spoon Sample

Well Diagram
Riser Pipe
Screen
Filter Sand
Cuttings
Grout
Concrete
Bentonite Seal

Summary
Overburden (ft) 16.0
Rock Cored (ft) -
Samples 4S

Boring No. HA16-2

Field Tests: **Dilatancy**: R - Rapid S - Slow N - None **Toughness**: L - Low M - Medium H - High **Plasticity**: N - Nonplastic L - Low M - Medium H - High **Dry Strength**: N - None L - Low M - Medium H - High V - Very High

†**Note: Maximum particle size is determined by direct observation within the limitations of sampler size.**

Note: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

HALEY ALDRICH

TEST BORING REPORT

Boring No. HA16-3 (OW)

Project	230 BEAL STREET, HINGHAM, MA	File No.	42837-003
Client	ALLIANCE RESIDENTIAL COMPANY NEW ENGLAND	Sheet No.	1 of 2
Contractor	NORTHERN DRILL SERVICE, INC.	Start	11 January 2016
		Finish	12 January 2016
		Driller	C. Beirholm
		H&A Rep.	S. Shay
		Elevation	29.5 (est.)
		Datum	NAVD 88
		Location	See Plan

	Casing	Sampler	Barrel	Drilling Equipment and Procedures
Type	HW	S	-	Rig Make & Model: Mobile Drill B-59 on Truck
Inside Diameter (in.)	4	1 3/8	-	Bit Type: Roller Bit; Drill Mud: None
Hammer Weight (lb)	300	140	-	Casing: HW Driven 36.0'
Hammer Fall (in.)	24	30	-	Hoist/Hammer: Cat-Head Automatic Hammer; PID Make & Model: MiniRAE 2000 10.6 eV

Depth (ft)	Sampler Blows per 6 in.	Sample No. & Rec. (in.)	Sample Depth (ft)	PID Readings (ppm) (sample/bkgd)	USCS Symbol	Stratum Change Elev/Depth (ft)	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Density/consistency, color, GROUP NAME, max. particle size†, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines
0					SM		Dark brown silty SAND (SM) Note: Push 3-in. spoon to 1.0 ft to prepare borehole for environmental composite.						
						28.5 / 1.0	-TOPSOIL/FILL-						
	14 42 53 25	S1* 10	1.0 3.0	0.5	SP		S1: Very dense brown poorly graded SAND with gravel (SP), mps 6.5 cm as 20% cobble, no structure, no odor, moist, trace plastic shards Note: *Denotes 3 in. spoon used for sample.						
	11 6 8 6	S2 10	3.0 5.0	0.6	SP		S2: Medium dense brown poorly graded SAND with gravel (SP), mps 2.5 cm, no structure, no odor, moist, appears to be disturbed -FILL-						
5	9 8 12 12	S3 16	5.0 7.0	0.3	SP		Similar to above, top 10 in.						
					SP	23.0 / 6.5	Note: Bottom of fill determined based on appearance of stratification in bottom 6 in. of S3.						
						21.5 / 8.0							
10	7 10 12 15	S4 13	9.0 11.0	1 3	SP-SM		Medium dense poorly graded SAND with silt (SP-SM), mps 1 mm, frequent partings, no odor, moist				5	85	10
							-GLACIOLACUSTRINE DEPOSITS-						
15	8 8 12 14	S5 15	14.0 16.0	0.6	SM/ML		Medium dense olive brown silty SAND and sandy SILT (SM/ML), mps 0.5 mm, interbedded, no odor, moist					50	50
20	7 12	S6 18	19.0 21.0	0.8	SM/ML		Similar to above, including interbedding					50	50

Water Level Data

Date	Time	Elapsed Time (hr.)	Depth (ft) to: Bottom of Casing	Bottom of Hole	Water
1/14/16	1029	2 days			28.5*

*Well installed, inital reading

Sample ID
O - Open End Rod
T - Thin Wall Tube
U - Undisturbed Sample
S - Split Spoon Sample

Well Diagram
Riser Pipe
Screen
Filter Sand
Cuttings
Grout
Concrete
Bentonite Seal

Summary
Overburden (ft) 36.5
Rock Cored (ft) -
Samples 9S

Boring No. HA16-3 (OW)

Field Tests: **Dilatancy**: R - Rapid S - Slow N - None **Toughness**: L - Low M - Medium H - High **Plasticity**: N - Nonplastic L - Low M - Medium H - High **Dry Strength**: N - None L - Low M - Medium H - High V - Very High

†Note: Maximum particle size is determined by direct observation within the limitations of sampler size.

Note: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

HALEY ALDRICH

TEST BORING REPORT

Boring No. HA16-3 (OW)
File No. 42837-003

Depth (ft)	Sampler Blows per 6 in.	Sample No. & Rec. (in.)	Sample Depth (ft)	PID Readings (ppm) (sample/bkgd)	USCS Symbol	Well Diagram	Stratum Change Elev/Depth (ft)	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Density/consistency, color, GROUP NAME, max. particle size†, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines
20	15 17													
25	11 9 17 17	S7 18	24.0 26.0	0.5	SM			Medium dense olive brown silty SAND (SM), mps 0.5 mm, frequent partings, no odor, wet					75	25
								-GLACIOLACUSTRINE DEPOSITS-						
30	7 7 12 11	S8 20	29.0 31.0	0.1	SM			Medium dense olive brown silty SAND (SM), mps 0.5 mm, frequent partings, and dilatant seams, no odor, wet					60	40
35	9 12 13 20	S9 6	34.0 36.0		SM			Medium dense olive brown silty SAND with gravel (SM), mps 2.8 cm, no structure, no odor, wet Note: Advanced borehole with roller bit to 36.5 ft.	10	5			50	35
							-7.0 36.5	BOTTOM OF EXPLORATION 36.5 FT						

NOTE: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

Boring No. HA16-3 (OW)

HALEY ALDRICH

TEST BORING REPORT

Boring No. HA16-4 (OW)

Project	230 BEAL STREET, HINGHAM, MA	File No.	42837-003
Client	ALLIANCE RESIDENTIAL COMPANY NEW ENGLAND	Sheet No.	1 of 2
Contractor	NORTHERN DRILL SERVICE, INC.	Start	11 January 2016
		Finish	11 January 2016
		Driller	C. Beirholm
		H&A Rep.	S. Shay
		Elevation	30.5 (est.)
		Datum	NAVD 88
		Location	See Plan

	Casing	Sampler	Barrel	Drilling Equipment and Procedures
Type	HW	S	-	Rig Make & Model: Mobile Drill B-59 on Truck
Inside Diameter (in.)	4	1 3/8	-	Bit Type: Roller Bit; Drill Mud: None
Hammer Weight (lb)	300	140	-	Casing: HW Driven 34.0'
Hammer Fall (in.)	24	30	-	Hoist/Hammer: Cat-Head Automatic Hammer; PID Make & Model: MiniRAE 2000 10.6 eV

Depth (ft)	Sampler Blows per 6 in.	Sample No. & Rec. (in.)	Sample Depth (ft)	PID Readings (ppm) (sample/bkgd)	USCS Symbol	Well Diagram	Stratum Change Elev/Depth (ft)	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Density/consistency, color, GROUP NAME, max. particle size†, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines
0							30.2 / 0.3	-ASPHALT-						
	12 6 4 4	S1 14	0.5 2.5	0.5	SP			S1, top 7 in.: Medium dense gray-brown poorly graded SAND with gravel (SP), mps 8 mm, no structure, no odor, wet from drilling -FILL-		15	20	35	25	5
				0.2	SM		28.5 / 2.0	S1, bottom 7 in.: Loose brown poorly graded SAND (SP), mps 3 mm, no structure, no odor, moist			10	15	70	5
							27.5 / 3.0	Note: Dark brown silty SAND in spoon tip.					60	40
5	5 8 8 9	S2 16	4.0 6.0	1.0	SP			S2: Medium dense olive brown poorly graded SAND (SP), mps 1 cm as trace gravel, no structure, no odor, moist -FILL-				70	25	5
					SP		25.0 / 5.5	Note: 5.5 to 6.0 ft stratification present with change in sand components.				30	70	
							23.0 / 7.5							
10	4 6 6 5	S3 16	9.0 11.0	0.2	SW			Medium dense olive brown well-graded SAND (SP), mps 1.5 cm, weak stratification, single-grain structure, no odor, wet from drilling -GLACIOFLUVIAL DEPOSITS-		10	30	30	30	
							18.0 / 12.5							
15	8 7 10 13	S4 13	14.0 16.0	0.4	SP			Medium dense olive brown poorly graded SAND (SP), mps 2 cm as rounded gravel, weak stratification, single-grain structure, no odor, wet from drilling	5	5	15	50	25	
							13.0 / 17.5	-GLACIOFLUVIAL DEPOSITS-						
20	6 8	S5 18	19.0 21.0	1.0	SW			Medium dense olive brown well-graded SAND (SW), mps 3 cm, stratified, sorted single-grain layers, no structure, no odor, wet from drilling	5	5	30	30	30	

Water Level Data

Date	Time	Elapsed Time (hr.)	Depth (ft) to: Bottom of Casing	Bottom of Hole	Water
1/11/16	1120	none	29.0	31.0	No water
1/11/16	1230	0.5	34.0	36.0	29.3

Sample ID
- O - Open End Rod
- T - Thin Wall Tube
- U - Undisturbed Sample
- S - Split Spoon Sample

Well Diagram
- Riser Pipe
- Screen
- Filter Sand
- Cuttings
- Grout
- Concrete
- Bentonite Seal

Summary

Overburden (ft)	36.0
Rock Cored (ft)	-
Samples	8S
Boring No.	HA16-4 (OW)

Field Tests: **Dilatancy**: R - Rapid S - Slow N - None **Toughness**: L - Low M - Medium H - High **Plasticity**: N - Nonplastic L - Low M - Medium H - High **Dry Strength**: N - None L - Low M - Medium H - High V - Very High

†**Note: Maximum particle size is determined by direct observation within the limitations of sampler size.**

Note: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

HALEY ALDRICH	TEST BORING REPORT	Boring No. HA16-4 (OW)
		File No. 42837-003
		Sheet No. 2 of 2

Depth (ft)	Sampler Blows per 6 in.	Sample No. & Rec. (in.)	Sample Depth (ft)	PID Readings (ppm) (sample/bkgd)	USCS Symbol	Well Diagram	Stratum Change Elev/Depth (ft)	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Density/consistency, color, GROUP NAME, max. particle size†, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines
20	13 39													
								-GLACIOFLUVIAL DEPOSITS-						
25	12 12 15 20	S6 16	24.0 26.0	0.2	SW			Similar to above, including sorting, wet from drilling only	5	5	30	30	30	
							3.0 27.5							
30	7 7 8 9	S7 9	29.0 31.0	0.2	GP			Medium dense olive brown poorly graded GRAVEL with sand (GP), mps 2.5 cm, stratified, interbedded, sand/gravel, no odor, wet -GLACIOFLUVIAL DEPOSITS-	10	40	15	15	20	
							-2.0 32.5							
35	12 11 17 18	S8 10	34.0 36.0	1.9	SW			Medium dense olive brown well-graded SAND with gravel (SW), mps 3.4 cm, stratified, no odor, wet	5	5	30	30	30	
							-5.5 36.0	BOTTOM OF EXPLORATION 36.0 FT						

TEST BORING REPORT

HALEY ALDRICH

Boring No. HA16-5

Project	230 BEAL STREET, HINGHAM, MA	File No.	42837-003
Client	ALLIANCE RESIDENTIAL COMPANY NEW ENGLAND	Sheet No.	1 of 1
Contractor	NORTHERN DRILL SERVICE, INC.	Start	8 January 2016
		Finish	8 January 2016
		Driller	C. Beirholm
		H&A Rep.	S. Shay
		Elevation	30.5 (est.)
		Datum	NAVD 88
		Location	See Plan

	Casing	Sampler	Barrel	Drilling Equipment and Procedures
Type	HW	S	-	Rig Make & Model: Mobile Drill B-59 on Truck
Inside Diameter (in.)	4	1 3/8	-	Bit Type: Roller Bit Drill Mud: None
Hammer Weight (lb)	300	140	-	Casing: HW Driven 14.0'
Hammer Fall (in.)	24	30	-	Hoist/Hammer: Cat-Head Automatic Hammer PID Make & Model: MiniRAE 2000 10.6 eV

Depth (ft)	Sampler Blows per 6 in.	Sample No. & Rec. (in.)	Sample Depth (ft)	PID Readings (ppm) (sample/bkgd)	USCS Symbol	Stratum Change Elev/Depth (ft)	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Density/consistency, color, GROUP NAME, max. particle size†, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines
0						30.2 0.3	-ASPHALT-						
	9 12 18 20	S1 12	0.5 2.5	0.8	SP		Medium dense brown poorly graded SAND with gravel (SP), mps 3.2 cm, no structure, no odor, moist	5	10	20	25	35	5
							-FILL-						
5	6 9 11 13	S2 6	4.0 6.0	0.0	SP		Medium dense olive brown poorly graded SAND (SP), mps 5 mm, no structure, no odor, wet from drilling, appears to be disturbed		10	15	25	45	5
						23.5 7.0	Note: Abrupt change in effort to advance casing at 7.0 ft.						
	13 16 17 14	S3 15	8.0 10.0	0.1	SP		Dense brown poorly graded SAND (SP), mps 4 mm, no structure, no odor, wet Note: No recovery first attempt, used 3-in. diameter spoon 8.0 to 10.0 ft for recovery.			15	20	60	5
10							-GLACIOFLUVIAL DEPOSITS-						
15	7 8 8 11	S4 9	14.0 16.0	0.1	SP		Medium dense brown poorly graded SAND (SP), mps 3 mm, moderately well-stratified, no odor, wet			20	40	40	
						14.5 16.0	BOTTOM OF EXPLORATION 16.0 FT Note: Planned well was not installed.						

Water Level Data

Date	Time	Elapsed Time (hr.)	Depth (ft) to: Bottom of Casing	Bottom of Hole	Water
1/8/16	1030	0.5	pulled only	16.0	No water

Sample ID

- O - Open End Rod
- T - Thin Wall Tube
- U - Undisturbed Sample
- S - Split Spoon Sample

Well Diagram

- Riser Pipe
- Screen
- Filter Sand
- Cuttings
- Grout
- Concrete
- Bentonite Seal

Summary

Overburden (ft)	16.0
Rock Cored (ft)	-
Samples	4S

Boring No. HA16-5

Field Tests: **Dilatancy**: R - Rapid S - Slow N - None **Plasticity**: N - Nonplastic L - Low M - Medium H - High
Toughness: L - Low M - Medium H - High **Dry Strength**: N - None L - Low M - Medium H - High V - Very High

†Note: Maximum particle size is determined by direct observation within the limitations of sampler size.

Note: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

HALEY ALDRICH

TEST BORING REPORT

Boring No. HA16-6

Project	230 BEAL STREET, HINGHAM, MA	File No.	42837-003
Client	ALLIANCE RESIDENTIAL COMPANY NEW ENGLAND	Sheet No.	1 of 1
Contractor	NORTHERN DRILL SERVICE, INC.	Start	8 January 2016
		Finish	8 January 2016
		Driller	C. Beirholm
		H&A Rep.	S. Shay
		Elevation	20.5 (est.)
		Datum	NAVD 88
		Location	See Plan

	Casing	Sampler	Barrel
Type	HW	S	-
Inside Diameter (in.)	4	1 3/8	-
Hammer Weight (lb)	300	140	-
Hammer Fall (in.)	24	30	-

Drilling Equipment and Procedures

Rig Make & Model: Mobile Drill B-59 on Truck
Bit Type: Roller Bit
Drill Mud: None
Casing: HW Driven 14.0'
Hoist/Hammer: Cat-Head Automatic Hammer
PID Make & Model: MiniRAE 2000 10.6 eV

Depth (ft)	Sampler Blows per 6 in.	Sample No. & Rec. (in.)	Sample Depth (ft)	PID Readings (ppm) (sample/bkgd)	USCS Symbol	Stratum Change Elev/Depth (ft)	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Density/consistency, color, GROUP NAME, max. particle size†, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines
0				0.1	SM		Dark brown silty SAND (SM) Note: Push 3-in. spoon to 1.0 ft to prepare borehole for environmental composite. -TOPSOIL/FILL-					70	30
	11 16 16 11	S1* 15	1.0 3.0	0.5	SP	19.5 1.0	S1: Dense brown poorly graded SAND with gravel (SP), mps 5 cm, no structure, no odor, moist Note: *Denotes 3 in. spoon used for sample.	5	10	10	15	60	
	7 10 10 9	S2 8	3.0 5.0	0.1	SP		S2: Medium dense brown poorly graded SAND with gravel (SP), mps 2.5 cm, no structure, no odor, moist -FILL-	5	10	15	15	55	
5						13.0 7.5							
10	5 6 6 7	S3 10	9.0 11.0	0.0	GP		Medium dense gray-brown poorly graded GRAVEL with sand (GP), mps 2.5 cm, no structure, no odor, wet from drilling -GLACIOFLUVIAL DEPOSITS-	25	50	10	10	5	
15	9 7 7 9	S4 6	14.0 16.0	0.0	GP	4.5 16.0	Similar to above	30	55	10	5		
							BOTTOM OF EXPLORATION 16.0 FT						

Water Level Data

Date	Time	Elapsed Time (hr.)	Depth (ft) to: Bottom of Casing	Bottom of Hole	Water
1/11/16	0410	64	14.0	16.0	No water

1/8/16 Casing was left in gravel over weekend

Sample ID
O - Open End Rod
T - Thin Wall Tube
U - Undisturbed Sample
S - Split Spoon Sample

Well Diagram
Riser Pipe
Screen
Filter Sand
Cuttings
Grout
Concrete
Bentonite Seal

Summary
Overburden (ft) 16.0
Rock Cored (ft) -
Samples 4S

Boring No. HA16-6

Field Tests:
Dilatancy: R - Rapid S - Slow N - None
Toughness: L - Low M - Medium H - High
Plasticity: N - Nonplastic L - Low M - Medium H - High
Dry Strength: N - None L - Low M - Medium H - High V - Very High

†**Note: Maximum particle size is determined by direct observation within the limitations of sampler size.**

Note: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

GROUNDWATER MONITORING REPORT

HALEY ALDRICH

HA16-1(OW)

Page of

PROJECT	230 BEAL STREET	**H&A FILE NO.**	42837-003
LOCATION	HINGHAM, MASSACHUSETTS	**PROJECT MGR.**	L. VANZLER
CLIENT	ALLIANCE RESIDENTIAL COMPANY	**FIELD REP.**	S. SHAY
CONTRACTOR	N/A	**DATE**	1/18/2016

ELEVATION OF REFERENCE POINT 27.9 NAVD88 **REFERENCE POINT:** **Ground Surface** ☐ **PVC** ☑ **Other** ☐

Date	Time	Elapsed Time (days)	Depth of Water from Reference Point	Elevation of Water	Remarks	Read By
1/20/2016	1215	0	25.1	2.8	Riser 2.9 ft above ground surface	S. Shay

GROUNDWATER MONITORING REPORT

HALEY ALDRICH

HA16-3(OW)

Page of

PROJECT	230 BEAL STREET	**H&A FILE NO.**	42837-003
LOCATION	HINGHAM, MASSACHUSETTS	**PROJECT MGR.**	L. VANZLER
CLIENT	ALLIANCE RESIDENTIAL COMPANY	**FIELD REP.**	S. SHAY
CONTRACTOR	N/A	**DATE**	1/18/2016

ELEVATION OF REFERENCE POINT 31.8 NAVD88 **REFERENCE POINT: Ground Surface** ☐ **PVC** ☑ **Other** ☐

Date	Time	Elapsed Time (days)	Depth of Water from Reference Point	Elevation of Water	Remarks	Read By
1/20/2016	958	0	30.6	1.2	Riser 2.3 ft above ground surface	S. Shay

GROUNDWATER MONITORING REPORT

HA16-4(OW)

Page **of**

PROJECT	230 BEAL STREET	**H&A FILE NO.**	42837-003
LOCATION	HINGHAM, MASSACHUSETTS	**PROJECT MGR.**	L. VANZLER
CLIENT	ALLIANCE RESIDENTIAL COMPANY	**FIELD REP.**	S. SHAY
CONTRACTOR	N/A	**DATE**	1/18/2016

ELEVATION OF REFERENCE POINT 30.5 NAVD88 **REFERENCE POINT: Ground Surface** ☐ **PVC** ☑ **Other** ☐

Date	Time	Elapsed Time (days)	Depth of Water from Reference Point	Elevation of Water	Remarks	Read By
1/18/2016	1035	0	24.0	6.5	Riser flush with ground surface	S. Shay

Form 2021

F-1. Rainfall Data for Massachusetts from *Rainfall Frequency Atlas of the United States* (TP-40)

- Users of this Handbook should note that current MA DEP written guidance (see DEP Waterlines newsletter -- Fall 2000) requires the use of TP-40 Rainfall Data for calculations under the Wetlands Protection Regulations and the Stormwater Management Policy. More stringent design storms may be used under a local bylaw or ordinance. However, DEP will continue to require the use of TP-40 in any case it reviews under the Wetlands Protection Act and Stormwater Management Policy.

Adjusted Technical Paper 40 Design Storms for 24-hour Event by County

County Name	1-yr 24-hr	2-yr 24-hr	5-yr 24-hr	10-yr 24-hr	25-yr 24-hr	50-yr 24-hr	100-yr 24-hr
Barnstable	2.5	3.6	4.5	4.8	5.7	6.4	7.1
Berkshire	2.5	2.9	3.8	4.4	5.1	5.9	6.4
Bristol	2.5	3.4	4.3	4.8	5.6	6.3	7.0
Dukes	2.5	3.6	4.6	4.9	5.8	6.5	7.2
Essex	2.5	3.1	3.9	4.5	5.4	5.9	6.5
Franklin	2.5	2.9	3.8	4.3	5.1	5.8	6.2
Hampden	2.5	3.0	4.0	4.6	5.3	6.0	6.5
Hampshire	2.5	3.0	3.9	4.5	5.2	5.9	6.4
Middlesex	2.5	3.1	4.0	4.5	5.3	5.9	6.5
Nantucket	2.5	3.6	4.6	4.9	5.8	6.5	7.2
Norfolk	2.5	3.2	4.1	4.7	5.5	6.1	6.7
Plymouth	2.5	3.4	4.3	4.7	5.6	6.2	7.0
Suffolk	2.5	3.2	4.0	4.6	5.5	6.0	6.6
Worcester	2.5	3.0	4.0	4.5	5.3	5.9	6.5

Manning's Roughness Coefficients ("n")

Conduit	Manning's Coefficients
Closed Conduits	
Asbestos-Cement Pipe	0.011 to 0.015
Brick	0.013 to 0.017
Cast Iron Pipe	
Cement-lined and seal-coated	0.011 to 0.015
Concrete (Monolithic)	
Smooth forms	0.012 to 0.014
Rough forms	0.015 to 0.017
Concrete Pipe	0.011 to 0.015
Corrugated-Metal Pipe (1/2 - STUL 34470 2 1/2-inch corrgtn.)	
Plain	0.022 to 0.026
Paved invert	0.018 to 0.022
Spun asphalt-lined	0.011 to 0.015
Plastic Pipe (Smooth)	0.011 to 0.015
Vitrified Clay	
Pipes	0.011 to 0.015
Liner channels	0.013 to 0.017
Open Channels	
Lined Channels	
Asphalt	0.013 to 0.017
Brick	0.012 to 0.018
Concrete	0.011 to 0.020
Rubble or riprap	0.020 to 0.035
Vegetal	0.030 to 0.040
Excavated or Dredged	
Earth, straight and uniform	0.020 to 0.030
Earth, winding, fairly uniform	0.025 to 0.040
Rock	0.030 to 0.045
Unmaintained	0.050 to 0.140
Natural Channels (minor streams, top width at flood state < 100 feet)	
Fairly regular section	0.030 to 0.070
Irregular section with pools	0.040 to 0.100

Source: Design and Construction of Sanitary and Storm Sewers, American Society of Civil Engineers and the Water Pollution Control Federation, 1969.

CDS ESTIMATED NET ANNUAL TSS REDUCTION
BASED ON THE RATIONAL RAINFALL METHOD

CONTECH ENGINEERED SOLUTIONS

BROADSTONE BARE COVE
HINGHAM, MA
for SYSTEM: CDS 1

Area	0.21	acres	CDS Model		
Weighted C	0.90			2015-4	
Tc	6	minutes	CDS Treatment Capacity		
				1.4	cfs

Rainfall Intensity[1] (in/hr)	**Percent Rainfall Volume[1]**	**Cumulative Rainfall Volume**	**Total Flowrate (cfs)**	**Treated Flowrate (cfs)**	**Removal Efficiency (%)**	**Incremental Removal (%)**
0.02	10.2%	10.2%	0.00	0.00	97.0	9.9
0.04	9.6%	19.8%	0.01	0.01	96.8	9.3
0.06	9.4%	29.3%	0.01	0.01	96.7	9.1
0.08	7.7%	37.0%	0.02	0.02	96.5	7.5
0.10	8.6%	45.6%	0.02	0.02	96.3	8.3
0.12	6.3%	51.9%	0.02	0.02	96.1	6.1
0.14	4.7%	56.5%	0.03	0.03	95.9	4.5
0.16	4.6%	61.2%	0.03	0.03	95.7	4.4
0.18	3.5%	64.7%	0.03	0.03	95.6	3.4
0.20	4.3%	69.1%	0.04	0.04	95.4	4.1
0.25	8.0%	77.1%	0.05	0.05	94.9	7.6
0.30	5.6%	82.7%	0.06	0.06	94.5	5.3
0.35	4.4%	87.0%	0.07	0.07	94.0	4.1
0.40	2.5%	89.5%	0.08	0.08	93.5	2.4
0.45	2.5%	92.1%	0.09	0.09	93.1	2.4
0.50	1.4%	93.5%	0.09	0.09	92.6	1.3
0.75	5.0%	98.5%	0.14	0.14	90.3	4.6
1.00	1.0%	99.5%	0.19	0.19	88.0	0.9
1.50	0.0%	99.5%	0.28	0.28	83.4	0.0
2.00	0.0%	99.5%	0.38	0.38	78.8	0.0
3.00	0.5%	100.0%	0.57	0.57	69.6	0.3
						95.3
					Removal Efficiency Adjustment[2] =	6.5%
					Predicted % Annual Rainfall Treated =	93.5%
					Predicted Net Annual Load Removal Efficiency =	**88.9%**

1 - Based on 10 years of hourly precipitation data from NCDC Station 770, Boston WSFO AP, Suffolk County, MA
2 - Reduction due to use of 60-minute data for a site that has a time of concentration less than 30-minutes.

CDS ESTIMATED NET ANNUAL TSS REDUCTION
BASED ON THE RATIONAL RAINFALL METHOD

BROADSTONE BARE COVE
HINGHAM, MA
for SYSTEM: CDS 2

Area	0.66	acres	CDS Model	
Weighted C	0.90		2015-4	
Tc	6	minutes	CDS Treatment Capacity	
			1.4	cfs

Rainfall Intensity[1] (in/hr)	Percent Rainfall Volume[1]	Cumulative Rainfall Volume	Total Flowrate (cfs)	Treated Flowrate (cfs)	Removal Efficiency (%)	Incremental Removal (%)
0.02	10.2%	10.2%	0.01	0.01	96.6	9.8
0.04	9.6%	19.8%	0.02	0.02	96.1	9.3
0.06	9.4%	29.3%	0.04	0.04	95.5	9.0
0.08	7.7%	37.0%	0.05	0.05	94.9	7.3
0.10	8.6%	45.6%	0.06	0.06	94.3	8.1
0.12	6.3%	51.9%	0.07	0.07	93.7	5.9
0.14	4.7%	56.5%	0.08	0.08	93.2	4.3
0.16	4.6%	61.2%	0.10	0.10	92.6	4.3
0.18	3.5%	64.7%	0.11	0.11	92.0	3.3
0.20	4.3%	69.1%	0.12	0.12	91.4	4.0
0.25	8.0%	77.1%	0.15	0.15	90.0	7.2
0.30	5.6%	82.7%	0.18	0.18	88.5	5.0
0.35	4.4%	87.0%	0.21	0.21	87.1	3.8
0.40	2.5%	89.5%	0.24	0.24	85.7	2.2
0.45	2.5%	92.1%	0.27	0.27	84.2	2.1
0.50	1.4%	93.5%	0.30	0.30	82.8	1.1
0.75	5.0%	98.5%	0.45	0.45	75.5	3.8
1.00	1.0%	99.5%	0.59	0.59	68.3	0.7
1.50	0.0%	99.5%	0.89	0.89	53.9	0.0
2.00	0.0%	99.5%	1.19	1.19	39.4	0.0
3.00	0.5%	100.0%	1.78	1.40	22.9	0.1
						91.3
					Removal Efficiency Adjustment[2] =	6.5%
					Predicted % Annual Rainfall Treated =	93.4%
					Predicted Net Annual Load Removal Efficiency =	**84.9%**

1 - Based on 10 years of hourly precipitation data from NCDC Station 770, Boston WSFO AP, Suffolk County, MA
2 - Reduction due to use of 60-minute data for a site that has a time of concentration less than 30-minutes.

CDS ESTIMATED NET ANNUAL TSS REDUCTION
BASED ON THE RATIONAL RAINFALL METHOD

BROADSTONE BARE COVE
HINGHAM, MA
for SYSTEM: CDS 3

Area	0.3	acres	CDS Model	
Weighted C	0.90		2015-4	
Tc	6	minutes	CDS Treatment Capacity	
			1.4	cfs

Rainfall Intensity[1] (in/hr)	Percent Rainfall Volume[1]	Cumulative Rainfall Volume	Total Flowrate (cfs)	Treated Flowrate (cfs)	Removal Efficiency (%)	Incremental Removal (%)
0.02	10.2%	10.2%	0.01	0.01	97.0	9.9
0.04	9.6%	19.8%	0.01	0.01	96.7	9.3
0.06	9.4%	29.3%	0.02	0.02	96.4	9.1
0.08	7.7%	37.0%	0.02	0.02	96.2	7.4
0.10	8.6%	45.6%	0.03	0.03	95.9	8.2
0.12	6.3%	51.9%	0.03	0.03	95.6	6.0
0.14	4.7%	56.5%	0.04	0.04	95.4	4.4
0.16	4.6%	61.2%	0.04	0.04	95.1	4.4
0.18	3.5%	64.7%	0.05	0.05	94.9	3.4
0.20	4.3%	69.1%	0.05	0.05	94.6	4.1
0.25	8.0%	77.1%	0.07	0.07	93.9	7.5
0.30	5.6%	82.7%	0.08	0.08	93.3	5.2
0.35	4.4%	87.0%	0.09	0.09	92.6	4.0
0.40	2.5%	89.5%	0.11	0.11	92.0	2.3
0.45	2.5%	92.1%	0.12	0.12	91.3	2.3
0.50	1.4%	93.5%	0.14	0.14	90.6	1.3
0.75	5.0%	98.5%	0.20	0.20	87.4	4.4
1.00	1.0%	99.5%	0.27	0.27	84.1	0.9
1.50	0.0%	99.5%	0.41	0.41	77.5	0.0
2.00	0.0%	99.5%	0.54	0.54	70.9	0.0
3.00	0.5%	100.0%	0.81	0.81	57.8	0.3
						94.5

Removal Efficiency Adjustment[2] = 6.5%
Predicted % Annual Rainfall Treated = 93.5%
Predicted Net Annual Load Removal Efficiency = 88.1%

1 - Based on 10 years of hourly precipitation data from NCDC Station 770, Boston WSFO AP, Suffolk County, MA
2 - Reduction due to use of 60-minute data for a site that has a time of concentration less than 30-minutes.

CDS ESTIMATED NET ANNUAL TSS REDUCTION
BASED ON THE RATIONAL RAINFALL METHOD

CONTECH ENGINEERED SOLUTIONS

BROADSTONE BARE COVE
HINGHAM, MA
for SYSTEM: CDS 4

Area	0.69	acres	CDS Model	
Weighted C	0.90		2015-4	
Tc	6	minutes	CDS Treatment Capacity	
			1.4	cfs

Rainfall Intensity[1] (in/hr)	Percent Rainfall Volume[1]	Cumulative Rainfall Volume	Total Flowrate (cfs)	Treated Flowrate (cfs)	Removal Efficiency (%)	Incremental Removal (%)
0.02	10.2%	10.2%	0.01	0.01	96.6	9.8
0.04	9.6%	19.8%	0.02	0.02	96.0	9.3
0.06	9.4%	29.3%	0.04	0.04	95.4	9.0
0.08	7.7%	37.0%	0.05	0.05	94.8	7.3
0.10	8.6%	45.6%	0.06	0.06	94.2	8.1
0.12	6.3%	51.9%	0.07	0.07	93.6	5.9
0.14	4.7%	56.5%	0.09	0.09	93.0	4.3
0.16	4.6%	61.2%	0.10	0.10	92.4	4.3
0.18	3.5%	64.7%	0.11	0.11	91.8	3.3
0.20	4.3%	69.1%	0.12	0.12	91.2	4.0
0.25	8.0%	77.1%	0.16	0.16	89.7	7.2
0.30	5.6%	82.7%	0.19	0.19	88.2	4.9
0.35	4.4%	87.0%	0.22	0.22	86.6	3.8
0.40	2.5%	89.5%	0.25	0.25	85.1	2.2
0.45	2.5%	92.1%	0.28	0.28	83.6	2.1
0.50	1.4%	93.5%	0.31	0.31	82.1	1.1
0.75	5.0%	98.5%	0.47	0.47	74.6	3.8
1.00	1.0%	99.5%	0.62	0.62	67.0	0.7
1.50	0.0%	99.5%	0.93	0.93	51.9	0.0
2.00	0.0%	99.5%	1.24	1.24	36.8	0.0
3.00	0.5%	100.0%	1.86	1.40	21.9	0.1
						91.1
					Removal Efficiency Adjustment[2] =	6.5%
					Predicted % Annual Rainfall Treated =	93.4%
					Predicted Net Annual Load Removal Efficiency =	**84.6%**

1 - Based on 10 years of hourly precipitation data from NCDC Station 770, Boston WSFO AP, Suffolk County, MA
2 - Reduction due to use of 60-minute data for a site that has a time of concentration less than 30-minutes.

CDS ESTIMATED NET ANNUAL TSS REDUCTION
BASED ON THE RATIONAL RAINFALL METHOD

BROADSTONE BARE COVE
HINGHAM, MA
for SYSTEM: CDS 5

Area	0.31	acres	CDS Model	
Weighted C	0.90		2015-4	
Tc	6	minutes	CDS Treatment Capacity	
			1.4	cfs

Rainfall Intensity[1] (in/hr)	Percent Rainfall Volume[1]	Cumulative Rainfall Volume	Total Flowrate (cfs)	Treated Flowrate (cfs)	Removal Efficiency (%)	Incremental Removal (%)
0.02	10.2%	10.2%	0.01	0.01	96.9	9.9
0.04	9.6%	19.8%	0.01	0.01	96.7	9.3
0.06	9.4%	29.3%	0.02	0.02	96.4	9.1
0.08	7.7%	37.0%	0.02	0.02	96.1	7.4
0.10	8.6%	45.6%	0.03	0.03	95.9	8.2
0.12	6.3%	51.9%	0.03	0.03	95.6	6.0
0.14	4.7%	56.5%	0.04	0.04	95.3	4.4
0.16	4.6%	61.2%	0.04	0.04	95.0	4.4
0.18	3.5%	64.7%	0.05	0.05	94.8	3.4
0.20	4.3%	69.1%	0.06	0.06	94.5	4.1
0.25	8.0%	77.1%	0.07	0.07	93.8	7.5
0.30	5.6%	82.7%	0.08	0.08	93.1	5.2
0.35	4.4%	87.0%	0.10	0.10	92.5	4.0
0.40	2.5%	89.5%	0.11	0.11	91.8	2.3
0.45	2.5%	92.1%	0.13	0.13	91.1	2.3
0.50	1.4%	93.5%	0.14	0.14	90.4	1.2
0.75	5.0%	98.5%	0.21	0.21	87.0	4.4
1.00	1.0%	99.5%	0.28	0.28	83.6	0.8
1.50	0.0%	99.5%	0.42	0.42	76.9	0.0
2.00	0.0%	99.5%	0.56	0.56	70.1	0.0
3.00	0.5%	100.0%	0.84	0.84	56.5	0.3
						94.4

Removal Efficiency Adjustment[2] =	6.5%
Predicted % Annual Rainfall Treated =	93.5%
Predicted Net Annual Load Removal Efficiency =	**88.0%**

1 - Based on 10 years of hourly precipitation data from NCDC Station 770, Boston WSFO AP, Suffolk County, MA
2 - Reduction due to use of 60-minute data for a site that has a time of concentration less than 30-minutes.

CDS ESTIMATED NET ANNUAL TSS REDUCTION
BASED ON THE RATIONAL RAINFALL METHOD

BROADSTONE BARE COVE
HINGHAM, MA
for SYSTEM: CDS 6

Area	0.94	acres	CDS Model	
Weighted C	0.90		2015-4	
Tc	6	minutes	CDS Treatment Capacity	
			1.4	cfs

Rainfall Intensity[1] (in/hr)	Percent Rainfall Volume[1]	Cumulative Rainfall Volume	Total Flowrate (cfs)	Treated Flowrate (cfs)	Removal Efficiency (%)	Incremental Removal (%)
0.02	10.2%	10.2%	0.02	0.02	96.4	9.8
0.04	9.6%	19.8%	0.03	0.03	95.6	9.2
0.06	9.4%	29.3%	0.05	0.05	94.7	9.0
0.08	7.7%	37.0%	0.07	0.07	93.9	7.3
0.10	8.6%	45.6%	0.08	0.08	93.1	8.0
0.12	6.3%	51.9%	0.10	0.10	92.3	5.8
0.14	4.7%	56.5%	0.12	0.12	91.5	4.3
0.16	4.6%	61.2%	0.14	0.14	90.6	4.2
0.18	3.5%	64.7%	0.15	0.15	89.8	3.2
0.20	4.3%	69.1%	0.17	0.17	89.0	3.9
0.25	8.0%	77.1%	0.21	0.21	86.9	7.0
0.30	5.6%	82.7%	0.25	0.25	84.9	4.7
0.35	4.4%	87.0%	0.30	0.30	82.8	3.6
0.40	2.5%	89.5%	0.34	0.34	80.8	2.0
0.45	2.5%	92.1%	0.38	0.38	78.7	2.0
0.50	1.4%	93.5%	0.42	0.42	76.6	1.1
0.75	5.0%	98.5%	0.63	0.63	66.3	3.3
1.00	1.0%	99.5%	0.85	0.85	56.1	0.6
1.50	0.0%	99.5%	1.27	1.27	35.5	0.0
2.00	0.0%	99.5%	1.69	1.40	24.1	0.0
3.00	0.5%	100.0%	2.54	1.40	16.1	0.1
						88.9
					Removal Efficiency Adjustment[2] =	6.5%
					Predicted % Annual Rainfall Treated =	93.3%
					Predicted Net Annual Load Removal Efficiency =	**82.5%**

1 - Based on 10 years of hourly precipitation data from NCDC Station 770, Boston WSFO AP, Suffolk County, MA
2 - Reduction due to use of 60-minute data for a site that has a time of concentration less than 30-minutes.

CDS ESTIMATED NET ANNUAL TSS REDUCTION
BASED ON THE RATIONAL RAINFALL METHOD

CONTECH ENGINEERED SOLUTIONS

BROADSTONE BARE COVE
HINGHAM, MA
for SYSTEM: CDS 7

Area	0.33	acres	CDS Model	
Weighted C	0.90		2015-4	
Tc	6	minutes	CDS Treatment Capacity	
			1.4	cfs

Rainfall Intensity[1] (in/hr)	Percent Rainfall Volume[1]	Cumulative Rainfall Volume	Total Flowrate (cfs)	Treated Flowrate (cfs)	Removal Efficiency (%)	Incremental Removal (%)
0.02	10.2%	10.2%	0.01	0.01	96.9	9.9
0.04	9.6%	19.8%	0.01	0.01	96.6	9.3
0.06	9.4%	29.3%	0.02	0.02	96.3	9.1
0.08	7.7%	37.0%	0.02	0.02	96.1	7.4
0.10	8.6%	45.6%	0.03	0.03	95.8	8.2
0.12	6.3%	51.9%	0.04	0.04	95.5	6.0
0.14	4.7%	56.5%	0.04	0.04	95.2	4.4
0.16	4.6%	61.2%	0.05	0.05	94.9	4.4
0.18	3.5%	64.7%	0.05	0.05	94.6	3.4
0.20	4.3%	69.1%	0.06	0.06	94.3	4.1
0.25	8.0%	77.1%	0.07	0.07	93.6	7.5
0.30	5.6%	82.7%	0.09	0.09	92.9	5.2
0.35	4.4%	87.0%	0.10	0.10	92.2	4.0
0.40	2.5%	89.5%	0.12	0.12	91.4	2.3
0.45	2.5%	92.1%	0.13	0.13	90.7	2.3
0.50	1.4%	93.5%	0.15	0.15	90.0	1.2
0.75	5.0%	98.5%	0.22	0.22	86.4	4.4
1.00	1.0%	99.5%	0.30	0.30	82.8	0.8
1.50	0.0%	99.5%	0.45	0.45	75.5	0.0
2.00	0.0%	99.5%	0.59	0.59	68.3	0.0
3.00	0.5%	100.0%	0.89	0.89	53.9	0.3
						94.2

Removal Efficiency Adjustment[2] =	6.5%
Predicted % Annual Rainfall Treated =	93.5%
Predicted Net Annual Load Removal Efficiency =	**87.8%**

1 - Based on 10 years of hourly precipitation data from NCDC Station 770, Boston WSFO AP, Suffolk County, MA
2 - Reduction due to use of 60-minute data for a site that has a time of concentration less than 30-minutes.

State of New Jersey

DEPARTMENT OF ENVIRONMENTAL PROTECTION
Bureau of Nonpoint Pollution Control
Division of Water Quality
Post Office Box 029
Trenton, New Jersey 08625-029
609-633-7021 Fax: 609-984-2147
http://www.state.nj.us/dep/dwq/bnpc_home.htm

CHRIS CHRISTIE
Governor

KIM GUADAGNO
Lt. Governor

BOB MARTIN
Acting Commissioner

Derek Berg
Regulatory Manager – Stormwater
CONTECH Engineered Solutions
200 Enterprise Drive
Scarborough, ME 04074

Re: Final Certification
Continuous Deflective Separator (CDS) by CONTECH Engineered Solutions LLC

Expiration Date: December 1, 2016
TSS Removal Rate: 50%

Dear Mr. Berg:

The Stormwater Management rules under N.J.A.C. 7:8-5.5(b) and 5.7(c) allow the use of manufactured treatment devices (MTDs) for compliance with the design and performance standards at N.J.A.C. 7:8-5 if the pollutant removal rates have been verified by the New Jersey Corporation for Advanced Technology (NJCAT) and have been certified by the New Jersey Department of Environmental Protection (NJDEP). CONTECH Engineered Solutions LLC has requested a Final Certification for the Continuous Deflective Separator (CDS) Stormwater Treatment System.

This project falls under the July 15, 2011 "Transition for Manufactured Treatment Devices," under *C. Manufactured Treatment Devices Seeking Final Certification – In Process* which are MTDs that have commenced field testing on or before August 1, 2011.

NJDEP received the required information and signed statements by the NJCAT Technical Director and the manufacturer indicating that the requirements of the Field Testing Protocols in place at the initiation of testing have been met or exceeded. The NJCAT letter also includes a recommended certified TSS removal rate and the required maintenance plan.

The NJDEP certifies the use of the CONTECH Engineered Solutions LLC CDS Stormwater Treatment System at a TSS removal rate of 50%, subject to the following conditions:

1. The various models and associated water quality flow capacities shall be sized for the peak flow of the New Jersey Water Quality Design Storm per N.J.A.C. 7:8-5, as shown in Table 1 below.

New Jersey Treatment Rates for CDS Models Based on a Surface Area Secific Loading Rate of 25.16gpm/ft^2		
CDS Model	**Manhole Diameter (ft)**	**Treatment Flow Rate (cfs)**
CDS-4	4	0.7
CDS-5	5	1.1
CDS-6	6	1.6
CDS-8	8	2.8
CDS-10	10	4.4
CDS-12	12	6.3

2. The CDS Stormwater Treatment System can be used on-line or off-line.

3. A hydrodynamic separator, such as the CDS Stormwater Treatment System, cannot be used in series with another hydrodynamic separator to achieve an enhanced removal rate for total suspended solids (TSS) removal under N.J.A.C. 7:8-5.5.

4. The maintenance plan for the sites using this device shall incorporate at a minimum, the maintenance requirements for the CDS Stormwater Treatment System shown attached.

In addition to the attached, the detailed maintenance plan must include all of the items identified in Chapter 8: Maintenance of the New Jersey Stormwater Best Management Manual. Such items include, but are not limited to, the list of inspection and maintenance equipment and tools, specific corrective and preventative maintenance tasks, indication of problems in the system, and training of maintenance personnel.

Additional information regarding the implementation of the Stormwater Management rules N.J.A.C. 7:8 are available at www.njstormwater.org. Please contact Sandra Blick of my office at (609) 633-7021 if you have any questions.

Sincerely,

James J. Murphy, Chief
Bureau of Nonpoint Pollution Control

c: Chron File
Richard Magee, NJCAT
Mark Pedersen, DLUR
Elizabeth Dragon, BNPC

CDS Maintenance

The CDS system must be inspected at regular intervals and maintained when necessary to ensure optimum performance. The rate at which the system collects pollutants will depend more heavily on site activities than the size of the unit, e.g., unstable soils or heavy winter sanding will cause the grit chamber to fill more quickly but regular sweeping will slow accumulation.

Inspection

Inspection is the key to effective maintenance and is easily performed. Pollutant deposition and transport may vary from year to year and regular inspections will help insure that the system is cleaned out at the appropriate time. At a minimum, inspections must be performed twice per year (i.e. spring and fall) however more frequent inspections may be necessary in climates where winter sanding operations may lead to rapid pollutant accumulations, or in equipment washdown areas. Additionally, installations where excessive amounts of trash are expected should be inspected more frequently.

The visual inspection must ascertain that the system components are in working order and that there are no blockages or obstructions to the inlet and/or separation screen. The inspection must also identify accumulations of hydrocarbons, trash, and sediment in the system. Measuring pollutant accumulation can be done with a calibrated dipstick such as a stadia rod, tape measure or other measuring instrument. If sorbent material is used for enhanced removal of hydrocarbons then the level of discoloration of the sorbent material should also be identified during inspection. Sorbent material must be replaced when it is predominantly dark in color (similar to oil). It is useful and often required as part of a permit to keep a record of each inspection.

Access to the CDS unit is typically achieved through two manhole access covers. One opening allows for inspection and cleanout of the separation chamber (screen/cylinder) and isolated sump. The other allows for inspection and cleanout of sediment captured and retained behind the screen. For units possessing a sizable depth below grade (depth to pipe), a single access point allows for both sump cleanout and access behind the screen.

The CDS system must be cleaned when the level of sediment in the sump has reached a depth of 12 inches or more to avoid exceeding the maximum 24 inch sediment depth and/or when an appreciable level of hydrocarbons and trash has accumulated. If sorbent material is used, it must be replaced when significant discoloration has occurred. Performance will not be impacted until 100% of the sump capacity is exceeded however it is recommended that the system be cleaned prior to that for easier removal of sediment. The level of sediment is easily determined by measuring from finished grade down to the top of the sediment pile. To avoid underestimating the level of sediment in the chamber, the measuring device must be lowered to the top of the sediment pile carefully. Finer, silty particles at the top of the pile typically offer less resistance to the end of the rod than larger particles toward the bottom of the pile. Once this measurement is recorded, it should be compared to the as-built drawing for the unit to determine if the height of the sediment pile off the bottom of the sump floor exceeds 75% (18 inches) of the total height of isolated sump.

Cleaning
Cleaning of the CDS systems should be done during dry weather conditions when no flow is entering the system. Cleanout of the CDS with a vacuum truck is generally the most effective and convenient method of excavating pollutants from the system. Simply remove the manhole covers and insert the vacuum hose into the sump. The system should be completely drained down and the sump fully evacuated of sediment. The area outside the screen should also be pumped out if pollutant build-up exists in this area.

In installations where the risk of petroleum spills is small, liquid contaminants may not accumulate as quickly as sediment. However, an oil or gasoline spill should be cleaned out immediately. Motor oil and other hydrocarbons that accumulate on a more routine basis must be removed when an appreciable layer has been captured. To remove these pollutants, it may be preferable to use adsorbent pads since they are usually less expensive to dispose of than the oil/water emulsion that may be created by vacuuming the oily layer. Trash can be netted out if you wish to separate it from the other pollutants. The screen should be power washed to ensure it is free of trash and debris.

Manhole covers should be securely seated following cleaning activities to prevent leakage of runoff into the system from above and also to ensure proper safety precautions. Confined Space Entry procedures need to be followed.

Disposal of all material removed from the CDS system must be done is accordance with local regulations. In many locations, disposal of evacuated sediments may be handled in the same manner as disposal of sediments removed from catch basins or deep sump manholes. Check your local regulations for specific requirements on disposal.

NJCAT TECHNOLOGY VERIFICATION

VortSentry® Stormwater Treatment System

December 2005

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1. Introduction

1.1 New Jersey Corporation for Advanced Technology (NJCAT) Program

NJCAT is a not-for-profit corporation to promote in New Jersey the retention and growth of technology-based businesses in emerging fields such as environmental and energy technologies. NJCAT provides innovators with the regulatory, commercial, technological and financial assistance required to bring their ideas to market successfully. Specifically, NJCAT functions to:

- Advance policy strategies and regulatory mechanisms to promote technology commercialization;
- Identify, evaluate, and recommend specific technologies for which the regulatory and commercialization process should be facilitated;
- Facilitate funding and commercial relationships/alliances to bring new technologies to market and new business to the state; and
- Assist in the identification of markets and applications for commercialized technologies.

The technology verification program specifically encourages collaboration between vendors and users of technology. Through this program, teams of academic and business professionals are formed to implement a comprehensive evaluation of vendor specific performance claims. Thus, suppliers have the competitive edge of an independent third party confirmation of claims.

Pursuant to N.J.S.A. 13:1D-134 et seq. (Energy and Environmental Technology Verification Program), the New Jersey Department of Environmental Protection (NJDEP) and NJCAT have established a Performance Partnership Agreement (PPA) whereby NJCAT performs the technology verification review and NJDEP certifies the net beneficial environmental effect of the technology. In addition, NJDEP/NJCAT work in conjunction to develop expedited or more efficient timeframes for review and decision-making of permits or approvals associated with the verified/certified technology.

The PPA also requires that:

- The NJDEP shall enter into reciprocal environmental technology agreements concerning the evaluation and verification protocols with the United States Environmental Protection Agency (USEPA), other local required or national environmental agencies, entities or groups in other states and New Jersey for the purpose of encouraging and permitting the reciprocal acceptance of technology data and information concerning the evaluation and verification of energy and environmental technologies; and

- The NJDEP shall work closely with the State Treasurer to include in State bid specifications, as deemed appropriate by the State Treasurer, any technology verified under the Energy and Environment Technology Verification Program.

1.2 Technology Verification Report

In October 2005, Stormwater360^{TM}, Inc., 200 Enterprise Drive, Scarborough, Maine, 04074, submitted a formal request for participation in the NJCAT Technology Verification Program. The technology proposed, The VortSentry® Stormwater Treatment System, is a hydrodynamic separator designed to enhance gravitational separation of floating and settling materials from stormwater flows. The system was developed in Scarborough, Maine and is described in greater detail later in this report. Through research and field application, the technology has been refined to capture total suspended solids (TSS), sediments, oil and grease, and trash and debris (including floatables and negatively buoyant debris). The request (after pre-screening by NJCAT staff personnel in accordance with the technology assessment guidelines) was accepted into the verification program. This verification report covers the evaluation based upon the performance claim of the vendor, Stormwater360^{TM}, Inc. (see Section 4). The verification report differs from typical NJCAT verification reports in that final verification of the VortSentry® System (and subsequent NJDEP certification of the technology) awaits completed field testing that meets the full requirements of the Technology Acceptance and Reciprocity Partnership (TARP) – Stormwater Best Management Practice Tier II Protocol for Interstate Reciprocity for stormwater treatment technology. This verification report is intended to evaluate the Stormwater360^{TM}, Inc. initial performance claim for the technology based primarily on carefully conducted laboratory studies. This claim is expected to be modified and expanded following completion of the TARP required field-testing.

This project included the evaluation of assembled reports, company manuals, and laboratory testing reports to verify that the VortSentry® System meets the performance claim of Stormwater360^{TM}, Inc.

1.3 Technology Description

1.3.1 Technology Status

In 1990 Congress established deadlines and priorities for USEPA to require permits for discharges of stormwater that are not mixed or contaminated with household or industrial wastewater. Phase I regulations established that a NPDES (National Pollutant Discharge Elimination System) permit is required for stormwater discharge from municipalities with a separate storm sewer system that serves a population greater than 100,000 and certain defined industrial activities. To receive a NPDES permit, the municipality or specific industry has to develop a stormwater management plan and identify best management practices for stormwater treatment and discharge. Best management practices (BMPs) are measures, systems, processes or controls that reduce pollutants at the source to prevent the pollution of stormwater runoff discharge from the site. Phase II stormwater discharges include all discharges composed entirely of stormwater, except those specifically classified as Phase I discharge.

The nature of pollutants emanating from differing land uses are very diverse. Stormwater360^{TM}, Inc. has developed a technology for separating and retaining floating and sinking pollutants including sediment, hydrocarbons and debris under rapid flow conditions using a hydrodynamic separator. The system is designed with a circular treatment chamber that promotes a gentle swirling motion to encourage settling pollutants to migrate to the center of the chamber where they are deposited. Floating pollutants are elevated above the bottom of the baffle wall where they collect over time. Between maintenance events, pollutants accumulate within the system and are therefore removed from the natural environment. These pollutants may otherwise become a human health hazard, an aesthetic issue or may be cycled within the food chain or water table even if trapped in a land based treatment system. Maintenance is performed from above by a vacuum truck and without interference from internal components.

General

The VortSentry® Stormwater Treatment System is a hydrodynamic separator designed to enhance gravitational separation of floating and settling materials from stormwater flows (See Figure 1). Stormwater flows enter the unit tangentially to the treatment chamber, which promotes a gentle swirling motion. As stormwater circles the treatment chamber, pollutants migrate toward the center of the unit where velocities are the lowest. Over time a conical pile tends to accumulate in the bottom of the treatment chamber containing sediment and associated metals, nutrients, hydrocarbons and other pollutants. Floating debris, oil and grease form a floating layer trapped in front of the treatment chamber baffle. These accumulated pollutants can be easily accessed through manholes conveniently located over the treatment chamber. Maintenance is typically performed through the manhole over the treatment chamber.

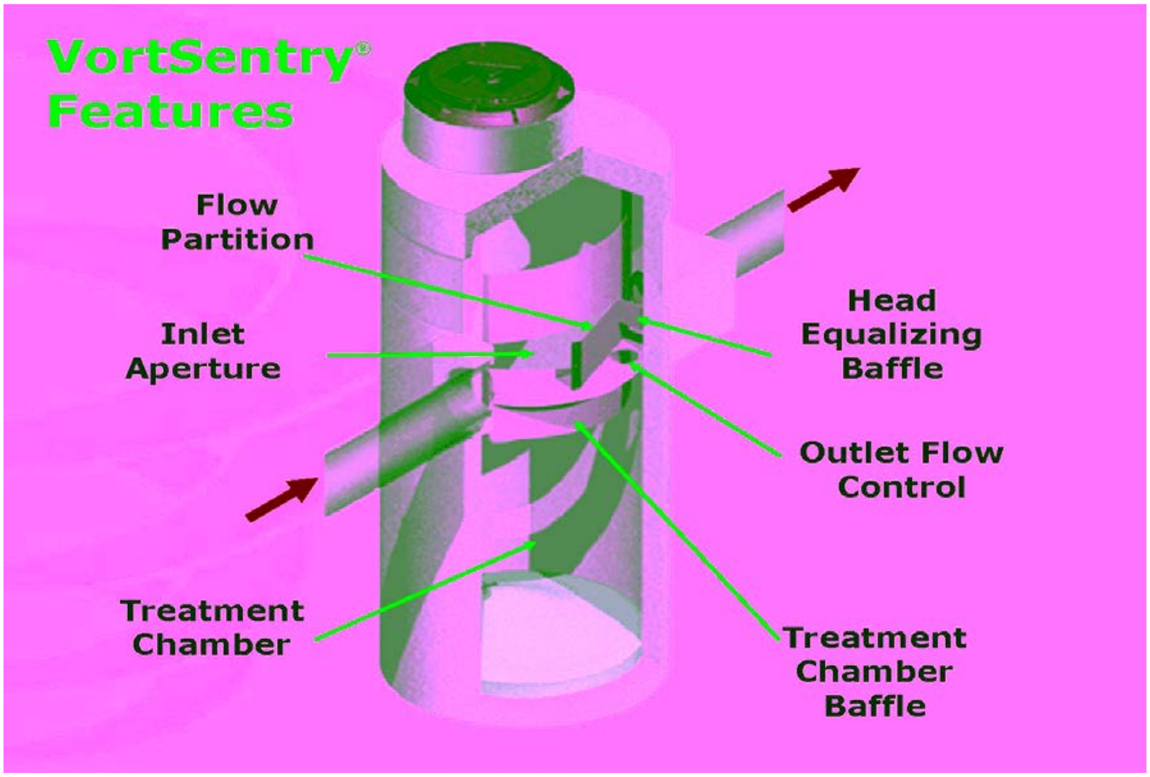

Figure 1. VortSentry® Features

1.3.2 Specific Applicability

The VortSentry® System is well suited to urban stormwater applications due to the following features:

- Laboratory testing has demonstrated that the system is capable of meeting stormwater treatment requirements;
- Below grade installation allows multiple land uses;
- Each system is custom designed to meet the hydraulic demands of site;
- Spill storage and sediment storage volumes can be increased as necessary;
- Technical support is available at no cost before and after the sale;
- There are no expendable or moving parts and a low cleanout volume minimizes operating costs.

The VortSentry® System is a compact, below grade system that is fabricated near the jobsite from concrete and marine grade aluminum. There are six standard precast models available, ranging from three to eight feet in diameter. In some regions VortSentry® systems are available in diameters up to 12 feet, but this is dependant on the capabilities of local precasters. Standard VortSentry® model sizes and dimensions are provided in Table 1.

Table 1. Standard VortSentry® Model Sizes and Dimensions

VortSentry® Model	Treatment Chamber Diameter		Depth (below invert)		Recommended Maximum Inlet / Outlet Pipe Size	
	(ft)	(m)	(ft)	(m)	(in)	(mm)
VS30	3	0.9	5.4	1.7	12	300
VS40	4	1.2	6.5	2.0	18	450
VS50	5	1.5	7.4	2.3	18	450
VS60	6	1.8	8.3	2.5	24	600
VS70	7	2.1	9.1	2.8	30	762
VS80	8	2.4	10.1	3.0	30	762

1.3.3 Range of Contaminant Characteristics

VortSentry® Systems have been shown to capture a wide range of pollutants of concern. These include: trash and debris (including floatables and negatively buoyant debris); total suspended solids; sediments; and oil and grease.

1.3.4 Range of Site Characteristics

Routine operation

Runoff from low intensity precipitation makes up the vast majority of the total annual flow volume from all sites. During low intensity precipitation events, all flow is diverted into the treatment chamber by the flow partition. The flow partition is designed to work in combination with the outlet flow control orifice to submerge the influent pipe during the water quality design storm. The effect of submerging the inlet pipe is to reduce inlet velocity and turbulence by increasing the cross sectional area of the flow path. Removal rates of sediment and floating pollutants are very high during routine operation since turbulence and internal velocities are very low, and residence times are relatively high. See Figure 2 for an illustration of routine VortSentry®operation.

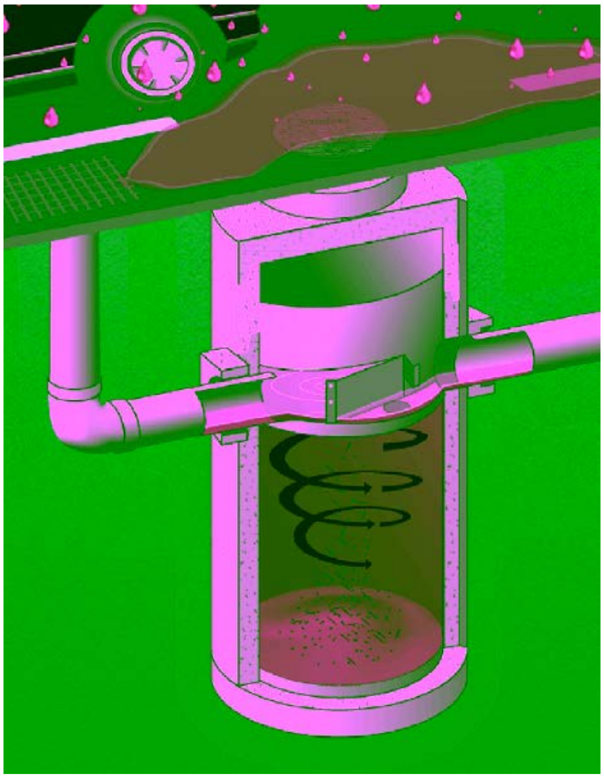

Figure 2. Routine VortSentry® Operation

Moderate intensity operation

As storm intensities and flow rates increase, the operating rate (gpm/ft3) in the VortSentry® also increases proportionally. At flow rates typical of moderate intensity storm events, a portion of flow begins to spill over the flow partition. Partitioning a portion of flow around the treatment chamber keeps velocities low in the treatment chamber. This allows the VortSentry® to continue to remove a high percentage of the pollutants from the runoff flowing through the treatment chamber. Maintaining low velocities in the treatment chamber also prevents scour of previously captured pollutants. The rising water surface elevation within the treatment chamber carries floating contaminants such as trash and oil and grease away from the inlet and above the bottom of the baffle wall. This effectively prevents re-entrainment by separating contaminants from the higher velocity zones within the system. The swirling action increases, which promotes the migration of particles toward the center of the treatment chamber where the particles then form a stable conical pile. See Figure 3 for an illustration of moderate intensity VortSentry® operation.

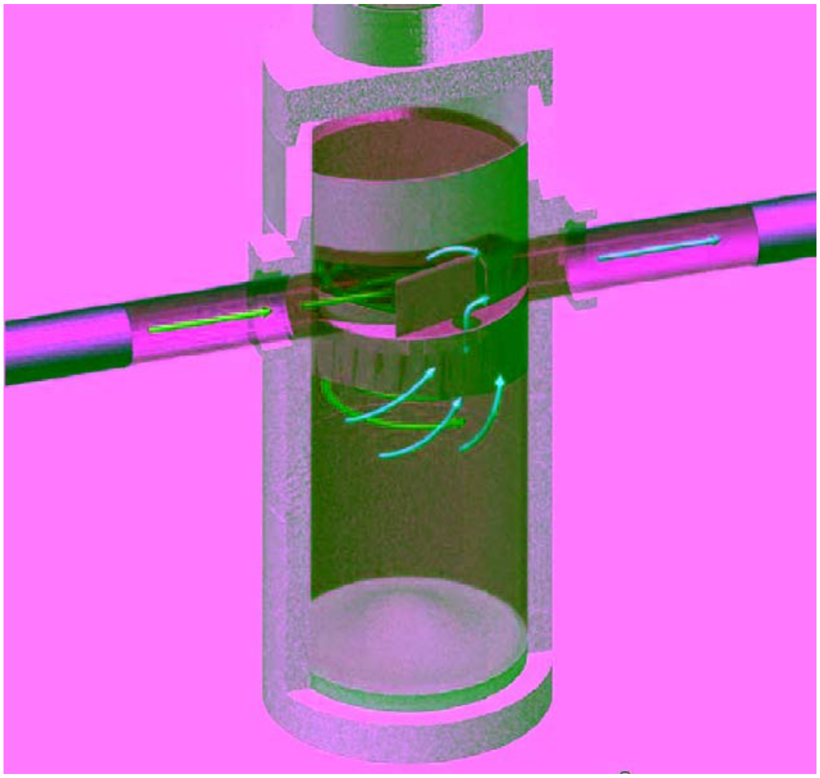

Figure 3. Moderate Intensity VortSentry® Operation

High Intensity Operation

At peak hydraulic capacity, the water surface elevation within the VortSentry® System increases and a substantial portion of the total flow passes over the flow partition submerging the head equalizing baffle. VortSentry® Systems are designed so that peak conveyance rates are representative of storm events such as the 5-yr or 10-yr rain event. Sediment and hydrocarbon removal rates are low, but previously captured materials remain trapped. This is accomplished by increasing the water surface elevation in the treatment chamber to isolate previously captured floatables and by maintaining low flow velocities in the treatment chamber. To accommodate large, infrequent storms, Stormwater360™, Inc. can also assist with the design of an external bypass to route peak-flows around the treatment unit.

Storm subsidence

As a storm subsides, treated runoff continues to flow out of the VortSentry® System through the outlet orifice until the water level returns to the dry-weather volume. This process typically takes several minutes after runoff has ceased.

1.3.5 Material Overview, Handling and Safety

Accumulated pollutants can easily be accessed through the manhole located above the treatment chamber. To clean out the VortSentry® System with a vacuum truck, it is generally most convenient and efficient to clean all captured pollutants including sediment, oil and grease, and floating debris through the manhole over the treatment chamber. Access to the treatment chamber is unrestricted making the vactor operation a simple task. Once the treatment chamber and captured pollutants have been vacuumed from the unit, the manhole cover is simply replaced to complete the maintenance event.

Solids recovered from the VortSentry® System can typically be land filled or disposed of at a wastewater treatment plant. It is possible that there may be some specific land use activities that create contaminated solids, which will be captured in the system. Such material would have to be handled and disposed of in accordance with hazardous waste management requirements.

1.4 Project Description

This project included the evaluation of assembled reports, company manuals, and laboratory testing reports to verify that VortSentry® Systems meet the performance claim of Stormwater360™, Inc.

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2. Evaluation of the Applicant

2.1 Corporate History

Stormwater Management, Inc. and Vortechnics, Inc. united as Stormwater360™, Inc. in April 2005. The two companies share over 25 years of experience in the stormwater industry. As a combined entity, their goal continues to be preserving and protecting water resources worldwide.

The joint company treats stormwater runoff from commercial, municipal and industrial sites, applying various technologies to address regulatory and customer requirements. Founded in 1988 and based in Scarborough, Maine, Vortechnics built their business on the development of hydrodynamic separation technology. Based in Portland Oregon, Stormwater Management led in the development of filtration technology, introducing a horizontal bed configuration with CSF leaf compost media in 1995.

In state-of-the-art laboratories at both locations, engineers and scientists continue to conduct research to further the understanding of nonpoint source pollution and develop practical product solutions. The parent company of Stormwater360™, Inc. is Contech Construction Products, Inc., a leading civil engineering site solutions products and services company involved in highway, drainage, sewage, and site-improvement. In 2004, Vortechnics was purchased by Contech; and in April 2005, Contech purchased Stormwater Management.

2.2 Organization and Management

The company Stormwater360™, Inc. is jointly headquartered in Scarborough, Maine, and Portland, Oregon with 19 regional sales offices throughout the United States and Canada. The management team consists of: David Miley, president and CEO; David Pollock, COO and VP of Sales; Jim Lenhart, Chief Technology Officer; Eric Roach, Chief Financial Officer; Fran Tighe, VP of Marketing; and Tom Gorrivan, National Sales Manager. The company has 23 regional sales managers, who report to Tom Gorrivan and work out of regional offices based in Maine, Maryland, Georgia, Texas, Ohio, California, Washington, Oregon, Wisconsin, Pennsylvania, Massachusetts, Nova Scotia, and Ontario.

2.3 Operating Experience with the Proposed Technology

Stormwater360™, Inc. has more than 15 years of experience with stormwater technology, and after several years of research and development the VortSentry® was released in 2003. Currently there are more than 300 installations throughout the United States and Canada. Most importantly, the technology is backed by years of full scale laboratory testing and rigorous field testing is ongoing, including third party studies from several universities and organizations.

2.4 Patents

Stormwater360™ has filed for patent protection for the VortSentry® System with the US Patent Office, and a patent is currently pending.

2.5 Technical Resources, Staff and Capital Equipment

Stormwater360™ completes all design work at its corporate headquarters in Scarborough, Maine and Portland, Oregon. Once a system design is complete, shop drawings are issued to a precast concrete contractor local to the installation site. Representatives from each precast company are trained in VortSentry® construction to ensure the details of construction are properly executed. Different contractors may elect to cast the system differently depending on their equipment and construction capabilities. For example, a precaster would have input regarding the details of construction such as how many pieces per system. They would also determine how the joints are formed and what type of lifting equipment is cast in. Stormwater360™, Inc. ultimately reviews all construction and installation decisions made by the precaster.

The VortSentry® System is delivered to the site by the precaster on the day of installation. VortSentry® systems typically arrive on site in three or more pieces and require some assembly. VortSentry® models VS30-VS50 typically do not require the use of a crane for installation. Once delivered to the site by the precaster the contractor is responsible for assembling and sealing the VortSentry® sections. VortSentry® models VS60 and larger typically require a crane for installation and additional sealing of the aluminum components onsite. The site contractor is responsible for making arrangements to have a crane on site, completing excavation prior to delivery and setting the system into the ground. The contractor is also responsible for grouting the inlet and outlet pipe into the VortSentry® System, backfilling around the system and bringing the manhole frames and covers up to grade. Any work required on components inside the system is typically the responsibility of the Stormwater360™ precast contractor. Installation for all model sizes can typically be completed in two to four hours. Heaviest pick weight will be confirmed by Stormwater360™ staff and communicated to the contractor prior to delivery.

Specific installation instructions and requirements are provided. Stormwater360™ tries to have a representative onsite during installation, but occasionally this is not possible. However, support representatives are always available to address questions that may arise during installation.

When the system arrives on site, it is inspected by the contractor. Any damage due to shipping and handling up to that point must be corrected by the precaster. Once the contractor takes delivery of the unit, it is their responsibility to lift it from the truck, place it in the ground, and connect the inlet and outlet pipes and backfill around it. The contractor will perform a final check against the VortSentry® Specification and the site plan before backfilling is initiated. If there are any installation errors at that point, the contractor will fix them and the system will be back filled.

Adjustments for buoyancy issues, calculation of pick weights, and other custom design items are confirmed before delivery. The inlet and outlet are clearly marked to avoid improper installation. It is especially important that the system be set in such a way that the inlet pipe is at a 90 degree angle to the side of the tank to encourage proper treatment chamber flow dynamics. This orientation is checked prior to backfilling the unit since a significantly different influent pipe angle may increase inlet turbulence or cause short-circuiting of the treatment chamber.

VortSentry® Systems are typically available within four to six weeks of shop drawing approval.

3. Treatment System Description

The VortSentry® Stormwater Treatment System was designed to capture a wide range of pollutants from stormwater including: trash and debris (including floatables and negatively buoyant debris); total suspended solids; sediments; and oil and grease. Figure 1 displays a simple schematic of the VortSentry® System. The VortSentry® is a compact, below grade stormwater treatment system that employs vortex technology to enhance gravitational separation of floating and settling pollutants from stormwater flows. The device has no moving parts and is fabricated from concrete and marine grade aluminum. The main components of the system are a flow partition, inlet aperture, head equalizing baffle, treatment chamber, outlet flow control orifice, and treatment chamber baffle. The system is also equipped with a manhole for easy inspection and maintenance access.

During operation, stormwater runoff enters the unit tangentially to promote a gentle swirling motion in the treatment chamber. As polluted water circles within the chamber, settleable solids fall into the sump and are retained. Buoyant debris and oil and grease rise to the surface and are separated from the water as it flows under the baffle wall. Finally, treated water exits the treatment chamber through a flow control orifice located behind the baffle wall.

During low-flow conditions, all runoff is diverted into the treatment chamber by the flow partition. At higher flow rates, a portion of the runoff spills over the flow partition and is diverted around the treatment chamber to prevent re-suspension and washout of previously trapped pollutants. Water that spills over the partition flows into the head equalization chamber above the treatment chamber outlet. As the head equalization chamber fills, the head differential driving flow through the treatment chamber collapses. The result is that flow rates in the treatment chamber remain relatively constant even as total flow rates increase substantially. This configuration further reduces the potential for re-suspension or washout.

There are typically six (6) precast VortSentry® System models available to meet the hydraulic and water quality needs of large and small projects (See Table 1). The VortSentry® Systems have the ability to treat a wide range of flows. In certain regions, larger systems are available to accommodate higher flow rates.

4. Technical Performance Claim

Claim - The VortSentry® Stormwater Treatment System, Model VS40, sized at a loading rate of 9.8 gpm/ft^3 (0.022cfs/ft^3) of treatment volume, has been shown to have a 69% total suspended solids (TSS) removal efficiency, as measured as suspended solids concentration (SSC) (as per the NJDEP methodology for calculation of treatment efficiency) for F-95 silica sand with an average d_{50} particle size of 120 microns, an average influent concentration of 209 mg/L and 50% initial sediment loading in laboratory studies using simulated stormwater.

5. Treatment System Performance

The VortSentry® System has been tested at the Stormwater360™, Inc. full-scale hydraulic laboratory. The laboratory tests were completed using F-95, a commercially available silica sand gradation. The particle size distribution is shown in Figure 4. Tests were performed with sediment influent concentrations ranging from 88 to 521 mg/l at operating rates from 0.27 to 1.35 cfs. In addition to specific testing, Stormwater360™, Inc. has developed the Rational Rainfall Method™, a model that estimates long term field performance based on site information, local precipitation patterns and laboratory performance data. The VortSentry® System is currently being tested in the field by Stormwater360™, Inc. staff as well as by independent researchers.

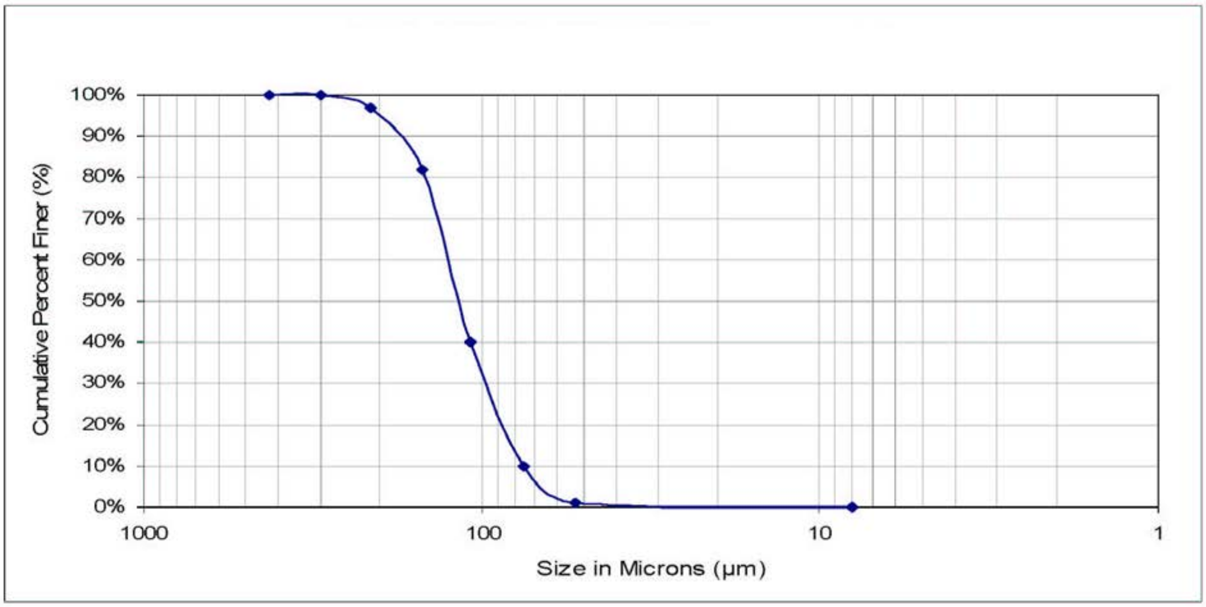

Figure 4. US Silica F-95 Particle Size Distribution

5.1 NJDEP Recommended TSS Laboratory Testing Procedure

Stormwater360™, Inc. designed their laboratory testing to comply with NJDEP's recommended TSS Laboratory Testing Procedure; the NJDEP testing procedure is presented herein. The NJDEP has prepared a Total Suspended Solids Laboratory Testing Procedure to help guide vendors as they prepare to test their stormwater treatment systems prior to applying for NJCAT verification.

The Testing Procedure has three components:

1. Particle size distribution

2. Full scale laboratory testing requirements
3. Measuring treatment efficiency

1. Particle size distribution:

The following particle size distribution was utilized to evaluate a manufactured treatment system (See Table 2). A natural/commercial soil representing the USDA definition of a sandy loam material was used. This hypothetical distribution was selected as it represents the various particles that would be associated with typical stormwater runoff from a post construction site.

Specifically, the following distribution can be utilized:

Table 2. Particle Size Distribution

Particle Size (microns)	**Sandy loam (percent by mass)**
500-1000 (coarse sand)	5.0
250-500 (medium sand)	5.0
100-250 (fine sand)	30.0
50-100 (very fine sand)	15.0
2-50 (silt)	(8-50 um, 25%) (2-8 um, 15%)*
1-2 (clay)	5.0

Notes:

1. Recommended density of particles ≤2.65 g/cm3

*The 8 um diameter is the boundary between very fine silt and fine silt according to the definition of American Geophysical Union. The reference for this division/classification is: Lane, E. W., et al. (1947), "Report of the Subcommittee on Sediment Terminology," Transactions of the American Geophysical Union, Vol. 28, No. 6, pp. 936-938.

2. Full scale lab test requirements
   A. At a minimum, complete a total of 15 test runs including three (3) tests each at a constant flow rate of 25, 50, 75, 100, and 125 percent of the treatment flow rate. These tests should be operated with initial sediment loading of 50% of the unit's capture capacity.
   B. The three tests for each treatment flow rate will be conducted for influent concentrations of 100, 200, and 300 mg/L.
   C. For an online system, complete two tests at the maximum hydraulic operating rate. Utilizing clean water, the tests will be operated with initial sediment loading at 50% and 100% of the unit's capture capacity. These tests will be utilized to check the potential for TSS resuspension and washout.
   D. The test runs should be conducted at a temperature between 73-79 degrees Fahrenheit or colder.

3. Measuring treatment efficiency
   A. Calculate the individual removal efficiency for the 15 test runs.
   B. Average the three test runs for each operating rate.

C. The average percent removal efficiency will then be multiplied by a specified weight factor (see Table 3) for that particular operating rate.
D. The results of the five numbers will then be summed to obtain the theoretical annual TSS load removal efficiency of the system.

Table 3. Treatment Operating Rates and Weight Factors

Treatment operating rate	Weight factor
25%	.25
50%	.30
75%	.20
100%	.15
125%	.10

Notes:

Weight factors were based upon the average annual distribution of runoff volumes in New Jersey and the assumed similarity with the distribution of runoff peaks. This runoff volume distribution was based upon accepted computation methods for small storm hydrology and a statistical analysis of 52 years of daily rainfall data at 92 rainfall gages.

5.2 Laboratory Studies

In June of 2005, Stormwater360™ initiated a VortSentry® laboratory testing program in accordance with the New Jersey Department of Environmental Protection's (NJDEP) Total Suspended Solids Laboratory Test Procedure. All testing was conducted in the Stormwater360™ laboratory in Scarborough, ME on a full scale 4-ft diameter VortSentry® model VS40. The ultimate objective of the testing program was to provide a sufficient body of performance data to warrant an interim certification from the NJDEP. In order to comply with the requirements of the NJDEP testing protocol and to provide a data set that is comparable to the data sets of other stormwater treatment technologies that have completed the Tier I testing program, Stormwater360™ modeled its VortSentry® test plan to be consistent with the test plans for other technologies that have participated in the Tier I testing program.

All testing was conducted using F-95, a commercially available silica sand gradation (See Figure 4). Sediment was mixed with tap water in a 55-gallon recirculating slurry bin. A peristaltic pump was utilized to meter the slurry mixture into the influent line upstream of the test apparatus at a known rate.

Influent samples were collected at a 6-inch gate valve located upstream of the VortSentry® System. Effluent samples were collected by sweeping a sample bottle through the free discharge of a down-turned 90° PVC elbow, which discharges into a catch tank downstream of the VortSentry® System. All samples were collected in 500 ml HDPE sample bottles. Once the system was stabilized at the desired flow rate the metering pump was activated, starting the delivery of sediment to the VortSentry® System. Once sediment introduction was initiated, the system was run for a period of time equal to three times the detention time of the system before the first samples were collected. This allows the system to reach equilibrium. After three detention times have passed, a series of ten paired influent and effluent samples were taken at one minute intervals. Effluent samples were staggered from influent samples by the detention time of the test unit. Once ten influent and effluent samples were collected, the system was shut down. Sediment was not removed from the test system after each test effectively allowing additional sediment to accumulate within the treatment chamber sump.

To reduce recirculation of material within the test system, a silt fence was constructed in the catch tank to filter the effluent before it was pumped back to the water supply tank. Background samples were drawn from the water supply tank using a GLI Automatic Vacuum Sampler to monitor the sediment concentration in the source water. If the mean sediment concentration in the source water exceeded 10 mg/l during a test, the water supply tank was drained and cleaned, and the test was then repeated.

5.2.1 Performance Testing Procedure

1. Prior to the start of each test, the VortSentry® System was filled to 50% of its sediment capture depth (1.5ft) with F-95 sediment.
2. A sediment/water slurry was prepared in a ratio of 1.25 lb of sediment/gallon of water in the slurry mixer.
3. Adequate mixing was ensured by starting the slurry mixture at least five minutes before the start of the sediment metering pump.
4. The inlet flow control valve was opened and the flow rate through the VortSentry® System was stabilized at the target flow rate. The system was considered stable when the flow rate remained stable for approximately one minute.
5. The metering pump was started at the target rpm rate (rate required to produce target influent concentration). This was time 0:00.
6. After three detention times, the first background sample was collected. Background samples were collected at a one minute interval for the duration of the test.
7. One minute after the first background sample was taken, the first influent sample was collected. Influent samples were collected at one minute intervals until ten samples are taken.

   Note: Immediately before each influent sample was taken, the gate valve was flushed by quickly opening and closing it. This cleared any settled material from the mouth of the valve.
8. One detention time after the first influent sample was taken, the first effluent sample was collected.
9. Effluent samples were collected at a one minute interval until ten samples were taken.
10. After ten influent and effluent samples were collected, the metering pump and slurry tank mixer were stopped.
11. The background sampler was then stopped.
12. The VortSentry® System was shut down.

5.2.2 Washout Testing Procedure

Upon completion of the required performance testing, two washout trials were conducted to determine the potential for material to be scoured from the VortSentry® System. The first trial was conducted with the VortSentry® model VS40 filled to 50% (19 ft^3) of its sediment capture volume with F-95. The second trial was conducted with the VortSentry® System filled to 100% (38 ft^3) of its sediment capture volume. Both of these trials were conducted at the system's peak hydraulic capacity. Both trials were conducted with clean water. No sediment was injected into the influent stream. Upon start up, the system was brought to its peak operating capacity. Effluent sampling was started as soon as flow was introduced to the unit and continued in 30-second intervals until the conclusion of the test. Sampling before the unit had reached its hydraulic capacity was allowed for documentation of any material that was scoured before the VortSentry® System reaches hydraulic capacity. Once the system had reached hydraulic capacity, sampling continued in 30 second intervals for five minutes. Given the relatively short detention time of the unit under peak operating conditions, this was ample time to determine the unit's scour potential.

5.2.3 Sample Analysis

Sample analysis was conducted at the Stormwater360™, Inc. laboratory by trained laboratory technicians. Samples were analyzed in compliance with ASTM D 3977-97 a whole sample variation of the TSS method, also referred to as the suspended sediment concentration (SSC) method.

5.2.4 Description of Laboratory Testing Facility

All VortSentry® System performance testing was conducted at the Stormwater360™, Inc. research laboratory in Scarborough, Maine. Water was stored in a 5,600 gallon supply tank and delivered to the VortSentry® System through a gravity fed 12-inch diameter PVC pipe. Flow through the pipe was regulated by a 12 inch butterfly valve located upstream of the VortSentry® System. A 1/3 horse power Dayton split phase motor was used to mix sediment and water into a slurry in a 55 gallon conical bottom mixing bin. The slurry was then metered into the 12 inch PVC pipe just downstream of the butterfly valve with a Watson Marlow peristaltic pump. The conical bottom slurry tank was equipped with an under drain which remained open during the test to allow the slurry to be continuously recirculated within the bin with a Randolph Model 750 peristaltic pump. Influent samples were collected through a 6 inch PVC gate valve located directly downstream of the sediment metering port. Flow was monitored with an ISCO 4250 Area Velocity flow meter that was installed in the influent pipe. Effluent discharged from a down turned 12 inch PVC elbow into an aluminum catch tank. A silt fence, consisting of standard landscaping fabric mounted to a frame, was installed in the catch tank to filter effluent before it was recirculated to the water supply tank. Two ten horsepower Zoeller sewage pumps returned flow from the catch tank to the supply tank. The layout of the VortSentry® System test setup is shown in Figure 5.

5.2.5 Laboratory Testing Results

Results of the 15 individual tests conducted in accordance with the NJDEP laboratory testing protocol are summarized in Table 4. The target flow rate for each test was determined assuming the target treatment flow rate was 1.1 cfs. The target treatment flow rate was identified through preliminary testing to gauge system performance. The actual flow rate as reported in Table 4 represents the mean flow rate measured during each test. The removal efficiency reported for each test represents the mean suspended solids load reduction for that test and is calculated using the following equation:

Removal Efficiency = (Influent Conc. – Effluent Conc.) / Influent Conc.

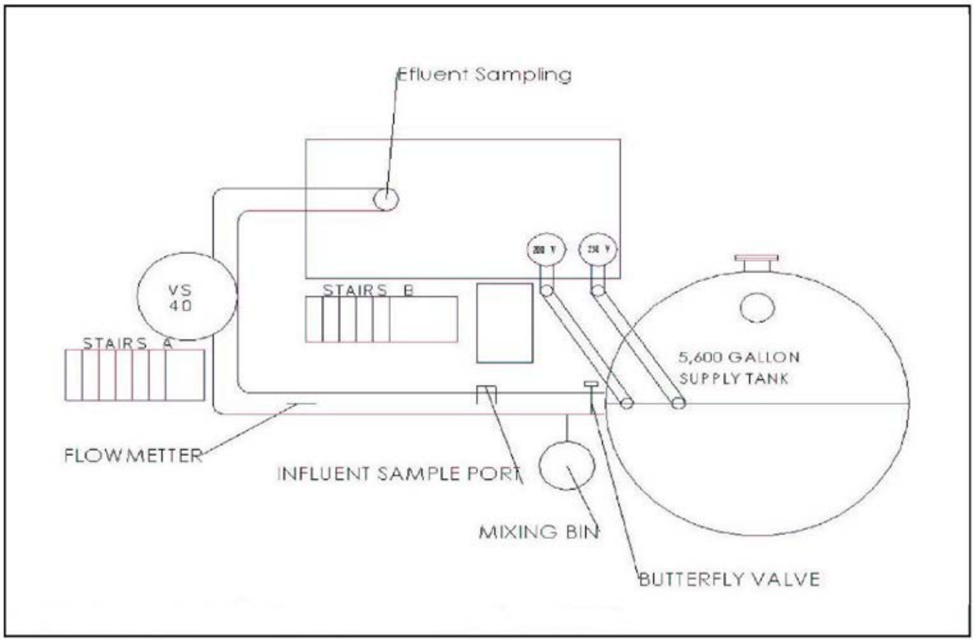

Figure 5. Laboratory Testing Facility for the VortSentry® System

Table 4. Summary of VortSentry® Laboratory Testing Results with F-95 Grade Silica

Test Number	Percent of Treatment Flow (%)	Target Flow Rate (cfs)	Target Conc. (mg/l)	Actual Flow Rate (cfs)	Influent Conc. (mg/l)	Effluent Conc. (mg/l)	Removal Efficiency (%)
1	25	0.27	100	0.27	88	6	93
2	25	0.27	200	0.27	200	12	94
3	25	0.27	300	0.26	266	13	95
4	50	0.55	100	0.56	92	23	75
5	50	0.55	200	0.54	219	60	73
6	50	0.55	300	0.54	521	121	77
7	75	0.82	100	0.84	130	44	66
8	75	0.82	200	0.83	142	53	63
9	75	0.82	300	0.81	304	122	60
10	100	1.10	100	1.11	95	49	48
11	100	1.10	200	1.10	167	80	52
12	100	1.10	300	1.09	277	164	41
13	125	1.35	100	1.35	137	102	26
14	125	1.35	200	1.24	233	163	30
15	125	1.35	300	1.35	263	179	32

5.2.6 Washout Testing Results

As required by the NJDEP laboratory testing protocol, a washout analysis was conducted at both 50 and 100 percent of the VortSentry® System sediment storage capacity. The protocol required each trial to be conducted at the maximum hydraulic operating rate of the unit. Due to the driving head limitations of the water supply tank in the laboratory, the maximum hydraulic operating rate for the model VS40 VortSentry® System was approximately 1.8 cfs. A VortSentry® model VS40 can be configured with additional hydraulic capacity, but this additional flow was directed over the flow partition and did not significantly impact the flow rate or velocity of flow through the treatment chamber. By limiting the flow rate and velocity through the treatment chamber, resuspension of previously captured material is unlikely.

The mean flow rate for the washout tests at both 50 and 100 percent of sediment storage capacity was 1.77 cfs. Results for both tests are shown in Table 5. During both tests the sediment concentration in the source water was monitored and subtracted from the VortSentry® System effluent concentration. Solids in the source water are typically attributable to recirculation of material during previous tests. With the sump filled to 50 percent of the VortSentry® System sediment storage capacity (1.5 feet), no washout was observed. The mean effluent concentration for suspended solids was less then the mean background concentration indicating a net removal of solids from the source water as it passed through the VortSentry® System. With the sump filled to 100 percent of the VortSentry® System sediment storage capacity (three feet), minimal washout was observed. The mean effluent concentration for suspended solids was slightly higher then the mean background concentration indicating a small amount of material was exported from the system. The mean effluent solids concentration after accounting for background solids was 8 mg/l, which is quite low; fine particles were present in the F-95 stock as a result of manufacture and handling. Most of the sediment was manually loaded into the VortSentry® System for this testing as opposed to being captured by the unit, so it is likely that residual fine material that would not typically be present in the sump was subsequently lost from the unit.

Table 5. Results of Washout Testing at 50% and 100% of the VortSentry® Sediment Storage Capacity

	Average Background Concentration (mg/l)	Average Effluent Concentration (mg/l)	Mean Adjusted Effluent Concentration (mg/l)
50% of sediment storage capacity (1.5 ft)	8	5	-3
100% of sediment storage capacity (3 ft)	5	14	8

5.3 Verification Procedures

All the data provided to NJCAT were reviewed to fully understand the capabilities of the VortSentry® System. To verify the Stormwater360™, Inc. claim, the laboratory data were reviewed and compared to the NJDEP Laboratory Testing Protocol. Although Stormwater360™, Inc. attempted to design their laboratory experiment to satisfy the NJDEP TSS laboratory testing protocol, there are two distinct differences between Stormwater360™, Inc. laboratory testing and the NJDEP protocol. The NJDEP protocol is for total suspended solids (TSS) laboratory testing, while Stormwater360™, Inc. analyzed their samples as suspended sediment concentration (SSC). Also, the d_{50} of the NJDEP recommended sediment is approximately 67 microns, while the d_{50} of the F-95 silica used in the Stormwater360™, Inc. laboratory testing was 120 microns.

The NJDEP weighting factors were used with the laboratory data that were presented in Table 4. The resulting overall removal efficiency based upon the NJDEP methodology is presented below in Table 6.

Since the treatment volume of the VS40 system is 50 ft^3, the tested flow rate of 1.1 cfs can be converted to 9.8 gpm/ft^3(0.022 cfs/ft^3). Based upon the data presented in Table 6, the removal efficiency of the system is 69%, thereby verifying the Stormwater360™, Inc. claim.

Based upon the wash out laboratory data presented by Stormwater360™, Inc., there is virtually no potential of re-suspension and wash out of sediment contained in the VortSentry® System.

Table 6. Weighted Removal Efficiency for the VortSentry® System

Percent of Treatment Flow Rate (%)	Target VS40 Flow Rate (cfs)	Removal Efficiency (%)	Weight factor	Weighted Removal Efficiency (%)
25	0.27	94	0.25	24
50	0.55	75	0.30	22
75	0.82	63	0.20	13
100	1.10	47	0.15	7
125	1.35	29	0.10	3
Weighted Removal Efficiency =				**69**

5.3.1 Verified Treatment Flow

In order to appropriately scale any hydraulic structure, there must be similitude between the proposed model and the tested laboratory prototype. Geometric similitude is achieved by maintaining a constant aspect ratio of 0.9 for all models. For modeling purposes, the treatment depth is considered to be the distance from the top of the flow partition to the top of the 3' deep storage sump.

It has been shown in the laboratory that VortSentry® removal rates are dependent on the volumetric operating rate. Therefore, treatment flow rates for models other than the tested unit have been calculated which provide the same volumetric operating rate of 9.8 gpm/ft^3 (0.022 cfs/ft^3). Table 7 shows these peak treatment flow rate for each VortSentry® model.

Table 7. VortSentry Treatment Flows Assuming Volumetric Scaling

Model Number	Diameter (ft)	Treatment Volume (ft^3)	Treatment Flow Rate		Operating Rate	
			(cfs)	(gpm)	(cfs/ft^3)	(gpm/ft^3)
VS30	3	21	0.46	207	0.022	9.8
VS40	4	50	1.1	494	0.022	9.8
VS50	5	98	2.15	965	0.022	9.8
VS60	6	170	3.71	1,665	0.022	9.8
VS70	7	269	5.90	2,648	0.022	9.8
VS80	8	402	8.80	3,950	0.022	9.8
VS100*	10*	785	17.19	7,715	0.022	9.8
VS120*	12*	1,357	29.70	13,330	0.022	9.8

* 10 and 12 ft. diameter units are not available in all markets.

5.4 Inspection and Maintenance

The VortSentry® System requires minimal routine maintenance. However, it is important that the system be inspected at regular intervals and cleaned when necessary to ensure optimum performance. The rate at which the system collects pollutants will depend more on site activities than the size of the unit (i.e., heavy winter sanding will cause the treatment chamber to fill more quickly but regular sweeping will slow accumulation).

5.4.1 Inspection

Inspection is the key to effective maintenance, and it is easily performed. Stormwater360™, Inc. recommends ongoing quarterly inspections of accumulated pollutants. Sediment accumulation may be especially variable during the first year after installation as catch basin sumps are filled and as construction disturbances and landscaping stabilize. Quarterly inspections are typically sufficient to ensure that systems are cleaned out at the appropriate time. Inspections may need to be performed more often in the winter months in climates where sanding operations may lead to rapid accumulations or in other areas with heavy sediment loading. It is very useful to keep a record of each inspection.

The VortSentry® System should be cleaned when inspection reveals that the sediment depth has accumulated to three feet in the treatment chamber sump. This determination can be made by taking two measurements with a stadia rod or similar measuring device. One measurement should be taken from the manhole opening to the top of the sediment pile and the other from the manhole opening to the water surface. The system should be cleaned out if the difference between the two measurements is three feet or more.

Note: To avoid underestimating the volume of sediment in the chamber, the measuring device must be lowered to the top of the sediment pile carefully. Finer, silty particles at the top of the pile may offer less resistance to the end of the rod than larger particles toward the bottom of the pile.

5.4.2 Maintenance

Maintaining the VortSentry® System is easiest when there is no flow entering the system. For this reason it is a good idea to schedule the cleanout during dry weather. Cleanout of the VortSentry® System with a vacuum truck is generally the most effective and convenient method of excavating pollutants from the system. If such a truck is not available, a “clamshell” grab may be used, but it is difficult to remove all accumulated pollutants with these devices.

Accumulated sediment is typically evacuated through the manhole over the treatment chamber. Simply remove the cover and insert the vacuum hose into the treatment chamber. All contents of the treatment chamber should be removed with the vacuum hose. The treatment chamber will contain a combination of liquid, sediment, floating debris, and oil and grease.

Motor oil and other hydrocarbons that accumulate on a more routine basis should be removed when an appreciable layer has been captured. To remove these pollutants, it may be preferable to use adsorbent pads since they are usually cheaper to dispose of than the oil water emulsion that may be created by vacuuming the oily layer. In VortSentry® System installations where there is little risk of petroleum spills, liquid contaminants may not accumulate as quickly as sediment. However, any oil or gasoline spill should be cleaned out immediately. Trash can be netted out if it needs to be separated from the other pollutants.

Manhole covers should be securely seated following cleaning activities, to ensure that surface runoff does not leak into the unit from above.

5.4.3 Solids Disposal

Solids recovered from the VortSentry® System can typically be land filled or disposed of at a wastewater treatment plant, but local regulations will ultimately govern disposal procedures.

5.4.4 Damage Due to Lack of Maintenance

It is unlikely that the VortSentry® System will become damaged due to lack of maintenance since there are no fragile internal parts. However, adhering to a regular maintenance plan ensures optimal performance of the system.

6. Technical Evaluation Analysis

6.1 Verification of Performance Claim

Based on the evaluation of the results from laboratory studies, sufficient data is available to support the Stormwater360™, Inc. claim: The VortSentry® Stormwater Treatment System, Model VS40, sized at a loading rate of 9.8 gpm/ft^3 (0.022cfs/ft^3) of treatment volume, has been shown to have a 69% total suspended solids (TSS) removal efficiency, as measured as suspended solids concentration (SSC) (as per the NJDEP methodology for calculation of treatment efficiency) for F-95 silica sand with an average d_{50} particle size of 120 microns, an average influent concentration of 209 mg/L and 50% initial sediment loading in laboratory studies using simulated stormwater.

6.2 Limitations

6.2.1 Factors Causing Under-Performance

If the VortSentry® System is designed and installed correctly, there is minimal possibility of failure. There are no moving parts to bind or break, nor are there parts that are particularly susceptible to wear or corrosion. Lack of maintenance may cause the system to operate at a reduced efficiency, and it is possible that eventually the system will become totally plugged with sediment.

6.2.2 Pollutant Transformation and Release

The VortSentry® System will not increase the net pollutant load to the downstream environment. However, pollutants may be transformed within the unit. For example, organic matter may decompose and release nitrogen in the form of nitrogen gas or nitrate. These processes are similar to those in wetlands but probably occur at slower rates in the VortSentry® System due to the absence of light and mixing by wind, thermal inputs and biological activity. Accumulated sediment will not be lost from the system under normal operating conditions.

6.2.3 Sensitivity to Heavy or Fine Sediment Loading

The VortSentry® System requires no pretreatment. Heavy loads of sediment will increase the needed maintenance frequency but will not negatively affect overall performance.

6.2.4 Bypass Flow

The VortSentry® System is typically designed such that a portion of the total conveyance flow through the system is bypassed around the treatment chamber. Flow rates exceeding the treatment capacity of the system are typically routed around the treatment chamber over the flow partition.

6.2.5 Mosquitoes

The VortSentry® System design incorporates standing water in the treatment chamber sump, which can be a breeding site for mosquitoes. To address this potential problem Stormwater360™ sells an optional manhole cover insert that allows outgassing but will prevent mosquitoes from entering the system through the manhole covers. A flap valve can be installed at the terminal end of the outlet pipe to prevent mosquitoes from entering the unit from the downstream side.

7. Net Environmental Benefit

The NJDEP encourages the development of innovative environmental technologies (IET) and has established a performance partnership between their verification/certification process and NJCAT's third party independent technology verification program. The NJDEP, in the IET data and technology verification/certification process, will work with any company that can demonstrate a net beneficial effect (NBE) irrespective of the operational status, class or stage of an IET. The NBE is calculated as a mass balance of the IET in terms of its inputs of raw materials, water and energy use and its outputs of air emissions, wastewater discharges, and solid waste residues. Overall the IET should demonstrate a significant reduction of the impacts to the environment when compared to baseline conditions for the same or equivalent inputs and outputs.

Once VortSentry® Systems have been certified for interim use within New Jersey, Stormwater360™, Inc. will then proceed to install and monitor systems in the field for the purpose of achieving goals set by the Tier II Protocol and final certification. At that time, a net environmental benefit evaluation will be completed. However, it should be noted that the Stormwater360™, Inc. technology requires no input of raw material, has no moving parts, and therefore, uses no water or energy.

8. References

Patel, M. 2003, *Draft Total Suspended Solids Laboratory Testing Procedures*, December 23, 2003, New Jersey Department of Environmental Protection, Office of Innovative Technology and Market Development.

Stormwater360™, Inc., October 2005, VortSentry® Stormwater Treatment System Technology Report, *Prepared for: New Jersey Corporation for Advanced Technology.*

Stormwater360™, Inc., October 2005, VortSentry® Technical Design Manual.

Title	***MA DEP Standard Calculations***	By	SJL
Project	*Broadstone Bare Cove*	Chk'd	CMQ
Date	August 12, 2016	Apprv'd	CMQ
Revised	October 25, 2016		

Stormwater Recharge/Water Quality Volume Table

Rv = F * Impervious Area

Rv *= Required Recharge Volume, expressed in ft^3, cubic yards or acre-feet*

F *= Target Depth Factor associated with each Hydraulic Soil Group*

Impervious Area *= pavement & rooftop area on site*

V_{WQ} *= Required Water Quality Treatment Volume (ft^3)*

D_{WQ} *= Water Quality Depth (in)*

A_{IMP} *= Impervious Area (excluding non-metal roofs)*

			Impervious Area (Square Feet)			Recharge Required			Water Quality Volume Required	
W'SHED	Area (Sq. Ft)	Landscaped	HSG A (F=.6)	HSG B (F=.35)	HSG D (F=.1)	*F Avg. (Inches)*	*Impervious Area (Sq. Ft)*	*Rv (ft^3)*	D_{WQ} *(Inch)*	V_{WQ}
P-1	19,602	16,202	100	3,300	0	0.357	3,400	101	1.0	283
P-2	9,533	2,529	0	7,004	0	0.350	7,004	204	1.0	584
P-3	25,878	22,195	0	3,683	0	0.350	3,683	107	1.0	307
P-4	3,443	0	0	3,443	0	0.350	3,443	100	1.0	287
P-5	26,819	5,874	12,978	7,967	0	0.505	20,945	881	1.0	1,745
P-6	22,639	22,346	293	0	0	0.600	293	15	1.0	24
P-7	13,890	4,869	0	9,021	0	0.350	9,021	263	1.0	752
P-8	8,052	1,629	0	6,423	0	0.350	6,423	187	1.0	535
P-9	12,329	7,309	0	5,020	0	0.350	5,020	146	1.0	418
P-10	34,442	24,720	1,812	7,910	0	0.397	9,722	321	1.0	810
P-11	21,449	11,375	0	10,074	0	0.350	10,074	294	1.0	840
P-12	15,395	6,480	0	8,915	0	0.350	8,915	260	1.0	743
P-13	4,800	1,566	0	3,234	0	0.350	3,234	94	1.0	270
P-14	24,445	11,965	0	12,480	0	0.350	12,480	364	1.0	1,040
P-15	16,750	14,165	0	2,585	0	0.350	2,585	75	1.0	215
P-16	18,626	8,929	0	9,697	0	0.350	9,697	283	1.0	808
P-17	23,626	22,326	0	1,300	0	0.350	1,300	38	1.0	108
P-18	89,505	89,505	0	0	0	0.000	0	0	1.0	0
P-19	33,178	33,178	0	0	0	0.000	0	0	1.0	0
R-1	31,613	0	7,300	24,313	0	0.408	31,613	1,074	1.0	2,634
R-2A	23,334	0	1,976	21,358	0	0.371	23,334	722	1.0	1,945
R-2B	35,439	0	8,577	26,862	0	0.411	35,439	1,212	1.0	2,953
R-2C	10,505	0	4,367	6,138	0	0.454	10,505	397	1.0	875
Total	525,292	307,162	37,403	180,727	0	0.393	218,130	**7,141**		**18,178**

Allen & Major Associates, Inc.	Computation Sheet

Title	***MA DEP Standard Calculations***	By	SJL
Project	*Broadstone Bare Cove*	Chk'd	CMQ
Date	August 12, 2016	Apprv'd	CMQ
Revised	October 25, 2016		

Stormwater Recharge Summary

Rv = F * Impervious Area

Rv *= Required Recharge Volume, expressed in* ft^3*, cubic yards or acre-feet*

F *= Target Depth Factor associated with each Hydraulic Soil Group*

	Required (cf)	Provided (cf)	
Rv =	1,193	3,067	Underground Infiltration System #1 (P-2, P-3, P-5)
Rv =	3,047	8,460	Underground Infiltration System #2 (P-4, P-7, P-8, P-9, P-11, P-12, R-1, R-2A)
Rv =	719	1,860	Underground Infiltration System #3 (P-10 & R-2C)
Rv =	1,991	5,276	Underground Infiltration Syetem #4 (P-13, P-14, P-16, P-17, R-2B)
Rv =	191	0	Unmitigated Areas (P-1, P-6, P-15, P-18, P-19)
Rv =	7,141	18,663	Total

Water Quality Volume

V_{WQ} *= Required Water Quality Treatment Volume, expressed in* ft^3

D_{WQ} *= Water Quality Depth*

A_{IMP} *= Impervious Area (pavement & rooftop area excluding non-metal roofs)*

**Volume was reduced from 2,636 c.f. to 2,106 c.f. by using the "Simple Dynamic" method. See calculations in Section 1 entitlted "MA DEP Stormwater Performance Standards."

	Required (cf)	Provided (cf)	
**V_{WQ} =	2,106	3,067	Underground Infiltration System #1 (P-2, P-3, P-5)
V_{WQ} =	8,154	8,460	Underground Infiltration System #2 (P-4, P-7, P-8, P-9, P-11, P-12, R-1, R-2A)
V_{WQ} =	1,686	1,860	Underground Infiltration System #3 (P-10 & R-2C)
V_{WQ} =	5,179	5,276	Underground Infiltration Syetem #4 (P-13, P-14, P-16, P-17, R-2B)
V_{WQ} =	523	0	Unmitigated Areas (P-1, P-6, P-15, P-18, P-19)
V_{WQ} =	17,648	18,663	Total

Draindown Within 72 Hours

$\text{Time}_{drawdown}$=(Rv) (1/Design Infiltration Rate in inches per hour) (Conversion for inches to feet) (1/bottom area in feet)

Underground Infiltration System #1 (B-3 - Sand)	
Infiltration Rate (in/Hr)=	8.27
Bottom Area (ft^2) =	3,065
Infiltration Volume (ft^3) =	3,067
$\text{Time}_{drawdown}$ (Hours)=	1.45

Underground Infiltration System #2 (Sandy Loam)	
Infiltration Rate (in/Hr)=	1.02
Bottom Area (ft^2) =	5,963
Infiltration Volume (ft^3) =	8,460
$\text{Time}_{drawdown}$ (Hours)=	16.69

Underground Infiltration System #3 (Sandy Loam)	
Infiltration Rate (in/Hr)=	1.02
Bottom Area (ft^2) =	1,597
Infiltration Volume (ft^3) =	1,860
$\text{Time}_{drawdown}$ (Hours)=	13.70

Underground Infiltration System #4 (Sandy Loam)	
Infiltration Rate (in/Hr)=	1.02
Bottom Area (ft^2) =	3,228
Infiltration Volume (ft^3) =	5,276
$\text{Time}_{drawdown}$ (Hours)=	19.23

Title	*MA DEP Standard Calculations*	By	SJL
Project	*Broadstone Bare Cove*	Chk'd	CMQ
Date	August 12, 2016	Apprv'd	CMQ
Revised	October 25, 2016		

TSS Removal Calculation Worksheet

B BMP[1]	C TSS Removal Rate[1]	D Starting TSS Load*	E Amount Removed (C*D)	F Remaining Load (D-E)
Deep Sump Catch Basins	0.25	1.00	0.25	0.75
Contech Proprietary Device #1	0.50	0.75	0.38	0.38
Subsurface Infiltration System #1	0.80	0.38	0.30	0.08
		Total TSS Removal =	93%	

B BMP[1]	C TSS Removal Rate[1]	D Starting TSS Load*	E Amount Removed (C*D)	F Remaining Load (D-E)
Deep Sump Catch Basins	0.25	1.00	0.25	0.75
Contech Proprietary Device #2	0.50	0.75	0.38	0.38
Subsurface Infiltration System #2	0.80	0.38	0.30	0.08
		Total TSS Removal =	93%	

B BMP[1]	C TSS Removal Rate[1]	D Starting TSS Load*	E Amount Removed (C*D)	F Remaining Load (D-E)
Deep Sump Catch Basins	0.25	1.00	0.25	0.75
Contech Proprietary Device #3	0.50	0.75	0.38	0.38
Subsurface Infiltration Structure #3	0.80	0.38	0.30	0.08
		Total TSS Removal =	93%	

B BMP[1]	C TSS Removal Rate[1]	D Starting TSS Load*	E Amount Removed (C*D)	F Remaining Load (D-E)
Deep Sump Catch Basins	0.25	1.00	0.25	0.75
Contech Proprietary Device #4	0.50	0.75	0.38	0.38
Subsurface Infiltration Structure #4	0.80	0.38	0.30	0.08
		Total TSS Removal =	93%	

Title	***MA DEP Standard Calculations***	By	SJL
Project	*Broadstone Bare Cove*	Chk'd	CMQ
Date	August 12, 2016	Apprv'd	CMQ
Revised	October 25, 2016		

Mounding Analysis

Infiltration System	*Water Table*	*System Bottom*	*Vertical Separation*	*Attenuated System*	Mounding Analysis Required
1	6.50	12.75	6.3	Yes	No
2	6.50	18.25	11.8	Yes	No
3	6.50	12.55	6.1	Yes	No
4	6.50	12.15	5.7	Yes	No

Water Quality Flow Rate Calculations for Proprietary Stormwater Separators

Reference: **Massachusetts Department of Environmental Protection Wetlands Program:** Standard Method to Convert Water Quality Volume to a Discharge Rate for Sizing Flow Based Manufactured Proprietary Stormwater Treatment Practices

Structure Name	Total Area (Acres)	Imp. Area (Acres)	A^{IMP} (Sq. Miles)	Tc (min.)	Tc (hrs.)	WQV (inches)	qu (csm/in)
CDS #1	0.22	0.15	0.00024	6.0	0.10	1	774
CDS #2	0.62	0.46	0.00072	6.0	0.10	1	774
CDS #3	0.40	0.21	0.00033	6.0	0.10	1	774
CDS #4	1.31	0.45	0.00070	6.0	0.10	1	774
CDS #5	0.79	0.23	0.00035	6.0	0.10	1	774
CDS #6	1.10	0.57	0.00089	6.0	0.10	1	774
CDS #7	0.33	0.21	0.00032	6.0	0.10	1	774

Water Quality Flow Rate = Q1 = (qu) (A) (WQV)

Structure Name	Q1 (cfs)
CDS #1	0.18
CDS #2	0.55
CDS #3	0.25
CDS #4	0.54
CDS #5	0.27
CDS #6	0.69
CDS #7	0.25

Allen & Major Associates, Inc.	Computation Sheet

Title	***Pipe Sizing Table***	Minimum Slope:	0.50%		By SJL
Project	Broadstone Bare Cove	Minimum Pipe Size:	12		Chk'd CMQ
Date	August 12, 2016	Rainfall Intensity (in/hr):	6.00	(25 year storm)	Apprv'd CMQ
Revised	October 25, 2016	Manning's n:	0.011	HDPE/PVC	
A&M Project Number: 2118-02		Minimum Pipe Cover:	1.34	(AREA DRAIN 1F)	

Broadstone Bare Cove

Line						Req'd. Capac.	Pipe Size	Slope	Design Capacity		Drop	Invert Elevation		Rim Elev.	
From Upper	To Lower	Length (feet)	Area (acres)	wgt. *C*	*C* A	*Qd* (cfs)	*D* (in)	*s* (%)	Q_{full} (cfs)	V_{full} (fps)	(feet)	Upper (ft)	Lower (ft)	Upper (ft)	Cover (ft)
CB1	CDS1	14	0.219	0.79	0.173	1.04	12	5.00%	9.4	11.99	0.70	20.00	19.30	24.50	3.38
CDS1	DMH1/UIS1	3				1.04	12	5.00%	9.4	11.99	0.15	19.30	19.15	24.50	4.08
CB2A	DMH2	22	0.283	0.81	0.229	1.37	12	1.00%	4.2	5.36	0.22	16.00	15.78	19.00	1.88
CB2B	DMH2	12	0.332	0.83	0.275	1.65	12	2.00%	6.0	7.58	0.24	16.00	15.76	19.00	1.88
DMH2	CDS2	50				3.02	12	3.00%	7.3	9.29	1.50	15.66	14.16	19.40	2.62
CDS2	UIS1	4				3.02	12	2.00%	6.0	7.58	0.08	14.16	14.08	21.00	5.72
OCS1	DMH12	80	***(From HydroCAD 25-Year Storm)***			**1.54**	12	1.00%	4.2	5.36	0.80	14.75	13.95	21.00	5.13
CB3A	DMH3	20	0.040	0.95	0.038	0.23	12	1.00%	4.2	5.36	0.20	11.30	11.10	14.30	1.88
CB3B	DMH3	20	0.040	0.95	0.038	0.23	12	1.00%	4.2	5.36	0.20	11.30	11.10	14.30	1.88
DMH3	TANK	90				0.45	12	1.00%	4.2	5.36	0.90	11.00	10.10	16.40	4.28
TANK	CDS3	9	***(Pump discharge - 100-Year Storm)***			**0.53**									
CB4	CDS3	7	0.319	0.74	0.236	1.42	12	5.00%	9.4	11.99	0.35	21.00	20.65	25.50	3.38
CDS3	DMH4/UIS2	7				1.95	12	5.00%	9.4	11.99	0.35	20.65	20.30	25.90	4.13
CB5A	DMH5	90	0.353	0.70	0.246	1.48	12	2.00%	6.0	7.58	1.80	24.20	22.40	27.20	1.88
CB5B	DMH5	6	0.283	0.59	0.168	1.01	12	5.00%	9.4	11.99	0.30	23.10	22.80	26.10	1.88
DMH5	DMH6	34				2.49	12	2.00%	6.0	7.58	0.68	22.30	21.62	26.40	2.98
CB6	DMH6	33	0.283	0.59	0.168	1.01	12	3.03%	7.3	9.33	1.00	23.00	22.00	26.70	2.58
DMH6	CDS4	37				3.50	15	1.00%	7.7	6.22	0.37	21.52	21.15	26.80	3.91
CB7	CDS4	11	0.185	0.83	0.153	0.92	12	5.00%	9.4	11.99	0.55	21.70	21.15	25.60	2.78
CDS4	UIS2	4				4.42	15	5.00%	17.1	13.91	0.20	21.15	20.95	25.80	3.28
AD1F	DMH8	209	0.187	0.95	0.177	1.06	12	2.00%	6.0	7.58	4.18	23.54	19.36	26.00	1.34
CO1	DMH8	722	0.539	0.95	0.512	3.07	15	0.50%	5.4	4.40	3.61	22.97	19.36	26.90	2.56
DMH8	DMH9/UIS2	16				4.14	12	1.00%	4.2	5.36	0.16	19.26	19.10	26.30	5.92
CO2B	DMH9	292	0.411	0.66	0.272	1.63	12	2.00%	6.0	7.58	5.84	26.19	20.35	28.90	1.59
CO2E	DMH9	172	0.124	0.95	0.118	0.71	12	1.00%	4.2	5.36	1.72	22.07	20.35	24.00	0.81
DMH9	UIS2	115				2.34	12	1.00%	4.2	5.36	1.15	20.25	19.10	28.20	6.83
OCS2	DMH10	52	***(From HydroCAD 25-Year Storm)***			4.58	15	2.00%	10.8	8.80	1.04	19.00	17.96	26.30	5.93
DMH10	DMH11	210				4.58	15	1.00%	7.7	6.22	2.10	17.86	15.76	26.70	7.47
CB13	CDS5	116	0.791	0.54	0.426	2.55	12	1.00%	4.2	5.36	1.16	14.50	13.34	17.50	1.88
CDS5	DMH13/UIS3	4				2.55	12	1.00%	4.2	5.36	0.04	13.34	13.30	22.70	8.24
CO2E	DMH14/UIS3	374	0.241	0.95	0.229	1.37	12	2.00%	6.0	7.58	7.48	20.88	13.40	26.00	4.00
OCS3	DMH11	24	***(From HydroCAD 25-Year Storm)***			**0.79**	12	1.00%	4.2	5.36	0.24	14.35	14.11	22.90	7.43
DMH11	DMH12	76				5.37	15	1.00%	7.7	6.22	0.76	14.01	13.25	22.10	6.72
DMH12	HW1	15				6.91	18	1.00%	12.4	7.03	0.15	13.15	13.00	19.80	5.03

Allen & Major Associates, Inc. Computation Sheet

Title	***Pipe Sizing Table***	Minimum Slope:	0.50%		By	SJL
Project	Broadstone Bare Cove	Minimum Pipe Size:	12		Chk'd	CMQ
Date	August 12, 2016	Rainfall Intensity (in/hr):	6.00	(25 year storm)	Apprv'd	CMQ
Revised	October 25, 2016	Manning's n:	0.011	HDPE/PVC		
A&M Project Number: 2118-02		Minimum Pipe Cover:	1.34	(AREA DRAIN 1F)		

Broadstone Bare Cove

Line						Req'd. Capac.	Pipe Size	Slope	Design Capacity		Drop	Invert Elevation		Rim Elev.	
From Upper	To Lower	Length (feet)	Area (acres)	wgt. *C*	*C* A	*Qd* (cfs)	*D* (in)	*s* (%)	Q_{full} (cfs)	V_{full} (fps)	(feet)	Upper (ft)	Lower (ft)	Upper (ft)	Cover (ft)
CB15	CDS6	124	0.110	0.75	0.083	0.50	12	5.00%	9.4	11.99	6.20	19.40	13.20	28.20	7.68
CB14A	DMH14	86	0.428	0.66	0.283	1.70	12	1.00%	4.2	5.36	0.86	14.31	13.45	19.60	4.17
CB14B	DMH14	14	0.561	0.66	0.368	2.21	12	5.00%	9.4	11.99	0.70	14.15	13.45	23.20	7.93
DMH14	CDS6	3				3.91	12	5.00%	9.4	11.99	0.15	13.35	13.20	22.80	8.33
CDS6	DMH15	6				4.41	12	5.00%	9.4	11.99	0.30	13.20	12.90	22.90	8.58
CO2C	DMH16	142	0.407	0.95	0.386	2.32	12	5.00%	9.4	11.99	7.10	21.85	14.75	28.90	5.93
CO2D	DMH16	354	0.407	0.95	0.386	2.32	12	2.00%	6.0	7.58	7.08	21.83	14.75	26.00	3.05
DMH16	DMH17/UIS4	33				4.64	12	5.00%	9.4	11.99	1.65	14.65	13.00	25.00	9.23
OCS4	DMH19	70	***(From HydroCAD 25-Year Storm)***			7.67	18	1.00%	12.4	7.03	0.70	14.95	14.25	20.20	3.63
DMH19	DMH20	75				7.67	18	1.00%	12.4	7.03	0.75	14.15	13.40	19.00	3.23
DMH20	HW2	20				7.67	18	1.00%	12.4	7.03	0.20	13.30	13.10	21.40	6.48

BROADSTONE BARE COVE, HINGHAM, MA

Allen & Major Associates, Inc.

Computation Sheet	
By	SJL
Chk'd	CMQ
Apprv'd	CMQ

Title:	***RipRap Sizing Spreadsheet***
Project:	Broadstone Bare Cove
Date:	August 12, 2016
Revised:	October 25, 2016
A&M Project Number:	2118-02

OUTLET	Do (ft.)	Q10 (cfs)	Tw (ft.)	La (ft.)	Wup (ft.)	Wdn (ft.)	d50 (ft.)*
HEADWALL-1	1.50	4.38	0.5	14.8	4.5	19.3	0.18
FES-2	1.50	6.05	0.5	16.4	4.5	20.9	0.28

Notes:

Assume 6" Tw at Outfall

z

Use MHD M2.02.2 Stone

Depth of Stone to be 6" or 1.5 times d50 - which ever is larger

* 6" Stone Minimum

**Apron width shall meet defined channel downstream

When Tw < 0.5Do at pipe outlet:

La = 1.8Q/Do^1.5 + 7Do

Wup = 3Do

Wdn = 3Do + La

d50 = (0.02Q^1.3)/(TwDo)

When Tw > or = 0.5Do at pipe outlet:

La = 3Q/Do^1.5 + 7Do

Wup = 3Do

Wdn = 3Do + 0.4La

d50 = (0.02Q^1.3)/(TwDo)

Where:

Tw = the tailwater depth at the outlet of the pipe or channel

Do = the diameter of the pipe or the width of channel

Q = the discharge from the pipe of channel (10 year Storm)

La = the length of apron

Wup = the upstream width of apron

Wdn = the downstream width of apron

d50 = the median stone diameter

Illicit Discharge Compliance Statement

Responsibility:

The Owner is responsible for ultimate compliance with all provisions of the Massachusetts Stormwater Management Policy, the USEPA NPDES Construction General Permit and responsible for identifying and eliminating illicit discharges (as defined by the USEPA).

OWNER NAME:	Alliance Residential Company
ADDRESS:	184 High Street, Suite 401
	Boston, MA 02110
TEL. NUMBER:	(617) 356-1000

Engineer's Compliance Statement:

To the best of my knowledge, the attached plans, computations and specifications meet the requirements of Standard 10 of the Massachusetts Stormwater Handbook regarding illicit discharges to the stormwater management system and that no detectable illicit discharges exist on the site. All documents and attachments were prepared under my direction and qualified personnel properly gathered and evaluated the information submitted, to the best of my knowledge.

Included with this statement are site plans, drawn to scale, that identify the location of systems for conveying stormwater on the site and show that these systems do not allow the entry of any illicit discharges into the stormwater management system. The plans also show any systems for conveying wastewater and/or groundwater on the site and show that there are no connections between the stormwater and wastewater systems.

For a redevelopment project (if applicable), all actions taken to identify and remove illicit discharges, including without limitation, visual screening, dye or smoke testing, and the removal of any sources of illicit discharges to the stormwater management system are documented and included with this statement.