Engineering Report

West Side Elementary School
250 Brandegee Avenue
Groton, Connecticut
June 18, 2019
(Revised July 26, 2019)

Prepared for:
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ENGINEERING | PLANNING | LANDSCAPE ARCHITECTURE | ENVIRONMENTAL SCIENCE

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1.0   PROJECT OVERVIEW

The descriptions and computations included within this engineering report are provided in support of the proposed construction of the new West Side Elementary School building to be located on the same parcel that currently houses the existing West Side STEM Middle School in the City of Groton, Connecticut. After the new school building is completed, the existing school building will be demolished, and the new parking area will be constructed. The new building will be located in the northwest corner of the ±40.6-acre site.

The subject parcel is located on the east side of Brandegee Avenue and lies within the residential (R-52) zone. The new school building will gain access from Brandegee Avenue via a new reconfigured driveway and bus drop-off loop west of the proposed school building. An additional entrance drive and new parking area will be provided south of the proposed school building.

The project will be serviced by the existing municipal water and sewer systems. Domestic and fire protection water services will be provided to the proposed school by an extension of the existing water main in Brandegee Avenue. Domestic sewage will be collected by a new gravity sanitary sewer line along the northern property boundary that will flow to a proposed pump station that will be located near the eastern building wing. The sewage flows will be pumped via a new force main to an existing sewer manhole in Brandegee Avenue. All other utilities such as electric, telephone, cable, and gas service will be located underground through extensions of the existing services in Brandegee Avenue. More detailed design information regarding the proposed utilities are depicted on the site plans.

The stormwater management system for this site has been designed utilizing Best Management Practices (BMPs) to provide water quality management while attenuating peak-flow rates from the site. The design goal is to provide water quality treatment and groundwater recharge in accordance with the Connecticut Department of Energy & Environmental Protection (CTDEEP) *2004 Stormwater Quality Manual* and prevent increases in the predevelopment runoff rates from the redeveloped site. The proposed system will use one aboveground detention basin along with water quality measures before discharging stormwater runoff from the project site. Temporary sediment and erosion controls will also be employed during construction to help prevent sediment transport from the site until construction is complete and permanent cover is established. For more detailed information regarding stormwater quantity, refer to Sections 3.0 and 4.0 of this report. Refer to Section 5.0 for stormwater quality management provided in the proposed design. Design computations and other relevant information are provided in the Appendix of this report.

2.0   EXISTING SITE CONDITIONS

The project site is located in the southwestern portion of Groton, Connecticut. The overall parcel is ±40.6 acres in size located at 250 Brandegee Avenue. Redevelopment of the existing West Side Middle School is proposed within the western property frontage that currently consists of the previously disturbed and currently maintained school grounds on the property. The site is located east of the intersection of Hynes Avenue and Morse Avenue with Brandegee Avenue in a moderately settled residential section within the City of Groton. The property has been utilized as a school for over 50 years. The developed school grounds within the property include the school buildings and surrounding parking area, a basketball court in the north end of the site, and a multipurpose athletic field to the east. Brandegee Avenue defines the western boundary of the site. Single family and multifamily residential properties border the site to the north and south. Beyond these residential developments, the property is bordered by undeveloped, forested land to the north, east, and south. Birch Plain Creek and its associated tidal wetlands bounds the property to the east.

The inland wetlands and watercourses were delineated on the site in June 2018 by Milone & MacBroom, Inc. (MMI). A woodland edge exists to the east of the school grounds and transitions to a rich mesophytic forest, which leads downgradient to a red maple forested floodplain wetland. Beyond this wetland, a tidal marsh abuts Birch Plain Creek on the eastern property limits, which flows south to Baker Cove before entering Long Island Sound. The proposed project was designed to minimize any direct impacts to wetlands and has incorporated design features to maintain the existing condition and functionality of the wetland systems. All construction activities will occur within the disturbed and currently maintained school grounds, except for the proposed detention basin, which will be installed in the sloped wooded land to the east of the school. Site protections are incorporated to avoid potential impacts during construction and maintain the long-term potential for wildlife species utilization through habitat protection.

Stormwater on the site is currently conveyed by two storm drainage systems. The stormwater from the northern portion of the school campus is collected and discharged through a 36-inch reinforced concrete pipe (RCP). This drainage system also collects runoff from a portion of Brandegee Avenue and other off-site residential lots on Brandegee Avenue. The final 36-inch pipe outlets to a ditch that runs into an intermittent watercourse and ultimately to the wetland system on the eastern portion of the property. The second storm drainage system outlets through an 18-inch RCP that collects stormwater from the existing building structure and the remaining developed portions of the school campus. This outlet is centrally located to the east of the existing school building and discharges into a ditch that leads to an intermittent watercourse that flows into the on-site wetlands.

The existing West Side STEM Magnet Middle School is located in an elevated area west of Birch Plain Creek as shown on the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) included in the Appendix of this report. The existing area of the property presently used for school and active recreation does not lie within the Special Flood Hazard Area (SFHA) as delineated by FEMA. The Zone AE floodplain area is located on the eastern portion of the property with a base flood elevation (BFE) of 10 feet, which is approximately 100 feet lower than the existing building structure.

The project site is bisected by a watershed divide between the Southeast Shoreline and the Thames River basins. The eastern portion of the site is located in the Southeast Shoreline Subregional Basin, which is located within the Southeast Shoreline Regional Basin, within the Southeast Coast Major Basin, identified as Regional Basin 2000 on the CTDEEP *Atlas of Public Water Supply Sources and Drainage Basins*. The western portion of the site is located in the Thames River Subregional Basin, which is located in the Thames Main Stem Regional Basin within the Thames Major Basin, identified as Regional Basin 3000. Furthermore, the site is not located within an aquifer protection zone. The school property is located within a ¼ mile of a mapped Natural Diversity Database (NDDB) area of endangered, threatened, or special concern species, so a determination is being sought from the CTDEEP. The groundwater in the site is classified as GB, and the nearby surface water is classified as A on the CTDEEP ECO website.

3.0   STORMWATER MANAGEMENT DESIGN

Stormwater management was achieved by collecting stormwater runoff and conveying it to the proposed aboveground stormwater basin, which has been designed to attenuate the proposed peak flows as well as provide retention storage for water quality and groundwater recharge before discharging to the existing wetland areas to the east. The goal of the storm drainage system design is to remove Total Suspended Solids (TSS) and other potential stormwater pollutants while attenuating the postdevelopment peak runoff rates. The stormwater management design will incorporate the use of water quality measures such as retention volume, level spreader outlet, catch basins with deep sumps, and hydrodynamic separators. More information regarding water quantity and quality is provided in the following sections.

The computer program entitled *Hydraflow Storm Sewers Extension for AutoCAD Civil 3D 2016* by Autodesk, Inc., Version 10.5, was used for designing the proposed stormwater collection system. Storm drainage computations performed include pipe conveyance capacity and hydraulic grade line calculations. The overall watershed was divided into subbasins to determine the drainage area and land coverage to each individual drainage inlet. These values were used to determine the stormwater runoff to each inlet using the rational method. The rainfall intensities utilized in the storm drainage computations were obtained from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14, Volume 10 Precipitation Frequency Data Server.

The proposed storm drainage systems were designed according to the town's standards to provide adequate pipe capacity to convey the 25-year storm event. In addition, the storm drainage design includes a hydraulic grade line computation for the storm drainage systems designed showing adequate capacity to meet the 25-year storm event. In addition, the outlet pipe from the outlet control structure of the proposed detention area was sized with adequate capacity to convey the 100-year storm event. All storm drainage computations described in this section are included in the Appendix of this report.

The use of a stormwater discharge/infiltration system or level spreader has been proposed at the final discharge point from the site. The purpose of the level spreader system is to encourage infiltration of stormwater while allowing the overflow discharge to be released through a level spreader promoting quiescent sheet flow rather than a concentrated point discharge. The flow from the level spreader will pass through a natural vegetative area before entering the downstream wetland area. The level spreader has been designed with adequate overflow discharge capacity to meet the 100-year peak-flow rate through the final outlet pipe. Sizing computations have been included in the Appendix of this report.

The proposed stormwater management system balances the safe conveyance of stormwater runoff with the attenuation of peak rates of runoff while maintaining stormwater quality from the project site. The design of the stormwater management system minimizes potential impacts to existing wetland areas, watercourses, and developed areas downstream of the site.

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4.0   HYDROLOGIC ANALYSIS

A hydrologic study has been conducted to analyze the predevelopment and postdevelopment peak-flow rates from the site. The overall hydrology for the site consists of four analysis points that represent specific locations where stormwater runoff leaves the site. Analysis Points A and B represent the two intermittent watercourses and wetland areas on the east side of the property. Analysis Point C consists of a small area that flows overland toward the southern property boundary. Analysis Point D represents the area from the site that drains toward Brandegee Avenue.

The existing watersheds were delineated based on current site conditions including the contributing off-site upstream areas. The existing watersheds were then modified and subdivided further to reflect the proposed changes to the site and to analyze the hydrology under proposed conditions. The total watershed area delineated is approximately 27.2 acres under both existing and proposed conditions. Watershed maps are included in the Appendix of this report.

The method of predicting the surface water runoff rates utilized in this analysis is a computer program entitled *Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2019* by Autodesk, Inc., Version 2020. The H*ydrographs* program is a computer model that utilizes the methodologies set forth in the *Technical Release No. 55* (TR-55) manual and *Technical Release No. 20* (TR-20) computer model, originally developed by the United States Department of Agriculture – Natural Resources Conservation Service (USDA-NRCS). The *Hydrographs* computer modeling program is primarily used for conducting hydrology studies such as this.

The *Hydrographs* computer program forecasts the rate of surface water runoff based upon several factors. The input data includes information on land use, hydrologic soil type, vegetation, contributing watershed area, time of concentration, rainfall data, storage volumes, and the hydraulic capacity of structures. The computer model predicts the amount of runoff as a function of time, with the ability to include the attenuation effect due to dams, lakes, large wetlands, floodplains, and stormwater management basins. The input data for rainfalls with statistical recurrence frequencies of 2, 10, 25, 50, and 100 years were obtained from the NOAA Atlas 14 database.

24-Hour NOAA Precipitation Amounts (Groton, Connecticut)

Storm Frequency	Rainfall (inches)
2-Year	3.43
10-Year	5.10
25-Year	6.15
50-Year	6.95
100-Year	7.76

Land use for the site under existing and proposed conditions was determined from field survey, the city's Geographic Information System (GIS) mapping, and aerial photogrammetry. Land use types used in the analysis included open space/lawn areas, bare soil, 1/4 and 1/8-acre residential lots, woods, gravel, buildings, and paved/impervious surfaces. Soil types in the watershed were

determined from the GIS database of the USDA-NRCS soil survey for New London County, Connecticut. The soil survey identifies the soils on the study area as Hydrologic Soil group "B."

The existing conditions were modeled with the *Hydrographs* program to determine the peak-flow rates for the various storm events at each analysis point. A revised model was developed incorporating the proposed site conditions, and the flows obtained with the revised model were then compared to the results of the existing conditions model. Peak-flow rates from the project site were controlled using the proposed stormwater basin, which includes an outlet control structure containing a combination of a V-notch weir and low-flow orifices. The aboveground basin has been designed to provide a minimum of 1 foot of freeboard to the top of the proposed berm elevation during the 100-year storm event. All *Hydrographs* input computations and model results are included in the Appendix of this report. The following peak rates of runoff were obtained from the *Hydrographs* hydrology results:

Point of Analysis A	**Peak Runoff Rate (cubic feet per second)**				
Storm Frequency (years)	**2**	**10**	**25**	**50**	**100**
Existing Conditions	7.5	18.4	26.3	32.6	39.3
Proposed Conditions	6.5	16.1	23.1	28.7	34.6

Point of Analysis B	**Peak Runoff Rate (cubic feet per second)**				
Storm Frequency (years)	**2**	**10**	**25**	**50**	**100**
Existing Conditions	8.5	18.2	25.6	31.6	38.0
Proposed Conditions	5.8	14.8	22.4	28.6	37.8

Point of Analysis C	**Peak Runoff Rate (cubic feet per second)**				
Storm Frequency (years)	**2**	**10**	**25**	**50**	**100**
Existing Conditions	0.4	1.2	1.8	2.3	2.9
Proposed Conditions	0.1	0.6	1.0	1.4	1.7

Point of Analysis D	**Peak Runoff Rate (cubic feet per second)**				
Storm Frequency (years)	**2**	**10**	**25**	**50**	**100**
Existing Conditions	0.6	1.2	1.6	1.9	2.2
Proposed Conditions	0.2	0.3	0.4	0.5	0.6

The summary of the results above shows that no increases in peak rates of runoff are anticipated at any of the analysis points. Instead, a decrease in flow rate for each of the storm events modeled can be anticipated due to the stormwater management system and the detention provided. The stormwater management system achieves the goal of attenuating the peak rates of runoff from the proposed site, minimizing potential impacts to existing receiving waters and developed areas downstream of the site.

5.0   WATER QUALITY MANAGEMENT

Water quality measures or BMPs are incorporated into the stormwater management design to maintain water quality. All of the treatment measures described in this section will help maintain water quality of the stormwater runoff from the proposed site. Stormwater runoff will be collected and conveyed via a subsurface pipe and catch basin drainage system. The drainage system will include catch basins with 2-foot sumps, which trap coarse sediments.

Hydrodynamic separators such as the CDS® system, manufactured by Contech® Engineered Solutions, or approved equivalent proprietary device, will be installed prior to final discharge from the proposed site. These units will further remove suspended solids before discharging downgradient, which in turn removes other potential pollutants that tend to attach to the suspended solids and effectively removes other debris and floatables that may be present in the stormwater runoff. The CDS® units have been designed to meet the criteria recommended by the CTDEEP *2004 Stormwater Quality Manual*. The units were designed based on the determined Water Quality Flow (WQF), which is the peak-flow rate associated with the Water Quality Volume (WQV), and sized based on manufacturer's specifications.

A sediment forebay is proposed around the proposed drainage pipe outlet into the existing stormwater basin. The forebay will improve water quality by trapping floatables as well as filtering coarse sediment and other pollutants. The forebay will be constructed with an earthen berm and a riprap splash pad. Riprap splash pads will be included at the final discharge of the drainage pipe to dissipate the potential erosive velocity of stormwater as well as trap sediments. The sediment forebay will contain the deposited sediment within a small area of the basin and allow for maintenance accessibility.

The stormwater basin has been designed considering the guidance provided in the CTDEEP *2004 Stormwater Quality Manual* to enhance water quality by providing retention volume in the bottom of the basin below the lowest hydraulic opening in the outlet control structure, thus creating a water quality feature within it. This serves several purposes including stormwater renovation, first flush retention, and infiltration. The vegetation provides pollutant removal by filtering stormwater runoff and will utilize excess nutrients that may be present in the stormwater.

The *Stormwater Quality Manual* (Chapter 7) recommends methods for sizing stormwater treatment measures with the WQV and Groundwater Recharge Volume (GRV) computations. The WQV addresses the initial stormwater runoff also commonly referred to as the "first flush" runoff. The WQV provides adequate volume to store the initial 1 inch of runoff, which tends to contain the highest concentrations of potential pollutants. The GRV provides adequate volume to maintain the predevelopment annual groundwater recharge and promote infiltration based on the soils found on the site. When provided, the GRV will achieve similar stormwater infiltration capabilities and maintain adequate groundwater recharge. Both required WQV and GRV for the site have been provided within the retention volume in the bottom of the proposed basin. Supporting calculations for the retention volume provided as well as the required WQV and GRV computations have been included in the Appendix of this report.

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The stormwater discharge/infiltration system or level spreader designed to release the final stormwater discharge from the development will also help improve water quality. The device consists of a single row of several 4-foot-by-4-foot concrete galleries normally used in the design of septic leaching systems. The number of galleries used was determined by the amount of stormwater they will receive from the final outlet pipe. The design calls for the top row of weep holes set at grade as an overflow outlet weir, which is designed to gradually release stormwater over a protective stone apron in a quiescent manner as sheet flow rather than a concentrated point discharge that results from typical storm pipe outlets or flared-end sections. The storage volume within the galleries will provide an additional opportunity for infiltration to occur into the surrounding soils prior to reaching the overflow outlet weir level.

A Sediment and Erosion (S&E) Control Plan has been developed to mitigate the short-term impacts of the development during construction. The S&E Control Plan includes descriptive specifications concerning land grading, topsoiling, temporary and permanent vegetative cover, vegetative cover selection and mulching, and erosion checks. Details have been provided for all erosion controls with corresponding labels on the S&E control site plan. In all cases, the S&E Control Plan shall be implemented in accordance with the *2002 Connecticut Guidelines for Soil Erosion and Sediment Control*.

The construction areas are to be surrounded by geotextile sediment filter fence that will be fortified with staked hay bales upgradient of any wetland areas or watercourses. A construction entrance has been provided at all entrance locations as well as temporary topsoil stockpile areas encircled with sediment filter fencing. In addition, erosion control blankets are proposed on critical slopes to protect the newly created slopes until permanent vegetation can be established. During the construction, inlet protection is proposed at each of the catch basin inlets to prevent sediment from entering the storm drainage system during construction. The temporary diversion berm and swales are provided to direct the stormwater runoff from the site to temporary sediment traps during construction and will include stone check dams to slow potential erosive velocities. The S&E controls are to be modified with the changing grades on site to ensure the protection of the surrounding areas throughout the construction process.

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6.0 CONCLUSION
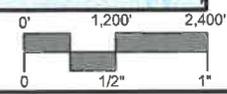
The hydrology results demonstrated that there will be no increases in flows to any of the analysis points through the use of the on-site detention basin. Hydrodynamic separators will be employed to pretreat stormwater runoff generated from the proposed bituminous paved surfaces prior to entering the receiving stormwater management basin and the final pipe discharges from the site. A High Efficiency CDS® unit, manufactured by Contech® Engineered Solutions, was selected and sized based on the contributing Water Quality Flow (WQF), which is the peak-flow rate associated with the Water Quality Volume (WQV). As the development is a public bid project, equivalent stormwater chamber devices from other manufacturers will be considered prior to final construction. Furthermore, the CTDEEP WQV, which is the runoff volume associated with the first inch of rainfall as well as the Ground Recharge volume (GRV) has been provided within the proposed stormwater management basin.

The provided stormwater control measures include short-term erosion controls to be implemented during the construction phase and long-term total suspended solids removal from stormwater runoff for the completed project. These measures will serve to mitigate water quality impacts during construction and improve the quality of stormwater runoff from the site after the site is developed. The focus of the water quality measures was to remove suspended solids and other potential pollutants as well as to protect against excessive erosion during and after construction. The S&E Control Plan will provide protection of the existing wetlands and watercourses by preventing sediment transport to areas downgradient of the site during construction and while the site is permanently established. The BMPs and S&E control measures described in this report will help maintain the water quality of the stormwater runoff from the proposed project

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APPENDIX A
USGS LOCATION MAP

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N

W — E

S

SITE LOCATION

NEW LONDON HARBOR

GROTON

GROTON-NEW LONDON AIRPORT

UNIVERSITY OF CONNECTICUT
(SOUTHEASTERN BRANCH)

0' 1,200' 2,400'

0 1/2" 1"

APPENDIX B
FEMA FLOOD INSURANCE RATE MAP

National Flood Hazard Layer FIRMette

FEMA

Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS

Without Base Flood Elevation (BFE)
Zone A, V, A99

With BFE or Depth Zone AE, AO, AH, VE, AR

Regulatory Floodway

0.2% Annual Chance Flood Hazard, Area of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile Zone X

Future Conditions 1% Annual Chance Flood Hazard Zone X

Area with Reduced Flood Risk due to Levee. See Notes. Zone X

Area with Flood Risk due to Levee Zone D

OTHER AREAS OF FLOOD HAZARD

Area of Minimal Flood Hazard Zone X

Effective LOMRs

Area of Undetermined Flood Hazard Zone D

OTHER AREAS

GENERAL STRUCTURES

Channel, Culvert, or Storm Sewer

Levee, Dike, or Floodwall

Cross Sections with 1% Annual Chance
20.2 Water Surface Elevation

17.5 Coastal Transect

Base Flood Elevation Line (BFE)

Limit of Study

Jurisdiction Boundary

Coastal Transect Baseline

OTHER FEATURES

Profile Baseline

Hydrographic Feature

MAP PANELS

Digital Data Available

No Digital Data Available

Unmapped

The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 8/8/2018 at 2:04:38 PM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

41°20'25.04"N

41°20'25.04"N

72°3'43.02"W

41°19'58.03"N

Zone AE (EL 10 Feet)

9.6 FEET

H 9.6 FEET

G

AREA OF MINIMAL FLOOD HAZARD

Zone X

City of Groton
090126

09011C0504J
eff.8/5/2013

USGS The National Map: Orthoimagery. Data refreshed October 2017.
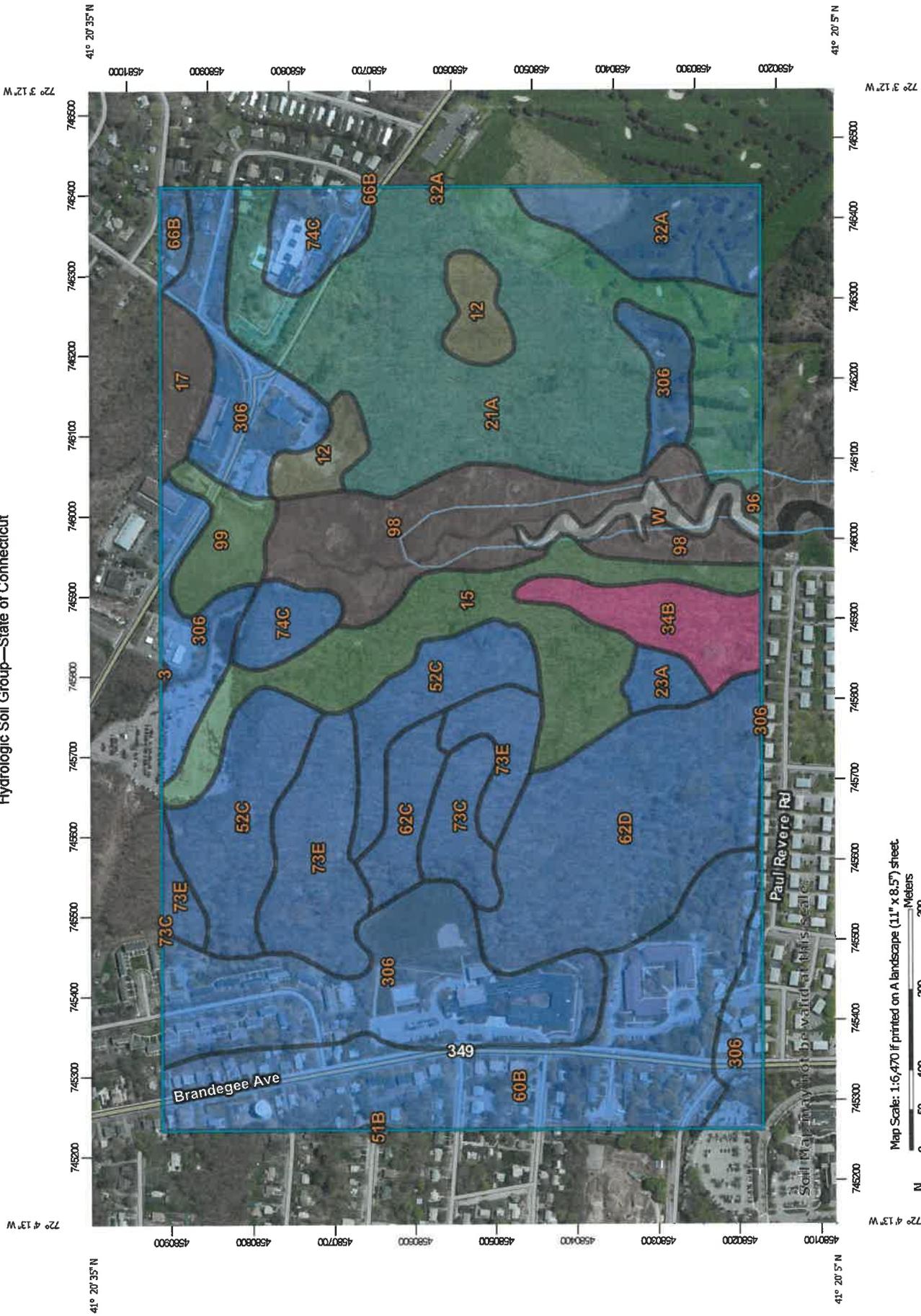
Feet   1:6,000

0   250   500   1,000   1,500   2,000
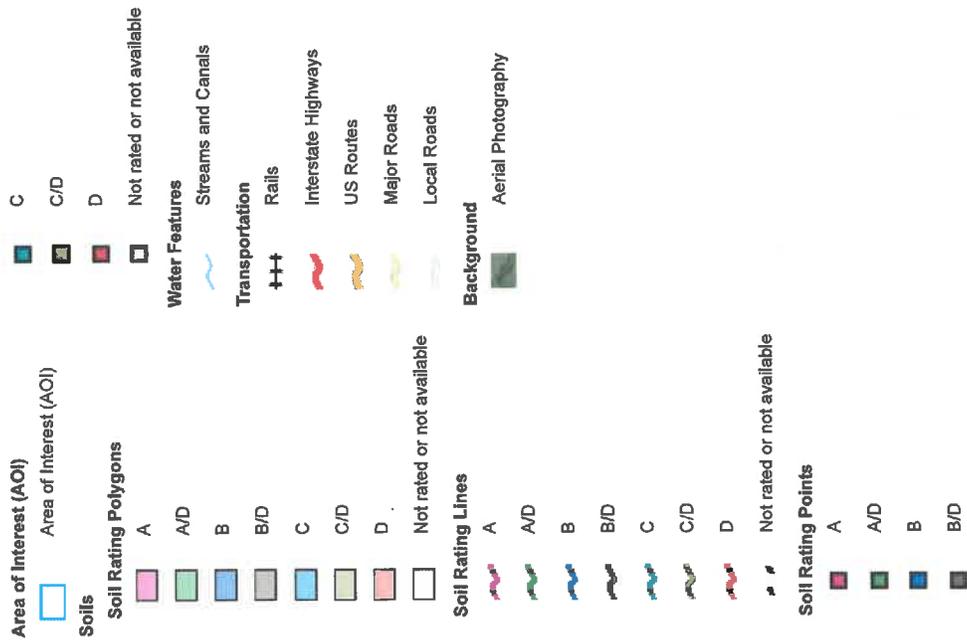
APPENDIX C
NRCS HYDROLOGIC SOIL GROUP MAP

Hydrologic Soil Group—State of Connecticut

Natural Resources
Conservation Service

Web Soil Survey
National Cooperative Soil Survey

Map Scale: 1:6,470 if printed on A landscape (11" x 8.5") sheet.

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

Soil Map may not be valid at this scale.

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Soil Rating Lines

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Soil Rating Points

A

A/D

B

B/D

C

C/D

D

Not rated or not available

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:
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: State of Connecticut
Survey Area Data: Version 16, Sep 15, 2017

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

Date(s) aerial images were photographed: Mar 28, 2011—May 12, 2011

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.

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
3	Ridgebury, Leicester, and Whitman soils, 0 to 8 percent slopes, extremely stony	D	0.1	0.0%
12	Raypol silt loam	C/D	4.3	2.0%
15	Scarboro muck, 0 to 3 percent slopes	A/D	15.1	7.0%
17	Timakwa and Natchaug soils, 0 to 2 percent slopes	B/D	2.7	1.2%
21A	Ninigret and Tisbury soils, 0 to 5 percent slopes	C	38.5	17.8%
23A	Sudbury sandy loam, 0 to 5 percent slopes	B	1.5	0.7%
32A	Haven and Enfield soils, 0 to 3 percent slopes	B	7.2	3.3%
34B	Merrimac fine sandy loam, 3 to 8 percent slopes	A	5.4	2.5%
51B	Sutton fine sandy loam, 2 to 8 percent slopes, very stony	B	0.0	0.0%
52C	Sutton fine sandy loam, 2 to 15 percent slopes, extremely stony	B	13.8	6.4%
60B	Canton and Charlton fine sandy loams, 3 to 8 percent slopes	B	25.0	11.5%
62C	Canton and Charlton fine sandy loams, 3 to 15 percent slopes, extremely stony	B	3.4	1.6%
62D	Canton and Charlton fine sandy loams, 15 to 35 percent slopes, extremely stony	B	19.8	9.2%
66B	Narragansett silt loam, 2 to 8 percent slopes	B	1.1	0.5%
73C	Charlton-Chatfield complex, 0 to 15 percent slopes, very rocky	B	3.5	1.6%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
73E	Charlton-Chatfield complex, 15 to 45 percent slopes, very rocky	B	12.0	5.5%
74C	Narragansett-Hollis complex, 3 to 15 percent slopes, very rocky	B	5.9	2.7%
96	Ipswich mucky peat, 0 to 2 percent slopes, very frequently flooded	A/D	0.2	0.1%
98	Westbrook mucky peat, 0 to 2 percent slopes, very frequently flooded	B/D	15.4	7.1%
99	Westbrook mucky peat, low salt	A/D	3.5	1.6%
306	Udorthents-Urban land complex	B	35.9	16.6%
W	Water		2.1	1.0%
Totals for Area of Interest			**216.2**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

APPENDIX D
ON-SITE SOIL TESTING RESULTS

TEST PIT LOG

MILONE & MACBROOM
99 Realty Drive
Cheshire, CT 06410
(203) 271-1773

PROJECT
Proposed West Side Elementary School
250 Brandegee Avenue
Groton, CT

Test Pit No: TP-1
Sheet: 1 of 2
MMI File No: 1777-43
Checked By: RDG

MMI Rep.: J. Montagno
Exc. Contractor: David M. Koch Landscaping, LLC
Exc. Operator: D. Koch
Weather: Sunny, 70s

Make: John Deere
Model: 35D
Capacity: 0.25 cy
Reach: ±10.0'
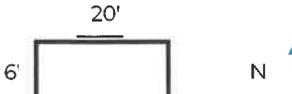
Ground Elev: ±96.0'
Datum: N/A
Date: 6/5/2019
Time Start: 11:15 AM

Depth Below Grade (ft)	Strata Change & Water Level	Subsurface Description	Excavation Effort	Boulder Qty/Class	Notes
1	TOPSOIL	Dark brown, fine to medium SAND, some Silt, trace fine Gravel, trace Roots.	E		
2	SUBSOIL	Light brown, fine to medium SAND, some Silt, trace fine Gravel, trace Roots.	E		
3		Gray, fine to coarse SAND, some fine to coarse Gravel, little Silt, with Cobbles.	M		
4			M		
5			M		
6			M		
7			M		
8			M	1C 2A	
9	GLACIAL TILL		M		
10			M	3A 1B	
11			M		
12		Gray, fine to coarse SAND, some fine to coarse Gravel, some Silt, with Cobbles.	M		
13			M		
14	G.W.T. ▼		D		1
15			D	1A	
16			D		

Notes: 1. Groundwater at ±14.0'.

Water Symbols
▼ = Groundwater

Test Pit Dimensions & Orientation	BOULDER COUNT		PROPORTIONS USED		EXCAVATION EFFORT
20' / 6' / N	Boulder	Class	< 10%	Trace	E = Easy
	12"-24"	A	10-20%	Little	M = Moderate
	24"-36"	B	20-35%	Some	D = Difficult
	>36"	C	35-50%	And	

TEST PIT LOG

MILONE & MACBROOM 99 Realty Drive Cheshire, CT 06410 (203) 271-1773	PROJECT Proposed West Side Elementary School 250 Brandegee Avenue Groton, CT	Test Pit No: TP-1 Sheet: 2 of 2 MMI File No: 1777-43 Checked By: RDG

MMI Rep.: J. Montagno Exc. Contractor: David M. Koch Landscaping, LLC Exc. Operator: D. Koch Weather: Sunny, 70s	Make: John Deere Model: 35D Capacity: 0.25 cy Reach: ±10.0'	Ground Elev: ±96.0' Datum: N/A Date: 6/5/2019 Time Start: 11:15 AM

Depth Below Grade (ft)	Strata Change & Water Level	Subsurface Description	Excavation Effort	Boulder Qty/Class	Notes
17	GLACIAL TILL	Gray, fine to coarse SAND, some Silt, little fine to coarse Gravel, with Cobbles.	D		
18		Bottom of Exploration ±17.0'			
19					
20					
21					
22					
23					
24					
25					
26					
27					
28					
29					
30					
31					
32					

Notes:

Water Symbols

▼ = Groundwater

Test Pit Dimensions & Orientation	BOULDER COUNT		PROPORTIONS USED		EXCAVATION EFFORT
	Boulder	Class	< 10%	Trace	E = Easy
20'	12"-24"	A	10-20%	Little	M = Moderate
6' ☐ N↑	24"-36"	B	20-35%	Some	D = Difficult
	>36"	C	35-50%	And	

TEST PIT LOG

MILONE & MACBROOM
99 Realty Drive
Cheshire, CT 06410
(203) 271-1773

PROJECT
Proposed West Side Elementary School
250 Brandegee Avenue
Groton, CT

Test Pit No: TP-2
Sheet: 1 of 1
MMI File No: 1777-43
Checked By: RDG

MMI Rep.: J. Montagno	Make: John Deere	Ground Elev: ±94.0'
Exc. Contractor: David M. Koch Landscaping, LLC	Model: 35D	Datum: N/A
Exc. Operator: D. Koch	Capacity: 0.25 cy	Date: 6/5/2019
Weather: Sunny, 70s	Reach: ±10.0'	Time Start: 2:30 PM

Depth Below Grade (ft)	Strata Change & Water Level	Subsurface Description	Excavation Effort	Boulder Qty/Class	Notes
1	TOPSOIL	Dark brown, fine to medium SAND, some Silt, trace fine Gravel, trace Roots.	E		
2	SUBSOIL	Light brown, fine to medium SAND, some Silt, trace fine Gravel, trace Roots.	E		
3			E		
4		Gray, fine to coarse SAND and fine to coarse GRAVEL, little Silt, with Cobbles.	M		
5			M	2A	
6			M		
7		Gray, fine to coarse SAND, some fine to coarse Gravel, some Silt, with Cobbles.	M	1A	
8			M	2A	
9			M		
10	GLACIAL TILL		M	2B	
11			M		
12		Gray, fine to coarse GRAVEL, some fine to coarse Sand, some Silt, with Cobbles.	M		
13			M		
14			M	1A	
15			M	1A	
16		Bottom of Exploration ±15.5'			

Notes:

Test Pit Dimensions & Orientation	BOULDER COUNT		PROPORTIONS USED		EXCAVATION EFFORT
	Boulder	Class	< 10%	Trace	E = Easy
18'	12"-24"	A	10-20%	Little	M = Moderate
6' N ←	24"-36"	B	20-35%	Some	D = Difficult
	>36"	C	35-50%	And	

W:\Geotech\1777-43-GT\Explorations\West Side Test Pit Logs.xlsx

LEGEND:

⊕ BORING BY MILONE & MACBROOM, INC.
MM-1

⊞ TEST PIT BY MILONE & MACBROOM, INC.
TP-1

NOTES:
1. BASEMAP DEVELOPED FROM AN ELECTRONIC FILE BY PERKINS EASTMAN TITLED "SITE PLAN - UTILITIES" AND DATED 5/1/2019.
2. BORINGS BY MILONE & MACBROOM, INC. WERE PERFORMED BY SITE, LLC ON 3/27/2019 AND 4/16/2019 - 4/17/2019. TEST PITS BY MILONE & MACBROOM, INC. WERE PERFORMED BY DAVID M. KOCH LANDSCAPING, LLC ON 6/5/2019.
3. THE LOCATIONS OF THE BORINGS WERE DETERMINED BY TAPING/PACING FROM EXISTING SITE FEATURES. THESE LOCATIONS SHOULD BE CONSIDERED ACCURATE ONLY TO THE DEGREE IMPLIED BY THE METHOD USED.
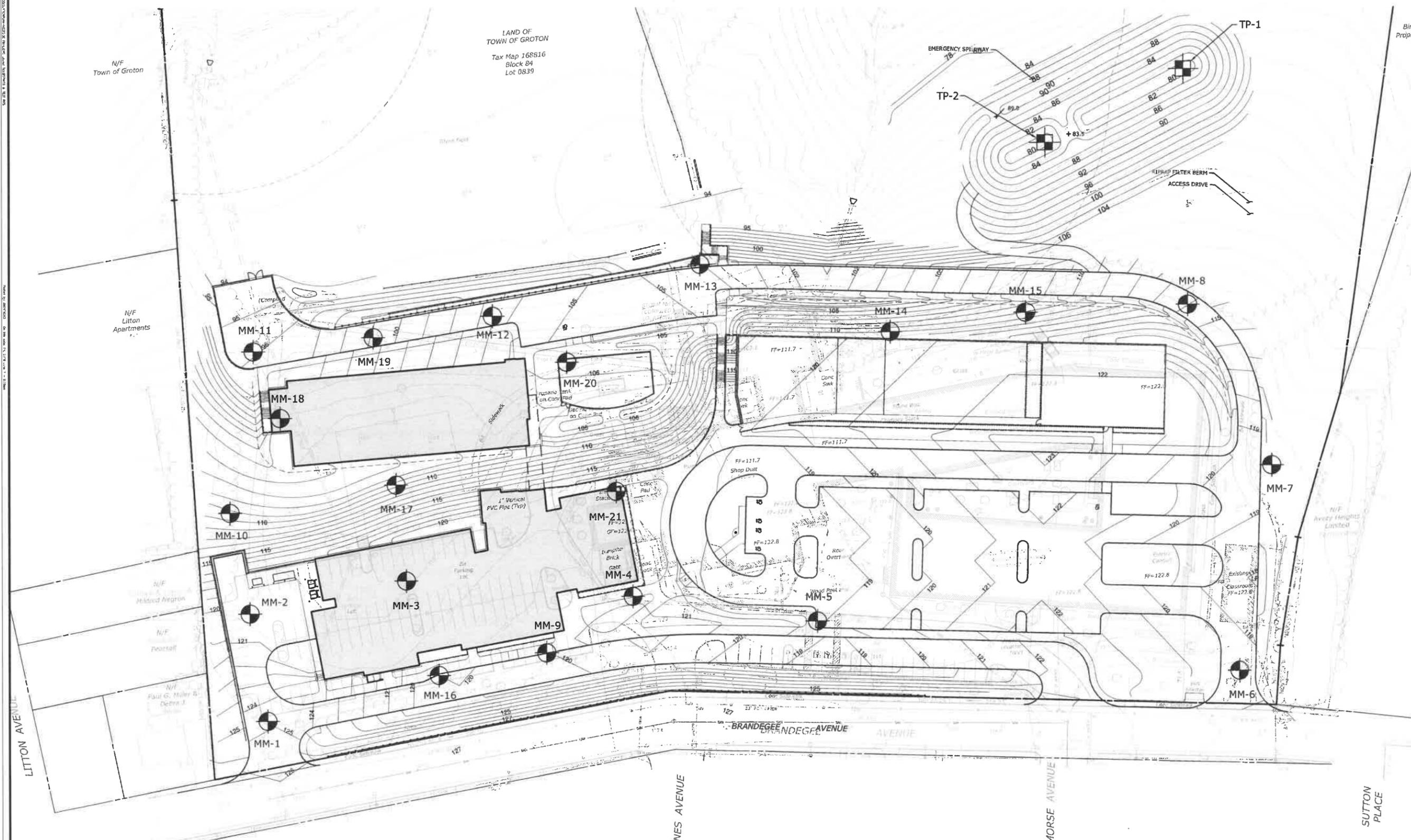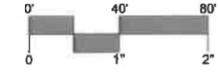
APPENDIX E
STORM DRAINAGE COMPUTATIONS

Time of Concentration (T$_c$) or Travel Time (T$_t$) Worksheet

Project: Westside Elementary School By: MCB Date: 05/09/19
Location: Groton, CT Checked: Date:
Circle one: Present **_Developed_** Watershed: DBLCCB 7
Circle one: **_T$_c$_** T$_t$ Subwatershed:

Sheet flow (applicable to T$_c$ only)

	Segment ID	**A-B**
1. Surface description (Table 3-1)		GRASS
2. Manning's roughness coeff. for sheet flow, n (Table 3-1)		0.240
3. Flow Length, L (< 300ft)	ft.	95.0
4. Two-year 24-hr rainfall, P$_2$	in.	3.43
5. Land slope, s	ft./ft.	0.030

6. $T_t = \dfrac{0.007\,(nL)^{0.8}}{P_2^{0.5}\,(s^{0.4})}$ hr. | 0.187 | = | 0.187

Shallow concentrated flow (assume hyd. radius = depth of flow)

	Segment ID	**B-C**			
7. Surface description		BIT			
8. Manning's roughness coeff., n		0.015			
9. Paved or unpaved		PVD			
10. Depth of flow, d (default values: d=.4 unpaved, d=.2 paved)	ft.	0.20			
11. Flow Length, L	ft.	73.0			
12. Watercourse slope, s	ft./ft.	0.030			

13. Average velocity, $V = \dfrac{1.49}{n}(d^{\frac{2}{3}})(s^{\frac{1}{2}})$ fps. | 5.88

14. $T_t = \dfrac{L}{3600 * V}$ hr. | 0.003 | + | + | + | = | 0.003

Channel flow

	Segment ID				
15. Channel Bottom width, b	ft.				
16. Horizontal side slope component, z (z horiz:1 vert)	ft.				
17. Depth of flow, d	ft.				
18. Cross sectional flow area, A (assume trapazoidal)	ft.^{2}				
19. Wetted perimeter, P$_w$	ft.				
20. Hydraulic Radius, $R = \dfrac{A}{P_w}$	ft.				
21. Channel slope, s	ft./ft.				
22. Manning's roughness coeff., n					

23. $V = \dfrac{1.49}{n}(R^{\frac{2}{3}})(s^{\frac{1}{2}})$ fps.

24. Flow length, L ft.

25. $T_t = \dfrac{L}{3600 * V}$ hr. | + | + | + | = | 0.000

26. Watershed or subarea T$_c$ or T$_t$ (add T$_t$ in steps 6, 14 & 25) hr. | 0.191

Time of Concentration (T_c) or Travel Time (T_t) Worksheet

Project: __Westside Elementary School__   By: __MCB__   Date: __05/09/19__
Location: __Groton, CT__   Checked: ____   Date: ____
Circle one: Present ***Developed***   Watershed: __EXYD__
Circle one: ***I_c*** T_t Subwatershed: ____

Sheet flow (applicable to T_c only)

	Segment ID	**A-B**	
1. Surface description (Table 3-1)		GRASS	
2. Manning's roughness coeff. for sheet flow, n (Table 3-1)		0.240	
3. Flow Length, L (< 300ft)	ft.	100.0	
4. Two-year 24-hr rainfall, P_2	in.	3.43	
5. Land slope, s	ft./ft.	0.023	
6. $T_t = \dfrac{0.007\,(nL)^{0.8}}{P_2^{0.5}(s^{0.4})}$	hr.	0.217	= 0.217

Shallow concentrated flow (assume hyd. radius = depth of flow)

	Segment ID	**B-C**				
7. Surface description		GRASS				
8. Manning's roughness coeff., n		0.080				
9. Paved or unpaved		UNPVD				
10. Depth of flow, d (default values: d=.4 unpaved, d=.2 paved)	ft.	0.40				
11. Flow Length, L	ft.	67.3				
12. Watercourse slope, s	ft./ft.	0.030				
13. Average velocity, $V = \dfrac{1.49}{n}(d^{2/3})(s^{1/2})$	fps.	1.75				
14. $T_t = \dfrac{L}{3600*V}$	hr.	0.011	+	+	+	= 0.011

Channel flow

	Segment ID					
15. Channel Bottom width, b	ft.					
16. Horizontal side slope component, z (z horiz:1 vert)	ft.					
17. Depth of flow, d	ft.					
18. Cross sectional flow area, A (assume trapazoidal)	ft.^{2}					
19. Wetted perimeter, P_w	ft.					
20. Hydraulic Radius, $R = \dfrac{A}{P_w}$	ft.					
21. Channel slope, s	ft./ft.					
22. Manning's roughness coeff., n						
23. $V = \dfrac{1.49}{n}(R^{2/3})(s^{1/2})$	fps.					
24. Flow length, L	ft.					
25. $T_t = \dfrac{L}{3600*V}$	hr.		+	+	+	= 0.000

26. Watershed or subarea T_c or T_t (add T_t in steps 6, 14 & 25)   hr.   0.228

Time of Concentration (T$_c$) or Travel Time (T$_t$) Worksheet

Project: Westside Elementary School   By: MCB   Date: 05/09/19
Location: Groton, CT   Checked: Date:
Circle one: Present **_Developed_**   Watershed: EXCCB
Circle one: **_T$_c$_**   T$_t$ Subwatershed:

Sheet flow (applicable to T$_c$ only)

		Segment ID	**A-B**
1. Surface description (Table 3-1)			GRASS
2. Manning's roughness coeff. for sheet flow, n (Table 3-1)			0.240
3. Flow Length, L (< 300ft)	ft.		83.7
4. Two-year 24-hr rainfall, P$_2$	in.		3.43
5. Land slope, s	ft./ft.		0.020

6. $T_t = \dfrac{0.007\,(nL)^{0.8}}{P_2^{0.5}\,(s^{0.4})}$ hr. | 0.199 | = | 0.199

Shallow concentrated flow (assume hyd. radius = depth of flow)

		Segment ID	**B-C**			
7. Surface description			BIT			
8. Manning's roughness coeff., n			0.015			
9. Paved or unpaved			PVD			
10. Depth of flow, d (default values: d=.4 unpaved, d=.2 paved)	ft.		0.20			
11. Flow Length, L	ft.		311.8			
12. Watercourse slope, s	ft./ft.		0.021			

13. Average velocity, $V = \dfrac{1.49}{n}(d^{\frac{2}{3}})(s^{\frac{1}{2}})$ fps. | 4.92

14. $T_t = \dfrac{L}{3600*V}$ hr. | 0.018 | + | + | + | = | 0.018

Channel flow

		Segment ID				
15. Channel Bottom width, b	ft.					
16. Horizontal side slope component, z (z horiz:1 vert)	ft.					
17. Depth of flow, d	ft.					
18. Cross sectional flow area, A (assume trapazoidal)	ft.^{2}					
19. Wetted perimeter, P$_w$	ft.					

20. Hydraulic Radius, $R = \dfrac{A}{P_w}$ ft.

21. Channel slope, s   ft./ft.

22. Manning's roughness coeff., n

23. $V = \dfrac{1.49}{n}(R^{\frac{2}{3}})(s^{\frac{1}{2}})$ fps.

24. Flow length, L   ft.

25. $T_t = \dfrac{L}{3600*V}$ hr. | + | + | + | = | 0.000

26. Watershed or subarea T$_c$ or T$_t$ (add T$_t$ in steps 6, 14 & 25)   hr. | 0.217

Milone & MacBroom Inc.

NOAA Atlas 14, Volume 10, Version 2
Location name: Groton, Connecticut, USA*
Latitude: 41.3384°, Longitude: -72.0671°
Elevation: 120.53 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sandra Pavlovic, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Orlan Wilhite

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

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

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	4.03 (3.07-5.26)	4.82 (3.67-6.29)	6.11 (4.64-7.99)	7.19 (5.42-9.42)	8.66 (6.37-11.7)	9.79 (7.08-13.4)	10.9 (7.72-15.4)	12.4 (8.32-17.6)	14.4 (9.31-20.9)	15.9 (10.1-23.4)
10-min	2.86 (2.18-3.72)	3.41 (2.60-4.45)	4.33 (3.29-5.66)	5.09 (3.85-6.68)	6.13 (4.51-8.30)	6.94 (5.02-9.52)	7.75 (5.47-10.9)	8.81 (5.89-12.5)	10.2 (6.60-14.8)	11.3 (7.13-16.5)
15-min	2.24 (1.71-2.92)	2.68 (2.04-3.49)	3.40 (2.58-4.44)	3.99 (3.02-5.24)	4.81 (3.54-6.51)	5.44 (3.93-7.47)	6.08 (4.28-8.56)	6.91 (4.62-9.79)	8.01 (5.18-11.6)	8.84 (5.60-13.0)
30-min	1.59 (1.21-2.08)	1.90 (1.45-2.48)	2.40 (1.82-3.14)	2.82 (2.13-3.70)	3.39 (2.49-4.59)	3.83 (2.77-5.26)	4.28 (3.02-6.03)	4.86 (3.25-6.89)	5.64 (3.64-8.17)	6.22 (3.94-9.14)
60-min	1.03 (0.787-1.35)	1.23 (0.936-1.60)	1.55 (1.18-2.03)	1.82 (1.38-2.39)	2.19 (1.61-2.96)	2.47 (1.79-3.39)	2.76 (1.95-3.89)	3.13 (2.10-4.44)	3.63 (2.35-5.27)	4.01 (2.54-5.89)
2-hr	0.676 (0.522-0.870)	0.806 (0.622-1.04)	1.02 (0.784-1.32)	1.20 (0.916-1.55)	1.44 (1.07-1.93)	1.63 (1.19-2.21)	1.82 (1.29-2.53)	2.06 (1.39-2.90)	2.39 (1.55-3.43)	2.63 (1.68-3.83)
3-hr	0.522 (0.406-0.667)	0.623 (0.484-0.796)	0.788 (0.610-1.01)	0.925 (0.712-1.19)	1.11 (0.833-1.48)	1.26 (0.924-1.70)	1.40 (1.00-1.94)	1.59 (1.08-2.22)	1.84 (1.20-2.63)	2.03 (1.30-2.94)
6-hr	0.332 (0.262-0.419)	0.396 (0.311-0.499)	0.500 (0.392-0.632)	0.586 (0.457-0.744)	0.705 (0.533-0.924)	0.796 (0.591-1.06)	0.888 (0.641-1.22)	1.01 (0.688-1.39)	1.16 (0.765-1.64)	1.28 (0.824-1.84)
12-hr	0.204 (0.163-0.254)	0.243 (0.194-0.302)	0.306 (0.243-0.382)	0.358 (0.283-0.449)	0.430 (0.329-0.557)	0.486 (0.365-0.639)	0.541 (0.395-0.733)	0.614 (0.423-0.838)	0.709 (0.470-0.993)	0.781 (0.506-1.11)
24-hr	0.120 (0.097-0.147)	0.143 (0.115-0.176)	0.181 (0.146-0.223)	0.213 (0.170-0.263)	0.256 (0.199-0.328)	0.290 (0.220-0.377)	0.323 (0.239-0.434)	0.369 (0.256-0.499)	0.429 (0.286-0.595)	0.474 (0.309-0.668)
2-day	0.066 (0.054-0.080)	0.080 (0.065-0.097)	0.102 (0.084-0.124)	0.121 (0.098-0.148)	0.147 (0.115-0.186)	0.166 (0.128-0.215)	0.186 (0.139-0.248)	0.214 (0.150-0.287)	0.252 (0.169-0.346)	0.280 (0.183-0.390)
3-day	0.048 (0.039-0.057)	0.057 (0.047-0.069)	0.073 (0.060-0.088)	0.087 (0.071-0.105)	0.105 (0.083-0.132)	0.119 (0.092-0.152)	0.133 (0.100-0.176)	0.153 (0.108-0.204)	0.180 (0.121-0.245)	0.200 (0.131-0.277)
4-day	0.038 (0.032-0.046)	0.046 (0.038-0.055)	0.058 (0.048-0.070)	0.068 (0.056-0.083)	0.083 (0.066-0.103)	0.094 (0.073-0.119)	0.105 (0.079-0.138)	0.120 (0.085-0.159)	0.141 (0.095-0.191)	0.156 (0.103-0.216)
7-day	0.026 (0.022-0.031)	0.030 (0.026-0.036)	0.038 (0.032-0.045)	0.044 (0.037-0.053)	0.053 (0.043-0.066)	0.060 (0.047-0.075)	0.066 (0.050-0.086)	0.076 (0.054-0.099)	0.088 (0.060-0.118)	0.097 (0.064-0.132)
10-day	0.021 (0.018-0.025)	0.024 (0.021-0.029)	0.030 (0.025-0.035)	0.034 (0.029-0.041)	0.041 (0.033-0.050)	0.046 (0.036-0.057)	0.051 (0.038-0.065)	0.057 (0.041-0.074)	0.065 (0.045-0.087)	0.071 (0.047-0.097)
20-day	0.015 (0.013-0.017)	0.017 (0.014-0.019)	0.020 (0.017-0.023)	0.022 (0.019-0.026)	0.026 (0.021-0.031)	0.028 (0.022-0.034)	0.031 (0.023-0.039)	0.034 (0.024-0.043)	0.037 (0.026-0.049)	0.040 (0.027-0.054)
30-day	0.012 (0.011-0.014)	0.014 (0.012-0.016)	0.016 (0.014-0.018)	0.017 (0.015-0.020)	0.020 (0.016-0.024)	0.022 (0.017-0.026)	0.024 (0.018-0.029)	0.025 (0.018-0.032)	0.028 (0.019-0.036)	0.029 (0.020-0.039)
45-day	0.010 (0.009-0.012)	0.011 (0.010-0.013)	0.013 (0.011-0.014)	0.014 (0.012-0.016)	0.016 (0.013-0.018)	0.017 (0.014-0.020)	0.018 (0.014-0.022)	0.019 (0.014-0.025)	0.021 (0.014-0.027)	0.022 (0.015-0.029)
60-day	0.009 (0.008-0.010)	0.010 (0.008-0.011)	0.011 (0.010-0.012)	0.012 (0.010-0.014)	0.013 (0.011-0.016)	0.014 (0.012-0.017)	0.015 (0.012-0.019)	0.016 (0.012-0.020)	0.017 (0.012-0.022)	0.018 (0.012-0.024)

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

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

Please refer to NOAA Atlas 14 document for more information.

Back to Top

Large scale terrain

Large scale map

Large scale aerial

Storm Sewer IDF Curves

Storm Sewer IDF Curves

Int. (in/hr)

14.00	100-Yr
12.00	50-Yr
10.00	25-Yr
8.00	10-Yr
6.00	5-Yr
4.00	2-Yr
2.00	
0.00	

Time (min)
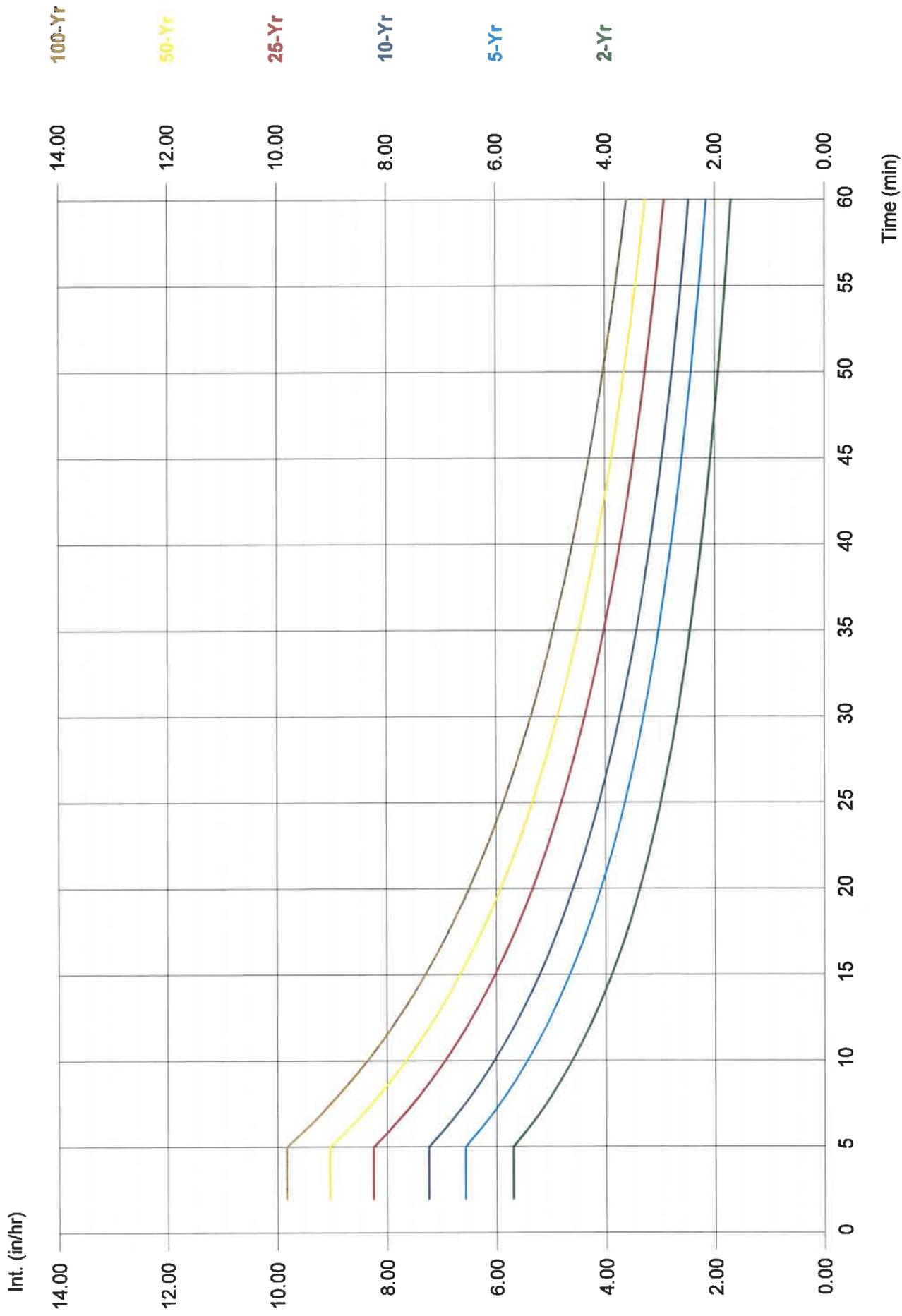
Rational Method Roof Drain System Calculations

Project: Westside Elementary School   By: MCB   Date: 6/18/19
Location: Groton, CT   Checked: Date:

$Q = C \times I \times A$, Where:
C = Runoff Coefficient
I = Rainfall Intensity (in/hr) => Tc = 5 min => i= 8.66 in/hr (25-year storm)
A = Area (acres)
Q = Flow (cfs)

	East Bldg to CCB 34	East Bldg to AD 30	West Bldg to MH 13	West Bldg to AD 12	West Bldg to CCB 21
C	0.90	0.90	0.90	0.90	0.90
I	8.66	8.66	8.66	8.66	8.66
A	0.18	0.17	0.10	0.25	0.29
Q	1.40	1.32	0.78	1.95	2.26

CAPACITY CHECK		
	SLOPE (%)	CAPACITY (CFS)
10" HDPE	0.50	1.66
8" HDPE	0.50	0.94
12" HDPE	0.50	2.73

Note:
- Pipe capacity was estimated using Manning's Equation
- n = 0.012 (HDPE)
- NOAA Atlas 14 Vol. 10 Rainfall Intensity

Channel Report

<Name>

Circular   **Highlighted**
Diameter (ft)   = 0.67   Depth (ft)   = 0.67
                                                   Q (cfs)   = 0.938
                                                   Area (sqft)   = 0.35
Invert Elev (ft)   = 100.00   Velocity (ft/s)   = 2.66
Slope (%)   = 0.50   Wetted Perim (ft)   = 2.10
N-Value   = 0.012   Crit Depth, Yc (ft)   = 0.46
                                                   Top Width (ft)   = 0.00
Calculations   EGL (ft)   = 0.78
Compute by: Q vs Depth
No. Increments   = 10

Elev (ft)   **Section**

Reach (ft)

Channel Report

Wednesday, Jun 12 2019

\<Name\>

Circular
Diameter (ft)	= 0.83

Invert Elev (ft)	= 100.00
Slope (%)	= 0.50
N-Value	= 0.012

Calculations
Compute by:	Q vs Depth
No. Increments	= 10

Highlighted
Depth (ft)	= 0.83
Q (cfs)	= 1.660
Area (sqft)	= 0.54
Velocity (ft/s)	= 3.07
Wetted Perim (ft)	= 2.61
Crit Depth, Yc (ft)	= 0.58
Top Width (ft)	= 0.00
EGL (ft)	= 0.98
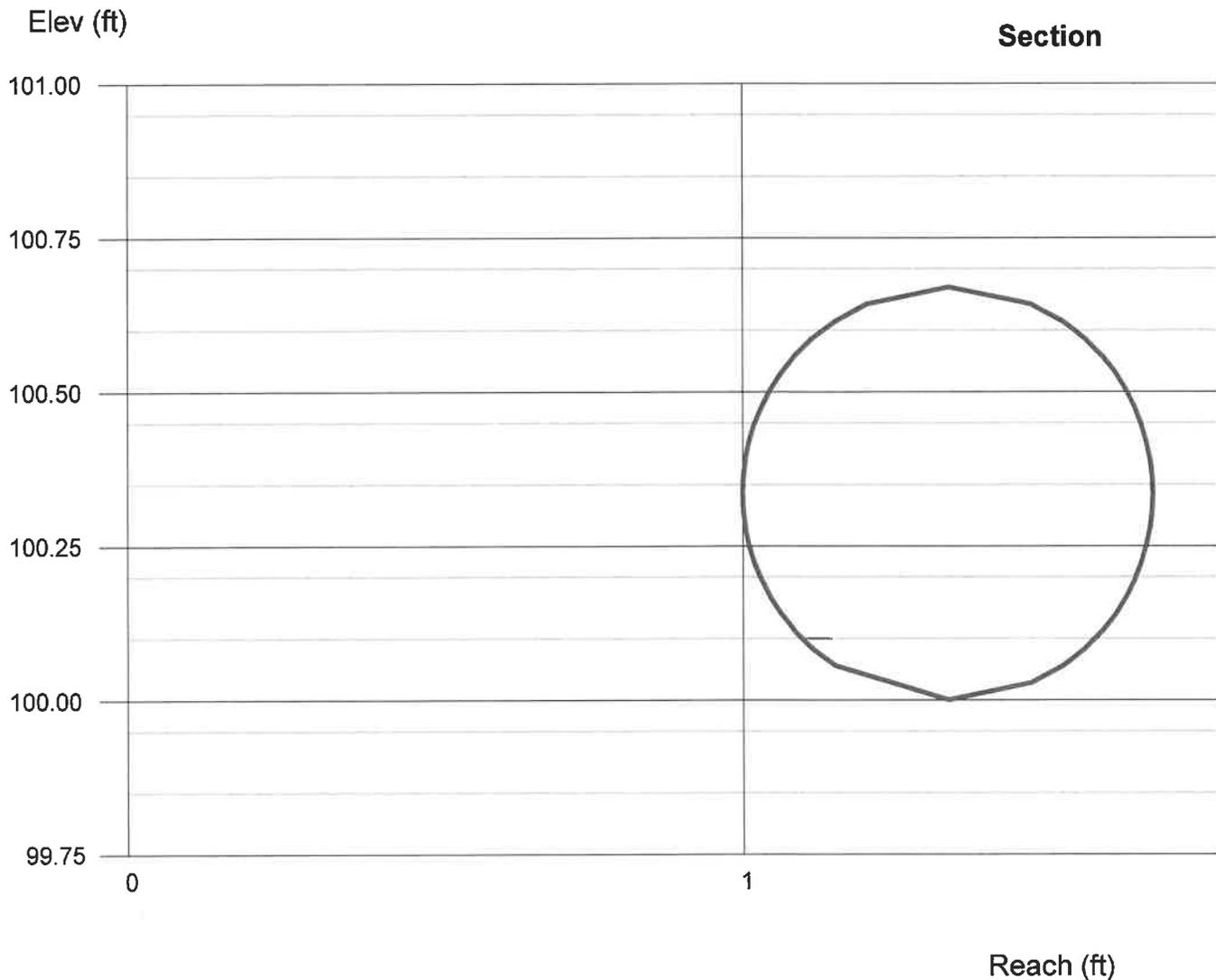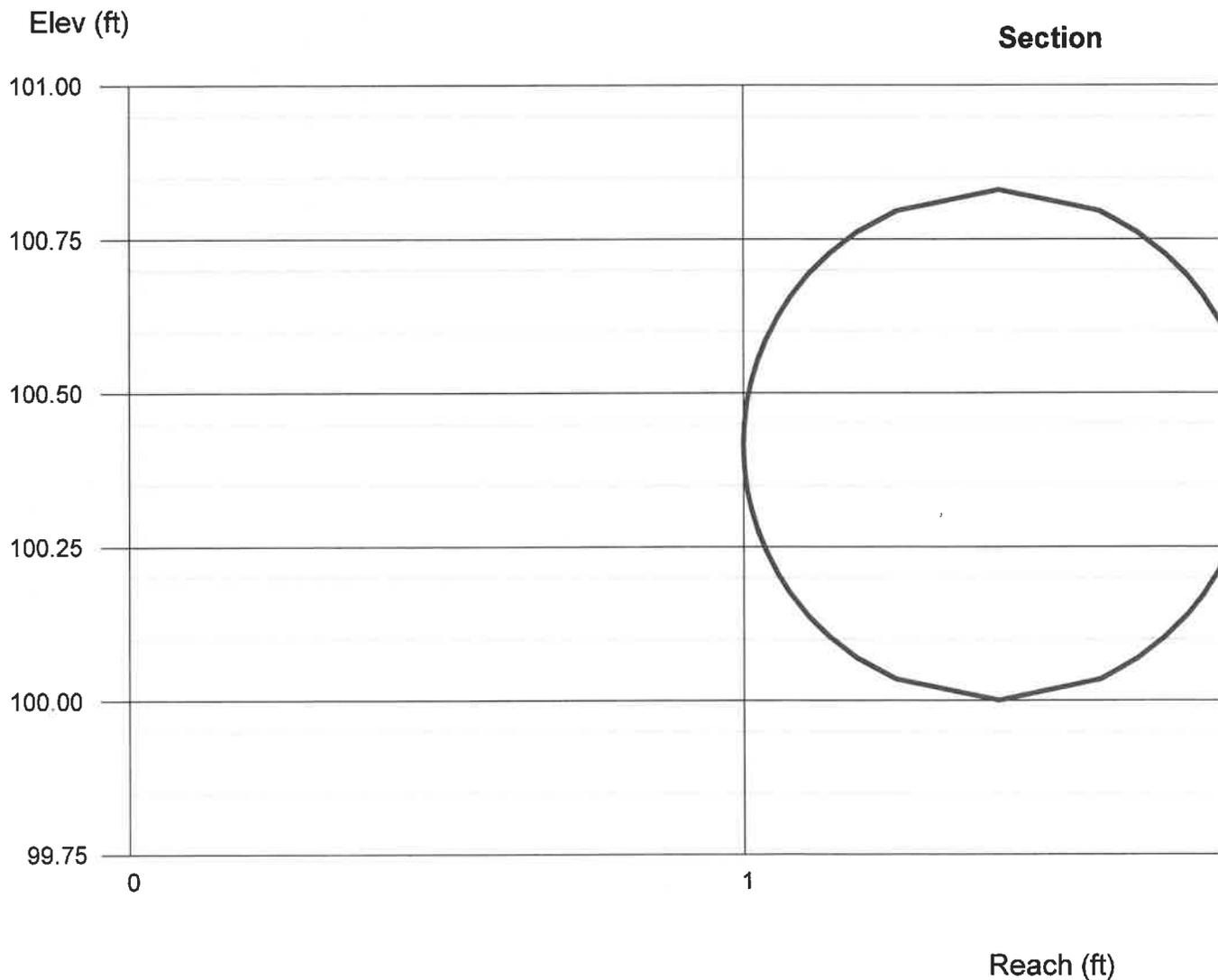
Channel Report

\<Name\>

Circular

Diameter (ft)	= 1.00
Invert Elev (ft)	= 100.00
Slope (%)	= 0.50
N-Value	= 0.012

Calculations

Compute by:	Q vs Depth
No. Increments	= 10

Highlighted

Depth (ft)	= 1.00
Q (cfs)	= 2.728
Area (sqft)	= 0.79
Velocity (ft/s)	= 3.47
Wetted Perim (ft)	= 3.14
Crit Depth, Yc (ft)	= 0.71
Top Width (ft)	= 0.00
EGL (ft)	= 1.19

Section

Reach (ft)

Hydraflow Storm Sewers Extension for Autodesk® AutoCAD® Civil 3D® Plan

Storm Sewer Inventory Report

Line No.	Alignment				Flow Data							Physical Data					Line ID
	Dnstr Line No.	Line Length (ft)	Defl angle (deg)	Junc Type	Known Q (cfs)	Drng Area (ac)	Runoff Coeff (C)	Inlet Time (min)	Invert El Dn (ft)	Line Slope (%)	Invert El Up (ft)	Line Size (in)	Line Shape	N Value (n)	J-Loss Coeff (K)	Inlet/ Rim El (ft)	
1	End	31.000	-131.481	MH	0.00	0.00	0.00	0.0	82.00	1.94	82.60	24	Cir	0.012	0.76	94.00	OUTFALL - MH 2
2	1	37.000	-45.553	MH	0.00	0.00	0.00	0.0	87.50	9.46	91.00	24	Cir	0.012	0.98	101.00	MH 2 - MH 3
3	2	123.000	77.165	Comb	0.00	0.34	0.84	5.0	92.00	2.44	95.00	24	Cir	0.012	1.47	100.90	MH 3 - CCB 8
4	3	20.000	-77.950	DrGrt	0.00	0.25	0.36	5.0	96.00	5.00	97.00	24	Cir	0.012	1.45	102.20	CCB 8 - MH 9
5	4	136.000	73.355	DrGrt	0.00	0.31	0.47	5.0	97.00	2.21	100.00	24	Cir	0.012	1.49	104.50	MH 9 - MH 10
6	5	54.000	-81.312	MH	0.00	0.00	0.00	0.0	100.00	2.78	101.50	24	Cir	0.012	1.00	108.00	MH 10 - MH 11
7	6	73.000	-34.696	MH	0.78	0.00	0.00	0.0	104.50	8.49	110.70	18	Cir	0.012	0.81	118.70	MH 11 - MH 13
8	7	81.000	37.652	Comb	0.00	0.24	0.62	5.0	111.00	2.10	112.70	15	Cir	0.012	1.47	118.20	MH 13 - CCB 19
9	8	125.000	76.658	DrGrt	0.00	0.06	0.62	5.0	112.70	1.28	114.30	15	Cir	0.012	0.73	120.50	CCB 19 - MH 20
10	9	95.000	-25.318	Comb	2.26	0.24	0.61	5.0	114.30	1.26	115.50	15	Cir	0.012	0.86	119.00	MH 20 - CCB 21
11	10	53.000	31.162	Comb	0.00	0.23	0.62	5.0	115.50	0.75	115.90	15	Cir	0.012	0.50	119.30	CCB 21 - CCB 22
12	11	84.000	0.421	MH	0.00	0.00	0.00	0.0	115.90	0.60	116.40	15	Cir	0.012	1.00	123.00	CCB 22 - MH 23
13	12	40.000	138.446	DrGrt	0.00	0.01	0.90	5.0	117.50	0.75	117.80	6	Cir	0.012	1.00	120.90	MH 23 - AWD 24
14	12	119.000	63.324	Grate	0.00	0.25	0.79	5.0	116.40	0.59	117.10	15	Cir	0.012	1.00	120.10	MH 23 - CLCB 25
15	7	17.000	-51.171	Comb	0.00	0.17	0.70	5.0	112.00	7.06	113.20	18	Cir	0.012	1.50	118.20	MH 13 - CCB 14
16	15	65.000	51.170	Comb	0.00	0.59	0.80	5.0	113.20	1.23	114.00	18	Cir	0.012	1.06	118.10	CCB 14 - CCB 16
17	16	35.000	41.336	Comb	0.00	0.32	0.85	5.0	114.00	0.86	114.30	15	Cir	0.012	0.52	118.10	CCB 16 - CCB 17
18	17	73.000	-17.147	Comb	0.00	0.47	0.66	5.0	114.30	0.82	114.90	15	Cir	0.012	1.00	118.40	CCB 17 - CCB 18
19	15	112.000	-94.809	DrGrt	0.00	0.42	0.85	5.0	113.50	1.70	115.40	12	Cir	0.012	1.00	118.90	CCB 14 - YD 15
20	2	65.000	-69.539	Comb	0.00	0.08	0.90	5.0	94.00	9.23	100.00	15	Cir	0.012	1.41	108.70	MH 3 - CCB 4
21	20	171.000	-1.254	Comb	0.00	0.04	0.90	5.0	105.00	3.51	111.00	15	Cir	0.012	1.39	116.00	CCB 4 - CCB 6
22	21	197.000	65.364	Comb	0.00	0.87	0.65	11.5	111.00	1.68	114.30	15	Cir	0.012	1.00	117.80	CCB 6 - DBCB 7

Storm Sewer Inventory Report

Line No.	Alignment				Flow Data					Physical Data							Line ID
	Dnstr Line No.	Line Length (ft)	Defl angle (deg)	Junc Type	Known Q (cfs)	Drng Area (ac)	Runoff Coeff (C)	Inlet Time (min)	Invert El Dn (ft)	Line Slope (%)	Invert El Up (ft)	Line Size (in)	Line Shape	N Value (n)	J-Loss Coeff (K)	Inlet/ Rim El (ft)	
23	20	24.000	67.433	DrGrt	0.00	0.44	0.59	5.0	105.00	5.42	106.30	12	Cir	0.012	1.00	109.50	CCB 4 - YD 5
24	6	83.000	85.565	DrGrt	1.95	0.13	0.50	5.0	101.50	1.33	102.60	15	Cir	0.012	1.00	105.60	MH 11 - MH 12

Storm Sewer Tabulation

Station Line	To Line	Len (ft)	Drng Area Incr (ac)	Drng Area Total (ac)	Rnoff coeff (C)	Area x C Incr	Area x C Total	Tc Inlet (min)	Tc Syst (min)	Rain (I) (in/hr)	Total flow (cfs)	Cap full (cfs)	Vel (ft/s)	Pipe Size (in)	Slope (%)	Invert Elev Dn (ft)	Invert Elev Up (ft)	HGL Elev Dn (ft)	HGL Elev Up (ft)	Grnd/Rim Elev Dn (ft)	Grnd/Rim Elev Up (ft)	Line ID
1	End	31.000	0.00	5.46	0.00	0.00	3.73	0.0	12.8	6.4	28.86	34.09	9.19	24	1.94	82.00	82.60	88.06	88.49	86.00	94.00	OUTFALL - MH 2
2	1	37.000	0.00	5.46	0.00	0.00	3.73	0.0	12.7	6.4	28.90	75.36	9.38	24	9.46	87.50	91.00	89.49	92.84	94.00	101.00	MH 2 - MH 3
3	2	123.000	0.34	4.03	0.84	0.29	2.80	5.0	7.6	7.5	25.97	38.27	10.93	24	2.44	92.00	95.00	93.21	96.78	101.00	100.90	MH 3 - CCB 8
4	3	20.000	0.25	3.69	0.36	0.09	2.51	5.0	7.6	7.5	23.85	54.79	12.54	24	5.00	96.00	97.00	96.92	98.73	100.90	102.20	CCB 8 - MH 9
5	4	136.000	0.31	3.44	0.47	0.15	2.42	5.0	7.3	7.6	23.35	36.39	8.11	24	2.21	97.00	100.00	98.73	101.72	102.20	104.50	MH 9 - MH 10
6	5	54.000	0.00	3.13	0.00	0.00	2.28	0.0	7.2	7.6	22.31	40.84	7.84	24	2.78	100.00	101.50	101.72	103.18	104.50	108.00	MH 10 - MH 11
7	6	73.000	0.00	3.00	0.00	0.00	2.21	0.0	7.1	7.6	19.91	33.15	15.47	18	8.49	104.50	110.70	105.34	112.17	108.00	118.70	MH 11 - MH 13
8	7	81.000	0.24	1.03	0.62	0.15	0.68	5.0	6.9	7.7	7.50	10.13	6.45	15	2.10	111.00	112.70	112.17	113.79	118.70	118.20	MH 13 - CCB 19
9	8	125.000	0.06	0.79	0.62	0.04	0.53	5.0	6.6	7.8	6.41	7.91	5.81	15	1.28	112.70	114.30	113.79	115.32	118.20	120.50	CCB 19 - MH 20
10	9	95.000	0.24	0.73	0.61	0.15	0.50	5.0	6.3	7.9	6.15	7.86	5.79	15	1.26	114.30	115.50	115.32	116.50	120.50	119.00	MH 20 - CCB 21
11	10	53.000	0.23	0.49	0.62	0.14	0.35	5.0	6.0	7.9	2.77	6.08	3.39	15	0.75	115.50	115.90	116.50	116.57	119.00	119.30	CCB 21 - CCB 22
12	11	84.000	0.00	0.26	0.00	0.00	0.21	0.0	5.6	8.1	1.67	5.40	3.01	15	0.60	115.90	116.40	116.57	116.91	119.30	123.00	CCB 22 - MH 23
13	12	40.000	0.01	0.01	0.90	0.01	0.01	5.0	5.0	8.2	0.07	0.53	1.82	6	0.75	117.50	117.80	117.63	117.93	123.00	120.90	MH 23 - AWD 24
14	12	119.000	0.25	0.25	0.79	0.20	0.20	5.0	5.0	8.2	1.63	5.37	3.47	15	0.59	116.40	117.10	116.91	117.61	123.00	120.10	MH 23 - CLCB 25
15	7	17.000	0.17	1.97	0.70	0.12	1.53	5.0	5.7	8.0	12.30	30.22	11.83	18	7.06	112.00	113.20	112.67	114.53	118.70	118.20	MH 13 - CCB 14
16	15	65.000	0.59	1.38	0.80	0.47	1.05	5.0	5.5	8.1	8.54	12.62	5.57	18	1.23	113.20	114.00	114.53	115.13	118.20	118.10	CCB 14 - CCB 16
17	16	35.000	0.32	0.79	0.85	0.27	0.58	5.0	5.4	8.1	4.74	6.48	4.59	15	0.86	114.00	114.30	115.13	115.18	118.10	118.10	CCB 16 - CCB 17
18	17	73.000	0.47	0.47	0.66	0.31	0.31	5.0	5.0	8.2	2.56	6.34	3.40	15	0.82	114.30	114.90	115.18	115.54	118.10	118.40	CCB 17 - CCB 18
19	15	112.000	0.42	0.42	0.85	0.42	0.36	5.0	5.0	8.2	2.94	5.02	4.25	12	1.70	113.50	115.40	114.53	116.13	118.20	118.90	CCB 14 - YD 15
20	2	65.000	0.08	1.43	0.90	0.07	0.93	5.0	12.6	6.4	6.00	21.25	10.32	15	9.23	94.00	100.00	94.45	100.99	101.00	108.70	MH 3 - CCB 4
21	20	171.000	0.04	0.91	0.90	0.04	0.60	5.0	12.2	6.5	3.91	13.10	7.02	15	3.51	105.00	111.00	105.47	111.80	108.70	116.00	CCB 4 - CCB 6

Project File: POA_B - 25 YR.stm

Number of lines: 24

Run Date: 6/14/2019

NOTES: Intensity = 102.61 / (Inlet time + 16.50) ^ 0.82; Return period =Yrs. 25 ; c = cir e = ellip b = box

Storm Sewer Tabulation

Station Line	Station To Line	Len (ft)	Drng Area Incr (ac)	Drng Area Total (ac)	Rnoff coeff (C)	Area x C Incr	Area x C Total	Tc Inlet (min)	Tc Syst (min)	Rain (I) (in/hr)	Total flow (cfs)	Cap full (cfs)	Vel (ft/s)	Pipe Size (in)	Pipe Slope (%)	Invert Elev Dn (ft)	Invert Elev Up (ft)	HGL Elev Dn (ft)	HGL Elev Up (ft)	Grnd / Rim Elev Dn (ft)	Grnd / Rim Elev Up (ft)	Line ID
22	21	197.000	0.87	0.87	0.65	0.57	0.57	11.5	11.5	6.6	3.75	9.05	4.59	15	1.68	111.00	114.30	111.80	115.08	116.00	117.80	CCB 6 - DBCB 7
23	20	24.000	0.44	0.44	0.59	0.26	0.26	5.0	5.0	8.2	2.14	8.98	6.76	12	5.42	105.00	106.30	105.33	106.92	108.70	109.50	CCB 4 - YD 5
24	6	83.000	0.13	0.13	0.50	0.07	0.07	5.0	5.0	8.2	2.49	8.05	2.93	15	1.33	101.50	102.60	103.18	103.25	108.00	105.60	MH 11 - MH 12

Project File: POA_B - 25 YR.stm

Number of lines: 24

Run Date: 6/14/2019

NOTES: Intensity = 102.61 / (Inlet time + 16.50) ^ 0.82; Return period =Yrs. 25 ; c = cir e = ellip b = box

Hydraulic Grade Line Computations

Line	Size (in)	Q (cfs)	Downstream Invert elev (ft)	Downstream HGL elev (ft)	Downstream Depth (ft)	Downstream Area (sqft)	Downstream Vel (ft/s)	Downstream Vel head (ft)	Downstream EGL elev (ft)	Downstream Sf (%)	Len (ft)	Invert elev (ft)	HGL elev (ft)	Upstream Depth (ft)	Upstream Area (sqft)	Upstream Vel (ft/s)	Upstream Vel head (ft)	Upstream EGL elev (ft)	Upstream Sf (%)	Check Ave Sf (%)	Check Enrgy loss (ft)	JL coeff (K)	Minor loss (ft)
1	24	28.86	82.00	88.06	2.00	3.14	9.19	1.31	89.37	1.388	31.000	82.60	88.49	2.00	3.14	9.19	1.31	89.80	1.387	1.387	0.430	0.76	1.00
2	24	28.90	87.50	89.49	1.99	3.03	9.21	1.42	90.90	0.000	37.000	91.00	92.84 j	1.84**	3.03	9.54	1.42	94.26	0.000	0.000	n/a	0.98	n/a
3	24	25.97	92.00	93.21	1.21*	1.98	13.09	1.20	94.41	0.000	123.000	95.00	96.78	1.78**	2.96	8.78	1.20	97.98	0.000	0.000	n/a	1.47	1.76
4	24	23.85	96.00	96.92	0.92*	1.42	16.82	1.06	97.98	0.000	20.000	97.00	98.73	1.73**	2.89	8.26	1.06	99.79	0.000	0.000	n/a	1.45	1.54
5	24	23.35	97.00	98.73	1.73	2.87	8.09	1.03	99.76	0.000	136.000	100.00	101.72 j	1.72**	2.87	8.14	1.03	102.75	0.000	0.000	n/a	1.49	n/a
6	24	22.31	100.00	101.72	1.72	2.82	7.78	0.97	102.69	0.000	54.000	101.50	103.18 j	1.68**	2.82	7.90	0.97	104.16	0.000	0.000	n/a	1.00	n/a
7	18	19.91	104.50	105.34	0.84*	1.02	19.61	2.00	107.33	0.000	73.000	110.70	112.17	1.47**	1.76	11.33	2.00	114.16	0.000	0.000	n/a	0.81	n/a
8	15	7.50	111.00	112.17	1.17	1.13	6.29	0.68	112.85	0.000	81.000	112.70	113.79 j	1.09**	1.13	6.61	0.68	114.47	0.000	0.000	n/a	1.47	0.13
9	15	6.41	112.70	113.79	1.09	1.07	5.65	0.56	114.34	0.000	125.000	114.30	115.32 j	1.02**	1.07	5.98	0.56	115.88	0.000	0.000	n/a	0.73	0.41
10	15	6.15	114.30	115.32	1.02	1.05	5.74	0.53	115.85	0.000	95.000	115.50	116.50 j	1.00**	1.05	5.84	0.53	117.03	0.000	0.000	n/a	0.86	n/a
11	15	2.77	115.50	116.50	1.00	0.67	2.63	0.27	116.77	0.000	53.000	115.90	116.57 j	0.67**	0.67	4.15	0.27	116.84	0.000	0.000	n/a	0.50	0.13
12	15	1.67	115.90	116.57	0.67	0.47	2.50	0.19	116.76	0.000	84.000	116.40	116.91 j	0.51**	0.47	3.52	0.19	117.11	0.000	0.000	n/a	1.00	0.05
13	6	0.07	117.50	117.63	0.13*	0.04	1.89	0.05	117.67	0.000	40.000	117.80	117.93	0.13**	0.04	1.75	0.05	117.98	0.000	0.000	n/a	1.00	n/a
14	15	1.63	116.40	116.91	0.51	0.47	3.44	0.19	117.10	0.000	119.000	117.10	117.61 j	0.51**	0.47	3.50	0.19	117.80	0.000	0.000	n/a	1.50	1.29
15	18	12.30	112.00	112.67	0.67*	0.76	16.22	0.86	113.53	0.000	17.000	113.20	114.53	1.33**	1.65	7.45	0.86	115.39	0.000	0.000	n/a	1.06	0.59
16	18	8.54	113.20	114.53	1.33	1.43	5.17	0.55	115.08	0.000	65.000	114.00	115.13 j	1.13**	1.43	5.97	0.55	115.69	0.000	0.000	n/a	0.52	n/a
17	15	4.74	114.00	115.13	1.13	0.93	4.06	0.41	115.54	0.000	35.000	114.30	115.18 j	0.88**	0.93	5.12	0.41	115.79	0.000	0.000	n/a	1.00	n/a
18	15	2.56	114.30	115.18	0.88	0.63	2.77	0.25	115.44	0.000	73.000	114.90	115.54 j	0.64**	0.63	4.04	0.25	115.79	0.000	0.000	n/a	1.00	n/a
19	12	2.94	113.50	114.53	1.00	0.62	3.75	0.22	114.74	0.583	112.000	115.40	116.13 j	0.73**	0.62	4.76	0.35	116.49	0.735	0.659	n/a	1.00	0.35
20	15	6.00	94.00	94.45	0.45*	0.40	14.88	0.52	94.97	0.000	65.000	100.00	100.99	0.99**	1.04	5.76	0.52	101.50	0.000	0.000	n/a	1.41	0.73
21	15	3.91	105.00	105.47	0.47*	0.42	9.31	0.35	105.82	0.000	171.000	111.00	111.80	0.80**	0.83	4.72	0.35	112.15	0.000	0.000	n/a	1.39	n/a

Project File: POA_B - 25 YR.stm

Number of lines: 24

Run Date: 6/14/2019

Notes: * depth assumed; ** Critical depth.; j-Line contains hyd. jump ; c = cir e = ellip b = box

Hydraulic Grade Line Computations

Line	Size (in)	Q (cfs)	Downstream Invert elev (ft)	Downstream HGL elev (ft)	Downstream Depth (ft)	Downstream Area (sqft)	Downstream Vel (ft/s)	Downstream Vel head (ft)	Downstream EGL elev (ft)	Downstream Sf (%)	Len (ft)	Upstream Invert elev (ft)	Upstream HGL elev (ft)	Upstream Depth (ft)	Upstream Area (sqft)	Upstream Vel (ft/s)	Upstream Vel head (ft)	Upstream EGL elev (ft)	Upstream Sf (%)	Check Ave Sf (%)	Check Enrgy loss (ft)	JL coeff (K)	Minor loss (ft)
22	15	3.75	111.00	111.80	0.80	0.81	4.53	0.34	112.13	0.000	197.000	114.30	115.08 j	0.78**	0.81	4.64	0.34	115.42	0.000	0.000	n/a	1.00	n/a
23	12	2.14	105.00	105.33	0.33*	0.23	9.37	0.27	105.60	0.000	24.000	106.30	106.92	0.62**	0.52	4.15	0.27	107.19	0.000	0.000	n/a	1.00	n/a
24	15	2.49	101.50	103.18	1.25	1.23	2.03	0.06	103.25	0.126	83.000	102.60	103.25	0.65	0.65	3.84	0.23	103.48	0.437	0.282	0.234	1.00	0.23

Project File: POA_B - 25 YR.stm

Number of lines: 24

Run Date: 6/14/2019

Notes: * depth assumed; ** Critical depth; j-Line contains hyd. jump ; c = cir e = ellip b = box

Hydraflow Storm Sewers Extension for Autodesk® AutoCAD® Civil 3D® Plan

Storm Sewer Inventory Report

Line No.	Alignment				Flow Data				Invert El Dn (ft)	Line Slope (%)	Invert El Up (ft)	Physical Data					Inlet/ Rim El (ft)	Line ID
	Dnstr Line No.	Line Length (ft)	Defl angle (deg)	Junc Type	Known Q (cfs)	Drng Area (ac)	Runoff Coeff (C)	Inlet Time (min)				Line Size (in)	Line Shape	N Value (n)	J-Loss Coeff (K)			
1	End	47.000	-172.562	DrGrt	0.00	0.46	0.31	13.5	83.20	0.85	83.60	36	Cir	0.013	0.65	88.95	OUTFALL - EXYD
2	1	129.000	-22.425	MH	0.00	0.00	0.00	0.0	84.00	4.57	89.90	24	Cir	0.013	1.00	93.80	EXYD - MH 26
3	2	5.000	88.392	Comb	0.00	0.25	0.72	5.0	89.90	2.00	90.00	18	Cir	0.012	1.47	93.70	MH 26 - CCB 27
4	3	84.000	-77.689	DrGrt	0.00	0.68	0.34	5.0	90.00	2.74	92.30	18	Cir	0.012	0.50	95.80	CCB 27 - MH 28
5	4	83.000	-3.712	DrGrt	0.00	0.01	0.30	5.0	92.30	9.88	100.50	15	Cir	0.012	1.50	105.60	MH 28 - MH 29
6	5	77.000	29.426	MH	0.00	0.00	0.00	0.0	101.00	9.09	108.00	15	Cir	0.012	0.62	120.80	MH 29 - MH 31
7	6	184.000	-34.672	Grate	0.00	0.29	0.90	5.0	115.00	2.72	120.00	15	Cir	0.012	0.50	125.50	MH 31 - CLCB 32
8	7	36.000	3.882	Comb	0.00	1.84	0.66	13.0	123.00	1.94	123.70	12	Cir	0.013	1.00	125.30	CLCB 32 - EXCB
9	5	79.000	-85.343	DrGrt	1.32	0.14	0.30	5.0	101.60	2.15	103.30	12	Cir	0.012	1.00	106.30	MH 29 - YD 30
10	2	101.000	-48.225	Comb	1.40	0.20	0.81	5.0	91.00	2.97	94.00	12	Cir	0.012	1.00	98.30	MH 26 - CCB 33

Storm Sewer Tabulation

Station Line	To Line	Len (ft)	Drng Area Incr (ac)	Drng Area Total (ac)	Rnoff coeff (C)	Area x C Incr	Area x C Total	Tc Inlet (min)	Tc Syst (min)	Rain (I) (in/hr)	Total flow (cfs)	Cap full (cfs)	Vel (ft/s)	Pipe Size (in)	Pipe Slope (%)	Invert Elev Dn (ft)	Invert Elev Up (ft)	HGL Elev Dn (ft)	HGL Elev Up (ft)	Grnd/Rim Elev Dn (ft)	Grnd/Rim Elev Up (ft)	Line ID
1	End	47.000	0.46	3.87	0.31	0.14	2.24	13.5	14.4	5.2	14.37	61.53	2.12	36	0.85	83.20	83.60	86.20	86.21	86.20	88.95	OUTFALL - EXY
2	1	129.000	0.00	3.41	0.00	0.00	2.09	0.0	14.0	5.3	13.80	48.37	5.29	24	4.57	84.00	89.90	86.26	91.24	88.95	93.80	EXYD - MH 26
3	2	5.000	0.25	3.21	0.72	0.18	1.93	5.0	14.0	5.3	11.54	16.09	7.03	18	2.00	89.90	90.00	91.24	91.29	93.80	93.70	MH 26 - CCB 27
4	3	84.000	0.68	2.96	0.34	0.23	1.75	5.0	13.7	5.3	10.67	18.82	6.67	18	2.74	90.00	92.30	91.29	93.55	93.70	95.80	CCB 27 - MH 28
5	4	83.000	0.01	2.28	0.30	0.00	1.52	5.0	13.6	5.4	9.49	21.99	7.84	15	9.88	92.30	100.50	93.55	101.67	95.80	105.60	MH 28 - MH 29
6	5	77.000	0.00	2.13	0.00	0.00	1.48	0.0	13.4	5.4	7.97	21.09	9.40	15	9.09	101.00	108.00	101.67	109.11	105.60	120.80	MH 29 - MH 31
7	6	184.000	0.29	2.13	0.90	0.26	1.48	5.0	13.1	5.5	8.09	11.53	8.58	15	2.72	115.00	120.00	115.77	121.12	120.80	125.50	MH 31 - CLCB 32
8	7	36.000	1.84	1.84	0.66	1.21	1.21	13.0	13.0	5.5	6.68	4.97	8.50	12	1.94	123.00	123.70	124.00	125.27	125.50	125.30	CLCB 32 - EXCB
9	5	79.000	0.14	0.14	0.30	0.04	0.04	5.0	5.0	8.7	1.68	5.66	5.04	12	2.15	101.60	103.30	101.97	103.85	105.60	106.30	MH 29 - YD 30
10	2	101.000	0.20	0.20	0.81	0.16	0.16	5.0	5.0	8.7	2.80	6.65	6.37	12	2.97	91.00	94.00	91.45	94.72	93.80	98.30	MH 26 - CCB 33

Project File: POA_A - 25 YR.stm

Number of lines: 10

Run Date: 6/14/2019

NOTES: Intensity = 37.34 / (Inlet time + 3.50) ^ 0.68; Return period = Yrs. 25 ; c = cir e = ellip b = box

Storm Sewers v10.514

Hydraulic Grade Line Computations

Line	Size (in)	Q (cfs)	Downstream Invert elev (ft)	Downstream HGL elev (ft)	Downstream Depth (ft)	Downstream Area (sqft)	Downstream Vel (ft/s)	Downstream Vel head (ft)	Downstream EGL elev (ft)	Downstream Sf (%)	Len (ft)	Invert elev (ft)	Upstream HGL elev (ft)	Upstream Depth (ft)	Upstream Area (sqft)	Upstream Vel (ft/s)	Upstream Vel head (ft)	Upstream EGL elev (ft)	Upstream Sf (%)	Check Ave Sf (%)	Check Enrgy loss (ft)	JL coeff (K)	Minor loss (ft)
1	36	14.37	83.20	86.20	3.00	7.07	2.03	0.06	86.26	0.046	47.000	83.60	86.21	2.61	6.53	2.20	0.08	86.29	0.042	0.044	0.021	0.65	0.05
2	24	13.80	84.00	86.26	2.00	2.23	4.39	0.30	86.56	0.372	129.000	89.90	91.24 j	1.34**	2.23	6.18	0.59	91.83	0.602	0.487	n/a	1.00	0.59
3	18	11.54	89.90	91.24	1.34	1.62	6.94	0.79	92.03	0.000	5.000	90.00	91.29 j	1.29**	1.62	7.12	0.79	92.08	0.000	0.000	n/a	1.47	n/a
4	18	10.67	90.00	91.29	1.29	1.58	6.58	0.71	92.01	0.000	84.000	92.30	93.55 j	1.25**	1.58	6.77	0.71	94.26	0.000	0.000	n/a	0.50	0.36
5	15	9.49	92.30	93.55	1.25	1.19	7.74	0.93	94.48	1.842	83.000	100.50	101.67 j	1.17**	1.19	7.95	0.98	102.65	1.591	1.716	n/a	1.50	1.47
6	15	7.97	101.00	101.67	0.67	0.67	11.90	0.74	102.41	0.000	77.000	108.00	109.11	1.11**	1.15	6.91	0.74	109.86	0.000	0.000	n/a	0.62	n/a
7	15	8.09	115.00	115.77	0.77*	0.80	10.17	0.76	116.53	0.000	184.000	120.00	121.12	1.12**	1.16	6.98	0.76	121.88	0.000	0.000	n/a	0.50	0.38
8	12	6.68	123.00	124.00	1.00*	0.79	8.51	1.12	125.12	3.519	36.000	123.70	125.27	1.00	0.79	8.50	1.12	126.39	3.517	3.518	1.266	1.00	1.12
9	12	1.68	101.60	101.97	0.37*	0.27	6.28	0.22	102.20	0.000	79.000	103.30	103.85	0.55**	0.44	3.79	0.22	104.07	0.000	0.000	n/a	1.00	n/a
10	12	2.80	91.00	91.45	0.45*	0.35	8.10	0.34	91.79	0.000	101.000	94.00	94.72	0.72**	0.60	4.65	0.34	95.05	0.000	0.000	n/a	1.00	0.34

Project File: POA_A - 25 YR.stm

Number of lines: 10

Run Date: 6/14/2019

Notes: * depth assumed; ** Critical depth.; j-Line contains hyd. jump ; c = cir e = ellip b = box

Hydraflow Storm Sewers Extension for Autodesk® AutoCAD® Civil 3D® Plan

Outfall

MH 200

1

2

OCS 200

Storm Sewer Inventory Report

Line No.	Alignment				Flow Data				Invert El Dn (ft)	Line Slope (%)	Invert El Up (ft)	Physical Data					Line ID
	Dnstr Line No.	Line Length (ft)	Defl angle (deg)	Junc Type	Known Q (cfs)	Drng Area (ac)	Runoff Coeff (C)	Inlet Time (min)				Line Size (in)	Line Shape	N Value (n)	J-Loss Coeff (K)	Inlet/ Rim El (ft)	
1	End	9.000	53.516	MH	0.00	0.00	0.00	0.0	76.00	8.89	76.80	24	Cir	0.012	0.70	79.00	OUTLET - MH 200
2	1	142.000	40.834	None	21.28	0.00	0.00	0.0	76.80	2.96	81.00	24	Cir	0.012	1.00	89.17	MH 200 - OCS 200

Project File: Outlet - 100 YR.stm

Number of lines: 2

Date: 6/14/2019

Storm Sewer Tabulation

Station Line	To Line	Len (ft)	Drng Area Incr (ac)	Drng Area Total (ac)	Rnoff coeff (C)	Area x C Incr	Area x C Total	Tc Inlet (min)	Tc Syst (min)	Rain (I) (in/hr)	Total flow (cfs)	Cap full (cfs)	Vel (ft/s)	Pipe Size (in)	Pipe Slope (%)	Invert Elev Dn (ft)	Invert Elev Up (ft)	HGL Elev Dn (ft)	HGL Elev Up (ft)	Grnd / Rim Elev Dn (ft)	Grnd / Rim Elev Up (ft)	Line ID
1	End	9.000	0.00	0.00	0.00	0.00	0.00	0.0	0.3	0.0	21.28	73.05	7.23	24	8.89	76.00	76.80	78.00	78.45	0.00	79.00	OUTLET - MH 20
2	1	142.000	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	21.28	42.14	7.68	24	2.96	76.80	81.00	78.45	82.65	79.00	89.17	MH 200 - OCS 20

Project File: Outlet - 100 YR.stm

Number of lines: 2

Run Date: 6/14/2019

NOTES:Intensity = 127.16 / (Inlet time + 17.80) ^ 0.82; Return period =Yrs. 100 ; c = cir e = ellip b = box
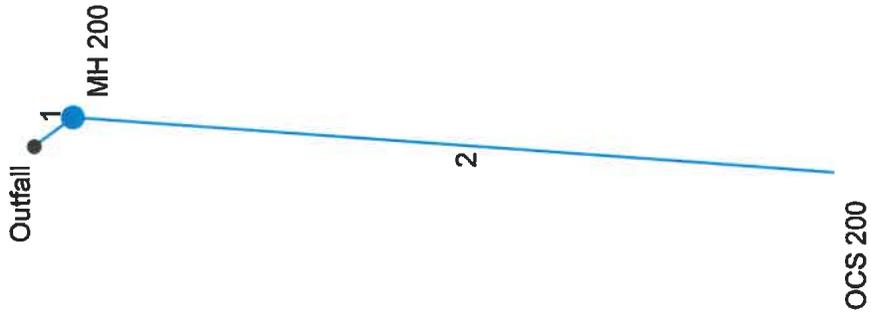
Hydraulic Grade Line Computations

Line	Size (in)	Q (cfs)	Downstream Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	Len (ft)	Invert elev (ft)	Upstream HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	Check Ave Sf (%)	Enrgy loss (ft)	JL coeff (K)	Minor loss (ft)
1	24	21.28	76.00	78.00	2.00	2.77	6.77	0.71	78.71	0.755	9.000	76.80	78.45 j	1.65**	2.77	7.68	0.92	79.37	0.746	0.750	n/a	0.70	n/a
2	24	21.28	76.80	78.45	1.65*	2.77	7.68	0.92	79.37	0.000	142.00	81.00	82.65	1.65**	2.77	7.68	0.92	83.57	0.000	0.000	n/a	1.00	n/a

Project File: Outlet - 100 YR.stm

Number of lines: 2

Run Date: 6/14/2019

Notes: * depth assumed; ** Critical depth.; j-Line contains hyd. jump ;   c = cir   e = ellip   b = box

Outlet Protection Calculations

Project: Westside Elementary School   By: MCB   Date: 06/18/19
Location: 250 Brandegee Avenue, Groton, CT   Checked: Date:
Outlet I.D. **FES 1**

*Based on Connecticut DOT Drainage Manual, Section 11.13

Description:
Preformed Scour Hole at FES 1

Design Criteria (25-yr Storm Event):

Q (cfs) = 28.9	R_p (ft)=	2
D (in) = 24	S_p (ft) =	2
V (fps) = 9.19	Tw (ft)=	2 (Pipe Full)

Q= Flow rate at discharge point in cubic feet per second (cfs)
D= Outlet pipe diameter (in)
V= Flow velocity at discharge point (ft/s)
R_p= Maximum inside pipe rise (ft)
S_p= inside diametere for circular sections of maximum inside pipe span for non-circular sections (ft)
T_w= Tailwater depth (ft)

Based on **Table 11.13.1**, A *Preformed Scour Hole* is used Full Pipe Rise (Type II)

Rip Rap Stone Size:

D_{50} Computed (ft)	Rip Rap Specification	D_{50} Stone Size Required
0.14	Modified	5 inches

Preformed Scour Hole Dimensions:

$F = R_p$	=	2 ft
$C = 3.0(S_p)+6.0(F)$	=	18 ft
$B = 2.0(S_p)+6.0(F)$	=	16 ft
d (Depth of Stone)	=	12 inches

Engineering, Planning,
Landscape Architecture
and Environmental Science

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JOB West Side Elementary School
SHEET NO. _____1_____ OF _____1_____
CALCULATED BY _____FAB_____ DATE 6/18/19
CHECKED BY _____ DATE _____
SCALE Level Spreader Design

The top row of openings are to be at grade to provide a free-flowing, unobstructed overflow from the concrete galleries. Each opening was treated as an orifice with dimensions of 2 inches wide by 5 inches high with 4 inches of head measured from the centroid of the opening. Each 4 foot gallery unit has 5 openings total in top row.

• Discharge Capacity per unit : (from CT DOT Manual - Section 10.0.2)

$$Q = C_0 A_0 (2gH_0)^{0.5}, \text{ where}$$

Q = discharge capacity in cfs
C_0 = coefficient of discharge = 0.6
A_0 = opening area = 10 in² = 0.069 ft²
g = gravitational acceleration = 32.2 ft/s
H_0 = head on the orifice measured from centroid of the opening = 4 in = 0.33'
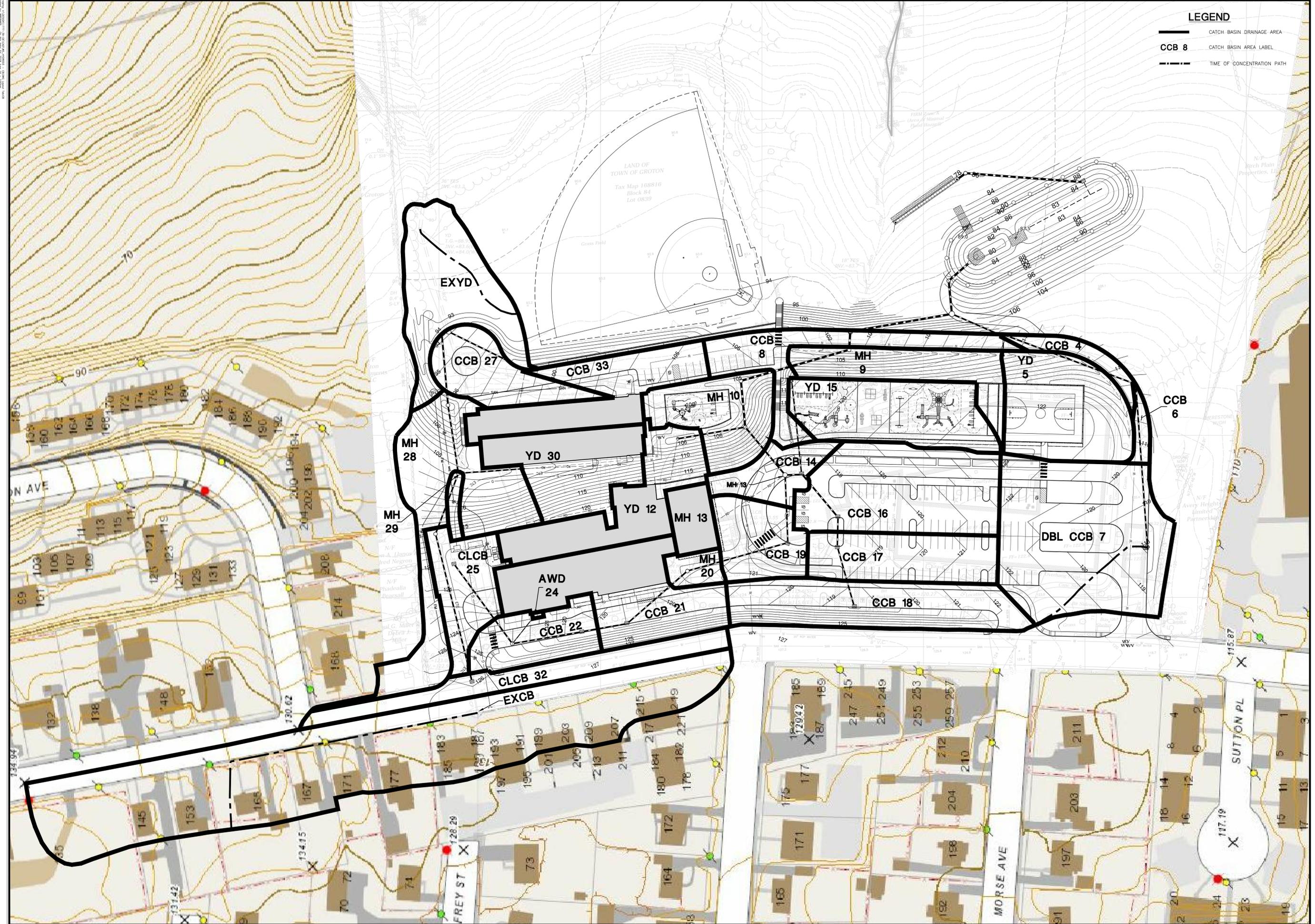
$$Q = (0.6)(0.069)[2(32.2) \times (0.33)]^{0.5} = 0.192 \text{ cfs/opening}$$

$$Q_{unit} = 0.192 \text{ cfs/opening} \times 5 \text{ openings} = 0.96 \text{ cfs/opening}$$

• Number of units required :

100-yr discharge from basin = 21.28 cfs

$$Q = \frac{21.28}{0.96} = 22.3 \Rightarrow 23 \text{ units} \Leftarrow$$

EXYD

CCB 27

CCB 33

CCB 8

MH 9

YD 5

CCB 4

MH 10

YD 15

CCB 6

MH 28

YD 30

CCB 14

MH 29

YD 12

MH 13

MH 19

CCB 16

DBL CCB 7

CLCB 25

MH 20

CCB 19

CCB 17

AWD 24

CCB 21

CCB 18

CCB 22

CLCB 32

EXCB

LAND OF
TOWN OF GROTON
Tax Map 168816
Block 84
Lot 0839

DESCRIPTION   DATE   BY

APPENDIX F
WATER QUALITY COMPUTATIONS

STORMWATER QUALITY CALCULATIONS:
Water Quality Volume (WQV)

Basin ID	Total Area (ac.)	Percent Impervious	Volumetric Runoff Coeff., R	WQV (ac-ft)	Total Volume Provided (ac-ft)
200	7.02	60.4%	0.59	0.347	*0.356*

$$WQV = \frac{(1.0 \text{ inches}) \times A \times R}{12}$$

Where: WQV = Water Quality Volume in acre-feet

A = Contributing Area in acres

R = 0.05 + 0.009 (I)

I = Site Imperviousness as percent

STORMWATER QUALITY CALCULATIONS:
Groundwater Recharge Volume (GRV)

Area ID	Total Site Area (ac.)	Impervious Area (ac.)	Percent Impervious	Recharge Depth[1], D (in.)	GRV (ac-ft)	Total Volume Provided[2] (ac-ft)
Study Area *	27.18	5.72	21.0%	0.25	0.119	0.356

* Development Area consists of the total area of Proposed WS 10, WS 11, WS 20, WS 21, WS 30 and WS40

[1] - Depth of Runoff to be Recharged or Recharge Depth taken from Table 7-4 found on page 7-6 of the CT DEEP Stormwater Quality Manual.

[2] - Groundwater recharge volume is provided within the basin below the low flow orifices.

$$GRV = \frac{D \times A \times I}{12}$$

Where: GRV = Groundwater Recharge Volume in acre-feet
D = Depth of Runoff to be Recharged in inches
A = Contributing Area in acres (B soil)
I = Site Imperviousness as decimal

STORMWATER QUALITY CALCULATIONS:
Storage Volume Provided

Detention Basin 200:

Sediment Forebay

Elevation (ft)	Surface Area (ft2)	Volume (ft3)	Volume (ac-ft)	Cumulative Volume (ac-ft)
80.0	425	0.0	0.000	0.000
81.0	750	587.5	0.013	0.013
82.0	1,150	950.0	0.022	0.035
83.0	1,600	1,375.0	0.032	0.067
83.5	1,825	856.3	0.020	0.087

Main Basin:

Elevation (ft)	Surface Area (ft2)	Volume (ft3)	Volume (ac-ft)	Cumulative Volume (ac-ft)
83.0	2,475	0.0	0.000	0.000
84.0	6,475	4,475.0	0.103	0.103
85.0	8,000	7,237.5	0.166	0.269

Hydrodynamic Separator MH3

CDS3020-6-C DESIGN NOTES
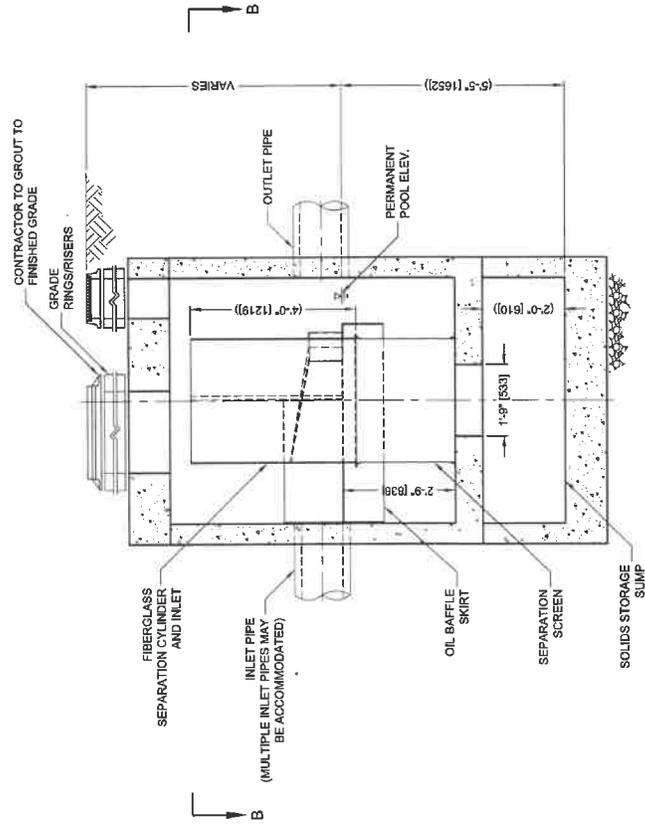
THE STANDARD CDS3020-6-C CONFIGURATION IS SHOWN. ALTERNATE CONFIGURATIONS ARE AVAILABLE AND ARE LISTED BELOW. SOME CONFIGURATIONS MAY BE COMBINED TO SUIT SITE REQUIREMENTS.

CONFIGURATION DESCRIPTION
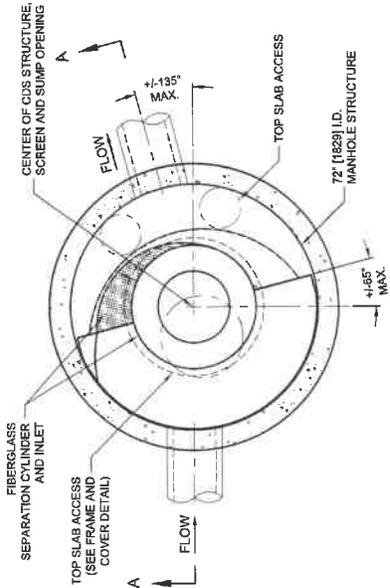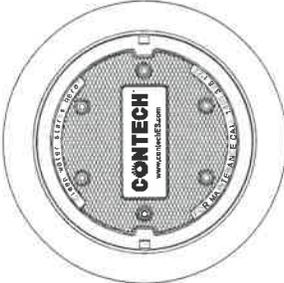
GRATED INLET ONLY (NO INLET PIPE)
GRATED INLET WITH INLET PIPE OR PIPES
CURB INLET ONLY (NO INLET PIPE)
CURB INLET WITH INLET PIPE OR PIPES
SEPARATE OIL BAFFLE (SINGLE INLET PIPE REQUIRED FOR THIS CONFIGURATION)
SEDIMENT WEIR FOR NJDEP / NJCAT CONFORMING UNITS

SITE SPECIFIC DATA REQUIREMENTS

STRUCTURE ID	*
WATER QUALITY FLOW RATE (CFS OR L/s)	*
PEAK FLOW RATE (CFS OR L/s)	*
RETURN PERIOD OF PEAK FLOW (YRS)	*
SCREEN APERTURE (2400 OR 4700)	*

PIPE DATA:	I.E.	MATERIAL	DIAMETER
INLET PIPE 1	*	*	*
INLET PIPE 2	*	*	*
OUTLET PIPE	*	*	*

RIM ELEVATION	
	WIDTH	HEIGHT
ANTI-FLOTATION BALLAST	*	*

NOTES/SPECIAL REQUIREMENTS:

* PER ENGINEER OF RECORD
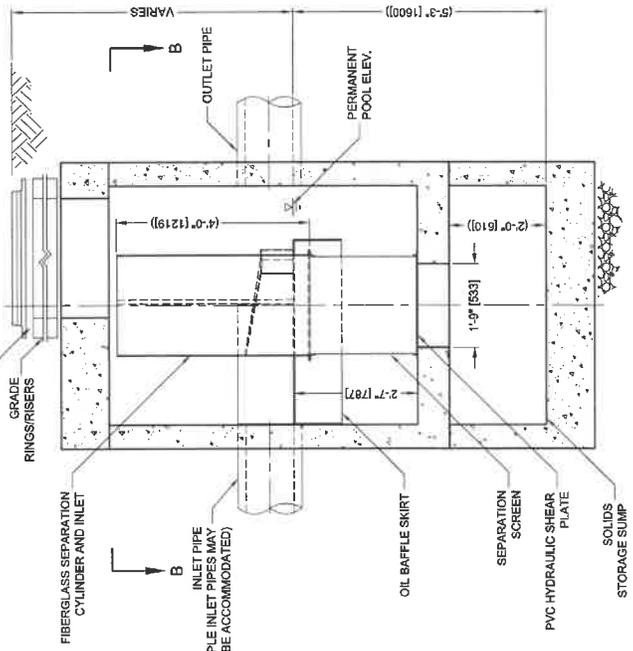
FRAME AND COVER
(DIAMETER VARIES)
N.T.S.

GENERAL NOTES
1. CONTECH TO PROVIDE ALL MATERIALS UNLESS NOTED OTHERWISE.
2. DIMENSIONS MARKED WITH ( ) ARE REFERENCE DIMENSIONS. ACTUAL DIMENSIONS MAY VARY.
3. FOR FABRICATION DRAWINGS WITH DETAILED STRUCTURE DIMENSIONS AND WEIGHTS, PLEASE CONTACT YOUR CONTECH ENGINEERED SOLUTIONS LLC REPRESENTATIVE. www.contechES.com
4. CDS WATER QUALITY STRUCTURE SHALL BE IN ACCORDANCE WITH ALL DESIGN DATA AND INFORMATION CONTAINED IN THIS DRAWING.
5. STRUCTURE SHALL MEET AASHTO HS20 AND CASTINGS SHALL MEET HS20 (AASHTO M 306) LOAD RATING, ASSUMING GROUNDWATER ELEVATION AT, OR BELOW, THE OUTLET PIPE INVERT ELEVATION. ENGINEER OF RECORD TO CONFIRM ACTUAL GROUNDWATER ELEVATION.
6. PVC HYDRAULIC SHEAR PLATE IS PLACED ON SHELF AT BOTTOM OF SCREEN CYLINDER. REMOVE AND REPLACE AS NECESSARY DURING MAINTENANCE CLEANING.

INSTALLATION NOTES
A. ANY SUB-BASE, BACKFILL DEPTH, AND/OR ANTI-FLOTATION PROVISIONS ARE SITE-SPECIFIC DESIGN CONSIDERATIONS AND SHALL BE SPECIFIED BY ENGINEER OF RECORD.
B. CONTRACTOR TO PROVIDE EQUIPMENT WITH SUFFICIENT LIFTING AND REACH CAPACITY TO LIFT AND SET THE CDS MANHOLE STRUCTURE (LIFTING CLUTCHES PROVIDED).
C. CONTRACTOR TO ADD JOINT SEALANT BETWEEN ALL STRUCTURE SECTIONS, AND ASSEMBLE STRUCTURE.
D. CONTRACTOR TO PROVIDE, INSTALL, AND GROUT PIPES. MATCH PIPE INVERTS WITH ELEVATIONS SHOWN.
E. CONTRACTOR TO TAKE APPROPRIATE MEASURES TO ASSURE UNIT IS WATER TIGHT, HOLDING WATER TO FLOWLINE INVERT MINIMUM. IT IS SUGGESTED THAT ALL JOINTS BELOW PIPE INVERTS ARE GROUTED.

CONTECH
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CDS3020-6-C
INLINE CDS
STANDARD DETAIL

PLAN VIEW B-B
N.T.S.

CENTER OF CDS STRUCTURE, SCREEN AND SUMP OPENING
+/-135° MAX.
FLOW
TOP SLAB ACCESS
72" [1829] I.D. MANHOLE STRUCTURE
+/-85° MAX.
FIBERGLASS SEPARATION CYLINDER AND INLET
TOP SLAB ACCESS (SEE FRAME AND COVER DETAIL)
FLOW

ELEVATION A-A
N.T.S.

VARIES
(5'-5" [1652])
OUTLET PIPE
PERMANENT POOL ELEV.
CONTRACTOR TO GROUT TO FINISHED GRADE
GRADE RINGS/RISERS
(4'-0" [1219])
(2'-0" [610])
1'-9" [533]
2'-9" [836]
FIBERGLASS SEPARATION CYLINDER AND INLET
INLET PIPE (MULTIPLE INLET PIPES MAY BE ACCOMMODATED)
OIL BAFFLE SKIRT
SEPARATION SCREEN
SOLIDS STORAGE SUMP

C:\USERS\SCHLACH\TER\DESKTOP\CDS DETAILS 180 MICRON SIZING\CAD\CDS3020-6-C-DTL.DWG 5/19/2014 5:21 PM

Purpose: To calculate the first flush runoff flow rate (WQF) over a given site area. In this situation the WQV to be analyzed is the runoff produced by the first 1" of rainfall.

Reference: United States Department of Agriculture Natural Resources Conservation Service TR-55 Manual

Given:

Structure Name	A (acres)	A (miles²)	Runoff Coefficient	Percent Imp. (%)*	t_c (min)	t_c (hr)
MH 3	7.02	0.01097	0.66	59.83	12.1	0.202

* Assumes runoff coefficient of 0.3 for pervious areas and 0.9 for impervious areas.

Procedure: The Water Quality Flow (WQF) is calculated using the Water Quality Volume (WQV). This WQV, converted to watershed inches, is substituted for the runoff depth (Q) in the Natural Resources Conservation Service (formerly Soil Conservation Service), TR-55 Graphical Peak Discharge Method.

1. Compute WQV in watershed inches using the following equation:

$$WQV = P * R$$

where: WQV = water quality volume (watershed inches)
P = design precipitation (inches) = (1" for water quality storm)
R = volumetric runoff coefficient = 0.05 + 0.009(I)
I = percent impervious cover

Structure Name	Percent Imp. (%)	R	P (in)	WQV (in)	WQV (ac-ft)
MH 3	59.83	0.588	1.0	0.588	0.3443

2. Compute the NRCS Runoff Curve Number (CN) using the following equation, or graphically using Figure 2-1 from TR-55 (USDA, 1986):

$$CN = 1000 / [10+5P+10Q-10(Q^2+1.25QP)^{1/2}]$$

where: CN = Runoff Curve Number
P = design precipitation (inches) = (1" for water quality storm)
Q = runoff depth (watershed inches)

Structure Name	Q (in)	CN
MH 3	0.588	95.39

3. Using computed CN, read initial abstraction (I_a) from Table 4-1 in Chapter 4 of TR-55; compute I_a/P, interpolating when appropriate.

Structure Name	I_a (in)	I_a/P
MH 3	0.097	0.097

4. Compute the time of concentration (t_c) in hours and the drainage area in square miles.

Structure Name	t_c (hr)	A (miles^2)
MH 3	0.202	0.01097

5. Read the unit peak discharge (q_u) from Exhibit 4-III in Chapter 4 of TR-55 for appropriate t_c for type III rainfall distribution.

Structure Name	t_c (hr)	I_a/P	q_u (csm/in)
MH 3	0.202	0.096666517	550

6. Substituting WQV (watershed inches) for runoff depth (Q), compute the water quality flow (WQF) from the following equation:

$$WQF = (q_u)*(A)*(Q)$$

where: WQF = water quality flow (cfs)
q_u = unit peak discharge (cfs/mi^2/inch)
A = drainage area (mi^2)
Q = runoff depth (watershed inches)

Structure Name	q_u (csm/in)	A (miles^2)	Q (in)	WQF (cfs)
MH 3	550	0.01097	0.588	3.55

CONTECH
ENGINEERED SOLUTIONS

CDS

CDS ESTIMATED NET ANNUAL SOLIDS LOAD REDUCTION
BASED ON THE RATIONAL RAINFALL METHOD

WESTSIDE ES
GROTON, CT

Area	**7.02 ac**	Unit Site Designation	**MH 3**
Weighted C	**0.66**	Rainfall Station #	**35**
t_c	**12 min**		
CDS Model	**3020-6**	CDS Treatment Capacity	**3.9 cfs**

Rainfall Intensity[1] (in/hr)	Percent Rainfall Volume[1]	Cumulative Rainfall Volume	Total Flowrate (cfs)	Treated Flowrate (cfs)	Incremental Removal (%)
0.08	41.6%	41.6%	0.37	0.37	39.3
0.16	21.0%	62.6%	0.74	0.74	18.5
0.24	11.1%	73.7%	1.11	1.11	9.1
0.32	6.6%	80.3%	1.48	1.48	5.0
0.40	3.6%	83.9%	1.85	1.85	2.5
0.48	2.5%	86.4%	2.22	2.22	1.6
0.56	1.8%	88.2%	2.59	2.59	1.0
0.64	1.1%	89.3%	2.96	2.96	0.5
0.72	1.4%	90.7%	3.33	3.33	0.6
0.80	1.5%	92.1%	3.70	3.70	0.6
1.00	1.7%	93.9%	4.63	3.90	0.5
1.20	1.4%	95.2%	5.55	3.90	0.3
1.40	1.4%	96.7%	6.48	3.90	0.3
1.60	0.6%	97.3%	7.40	3.90	0.1
1.80	0.7%	97.9%	8.33	3.90	0.1
2.00	0.4%	98.3%	9.25	3.90	0.1
3.00	1.3%	99.6%	13.88	3.90	0.1
4.00	0.4%	100.0%	18.50	3.90	0.0
0.00	0.0%	100.0%	0.00	0.00	0.0
0.00	0.0%	100.0%	0.00	0.00	0.0
					80.3

Removal Efficiency Adjustment[2] =	0.0%
Predicted % Annual Rainfall Treated =	96.7%
Predicted Net Annual Load Removal Efficiency =	**80.3%**

1 - Based on 14 years of 15-minute precipitation data from NCDC station 5445, Norfolk 2 SW, Litchfield County, CT
2 - Reduction due to use of 60-minute data for a site that has a time of concentration less than 30-minutes.

Hydrodynamic Separator MH 5T

CDS2020-5-C DESIGN NOTES

THE STANDARD CDS2020-5-C CONFIGURATION IS SHOWN. ALTERNATE CONFIGURATIONS ARE AVAILABLE AND ARE LISTED BELOW. SOME CONFIGURATIONS MAY BE COMBINED TO SUIT SITE REQUIREMENTS.

CONFIGURATION DESCRIPTION

GRATED INLET ONLY (NO INLET PIPE)
GRATED INLET WITH INLET PIPE OR PIPES
CURB INLET ONLY (NO INLET PIPE)
CURB INLET WITH INLET PIPE OR PIPES
SEPARATE OIL BAFFLE (SINGLE INLET PIPE REQUIRED FOR THIS CONFIGURATION)
SEDIMENT WEIR FOR NJDEP / NJCAT CONFORMING UNITS

GENERAL NOTES
1. CONTECH TO PROVIDE ALL MATERIALS UNLESS NOTED OTHERWISE.
2. DIMENSIONS MARKED WITH ( ) ARE REFERENCE DIMENSIONS. ACTUAL DIMENSIONS MAY VARY.
3. FOR FABRICATION DRAWINGS WITH DETAILED STRUCTURE DIMENSIONS AND WEIGHTS, PLEASE CONTACT YOUR CONTECH ENGINEERED SOLUTIONS LLC REPRESENTATIVE. www.conteches.com
4. CDS WATER QUALITY STRUCTURE SHALL BE IN ACCORDANCE WITH ALL DESIGN DATA AND INFORMATION CONTAINED IN THIS DRAWING.
5. STRUCTURE AND CASTINGS SHALL MEET AASHTO HS20 LOAD RATING, ASSUMING GROUNDWATER ELEVATION AT, OR BELOW, THE OUTLET PIPE INVERT ELEVATION. ENGINEER OF RECORD TO CONFIRM ACTUAL GROUNDWATER ELEVATION.
6. PVC HYDRAULIC SHEAR PLATE IS PLACED ON SHELF AT BOTTOM OF SCREEN CYLINDER. REMOVE AND REPLACE AS NECESSARY DURING MAINTENANCE CLEANING.

INSTALLATION NOTES
A. ANY SUB-BASE, BACKFILL DEPTH, AND/OR ANTI-FLOTATION PROVISIONS ARE SITE-SPECIFIC DESIGN CONSIDERATIONS AND SHALL BE SPECIFIED BY ENGINEER OF RECORD.
B. CONTRACTOR TO PROVIDE EQUIPMENT WITH SUFFICIENT LIFTING AND REACH CAPACITY TO LIFT AND SET THE CDS MANHOLE STRUCTURE (LIFTING CLUTCHES PROVIDED).
C. CONTRACTOR TO ADD JOINT SEALANT BETWEEN ALL STRUCTURE SECTIONS, AND ASSEMBLE STRUCTURE.
D. CONTRACTOR TO PROVIDE, INSTALL, AND GROUT PIPES. MATCH PIPE INVERTS WITH ELEVATIONS SHOWN.
E. CONTRACTOR TO TAKE APPROPRIATE MEASURES TO ASSURE UNIT IS WATER TIGHT, HOLDING WATER TO FLOWLINE INVERT MINIMUM. IT IS SUGGESTED THAT ALL JOINTS BELOW PIPE INVERTS ARE GROUTED.

FRAME AND COVER
(DIAMETER VARIES)
N.T.S.

PLAN VIEW B-B
N.T.S.

CENTER OF CDS STRUCTURE, SCREEN AND SUMP OPENING
FLOW
+/-135° MAX.
TOP SLAB ACCESS (SEE FRAME AND COVER DETAIL)
60" [1524] I.D. MANHOLE STRUCTURE
FIBERGLASS SEPARATION CYLINDER AND INLET
FLOW
+/-65° MAX.
PVC HYDRAULIC SHEAR PLATE

ELEVATION A-A
N.T.S.

VARIES
OUTLET PIPE
(5'-3" [1600])
PERMANENT POOL ELEV.
CONTRACTOR TO GROUT TO FINISHED GRADE
GRADE RINGS/RISERS
FIBERGLASS SEPARATION CYLINDER AND INLET
INLET PIPE (MULTIPLE INLET PIPES MAY BE ACCOMMODATED)
OIL BAFFLE SKIRT
SEPARATION SCREEN
PVC HYDRAULIC SHEAR PLATE
SOLIDS STORAGE SUMP
(4'-0" [1219])
(2'-0" [610])
1'-9" [533]
2'-7" [787]

CDS

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www.conteches.com
800-338-1122   513-645-7000   513-645-7993 FAX

CDS2020-5-C
INLINE CDS
STANDARD DETAIL

Project:	Westside ES
Location:	Groton, CT
Prepared For:	Milone & Macbroom

Purpose: To calculate the first flush runoff flow rate (WQF) over a given site area. In this situation the WQV to be analyzed is the runoff produced by the first 1" of rainfall.

Reference: United States Department of Agriculture Natural Resources Conservation Service TR-55 Manual

Given:

Structure Name	A (acres)	A (miles^2)	Runoff Coefficient	Percent Imp. (%)*	t_c (min)	t_c (hr)
MH 27	4.23	0.00661	0.60	50.59	13.7	0.229

* Assumes runoff coefficient of 0.3 for pervious areas and 0.9 for impervious areas.

Procedure: The Water Quality Flow (WQF) is calculated using the Water Quality Volume (WQV). This WQV, converted to watershed inches, is substituted for the runoff depth (Q) in the Natural Resources Conservation Service (formerly Soil Conservation Service), TR-55 Graphical Peak Discharge Method.

1. Compute WQV in watershed inches using the following equation:

$$WQV = P * R$$

where: WQV = water quality volume (watershed inches)
P = design precipitation (inches) = (1" for water quality storm)
R = volumetric runoff coefficient = $0.05 + 0.009(I)$
I = percent impervious cover

Structure Name	Percent Imp. (%)	R	P (in)	WQV (in)	WQV (ac-ft)
MH 27	50.59	0.505	1.0	0.505	0.1781

2. Compute the NRCS Runoff Curve Number (CN) using the following equation, or graphically using Figure 2-1 from TR-55 (USDA, 1986):

$$CN = 1000 / [10+5P+10Q-10(Q^2+1.25QP)^{1/2}]$$

where: CN = Runoff Curve Number
P = design precipitation (inches) = (1" for water quality storm)
Q = runoff depth (watershed inches)

Structure Name	Q (in)	CN
MH 27	0.505	94.03

3. Using computed CN, read initial abstraction (I_a) from Table 4-1 in Chapter 4 of TR-55; compute I_a/P, interpolating when appropriate.

Structure Name	I_a (in)	I_a/P
MH 27	0.127	0.127

4. Compute the time of concentration (t_c) in hours and the drainage area in square miles.

Structure Name	t_c (hr)	A (miles^2)
MH 27	0.229	0.00661

5. Read the unit peak discharge (q_u) from Exhibit 4-III in Chapter 4 of TR-55 for appropriate t_c for type III rainfall distribution.

Structure Name	t_c (hr)	I_a/P	q_u (csm/in)
MH 27	0.229	0.127032257	524

6. Substituting WQV (watershed inches) for runoff depth (Q), compute the water quality flow (WQF) from the following equation:

$$WQF = (q_u)*(A)*(Q)$$

where: WQF = water quality flow (cfs)
q_u = unit peak discharge (cfs/mi^2/inch)
A = drainage area (mi^2)
Q = runoff depth (watershed inches)

Structure Name	q_u (csm/in)	A (miles^2)	Q (in)	WQF (cfs)
MH 27	524	0.00661	0.505	1.75

CONTECH ENGINEERED SOLUTIONS

CDS TECHNOLOGIES

CDS ESTIMATED NET ANNUAL SOLIDS LOAD REDUCTION
BASED ON THE RATIONAL RAINFALL METHOD

WESTSIDE ES
GROTON, CT

Area	4.23 ac		Unit Site Designation	MH 27
Weighted C	0.60		Rainfall Station #	35
t_c	14 min			
CDS Model	2020-5		CDS Treatment Capacity	2.2 cfs

Rainfall Intensity[1] (in/hr)	Percent Rainfall Volume[1]	Cumulative Rainfall Volume	Total Flowrate (cfs)	Treated Flowrate (cfs)	Incremental Removal (%)
0.08	41.6%	41.6%	0.20	0.20	39.3
0.16	21.0%	62.6%	0.41	0.41	18.5
0.24	11.1%	73.7%	0.61	0.61	9.1
0.32	6.6%	80.3%	0.82	0.82	5.0
0.40	3.6%	83.9%	1.02	1.02	2.5
0.48	2.5%	86.4%	1.23	1.23	1.6
0.56	1.8%	88.2%	1.43	1.43	1.0
0.64	1.1%	89.3%	1.63	1.63	0.5
0.72	1.4%	90.7%	1.84	1.84	0.6
0.80	1.5%	92.1%	2.04	2.04	0.6
1.00	1.7%	93.9%	2.55	2.20	0.5
1.20	1.4%	95.2%	3.06	2.20	0.3
1.40	1.4%	96.7%	3.57	2.20	0.3
1.60	0.6%	97.3%	4.08	2.20	0.1
1.80	0.7%	97.9%	4.60	2.20	0.1
2.00	0.4%	98.3%	5.11	2.20	0.1
3.00	1.3%	99.6%	7.66	2.20	0.1
4.00	0.4%	100.0%	10.21	2.20	0.0
0.00	0.0%	100.0%	0.00	0.00	0.0
0.00	0.0%	100.0%	0.00	0.00	0.0
					80.2

Removal Efficiency Adjustment[2] =	0.0%
Predicted % Annual Rainfall Treated =	96.8%
Predicted Net Annual Load Removal Efficiency =	**80.2%**

1 - Based on 14 years of 15-minute precipitation data from NCDC station 5445, Norfolk 2 SW, Litchfield County, CT
2 - Reduction due to use of 60-minute data for a site that has a time of concentration less than 30-minutes.

CDS Guide
Operation, Design, Performance and Maintenance
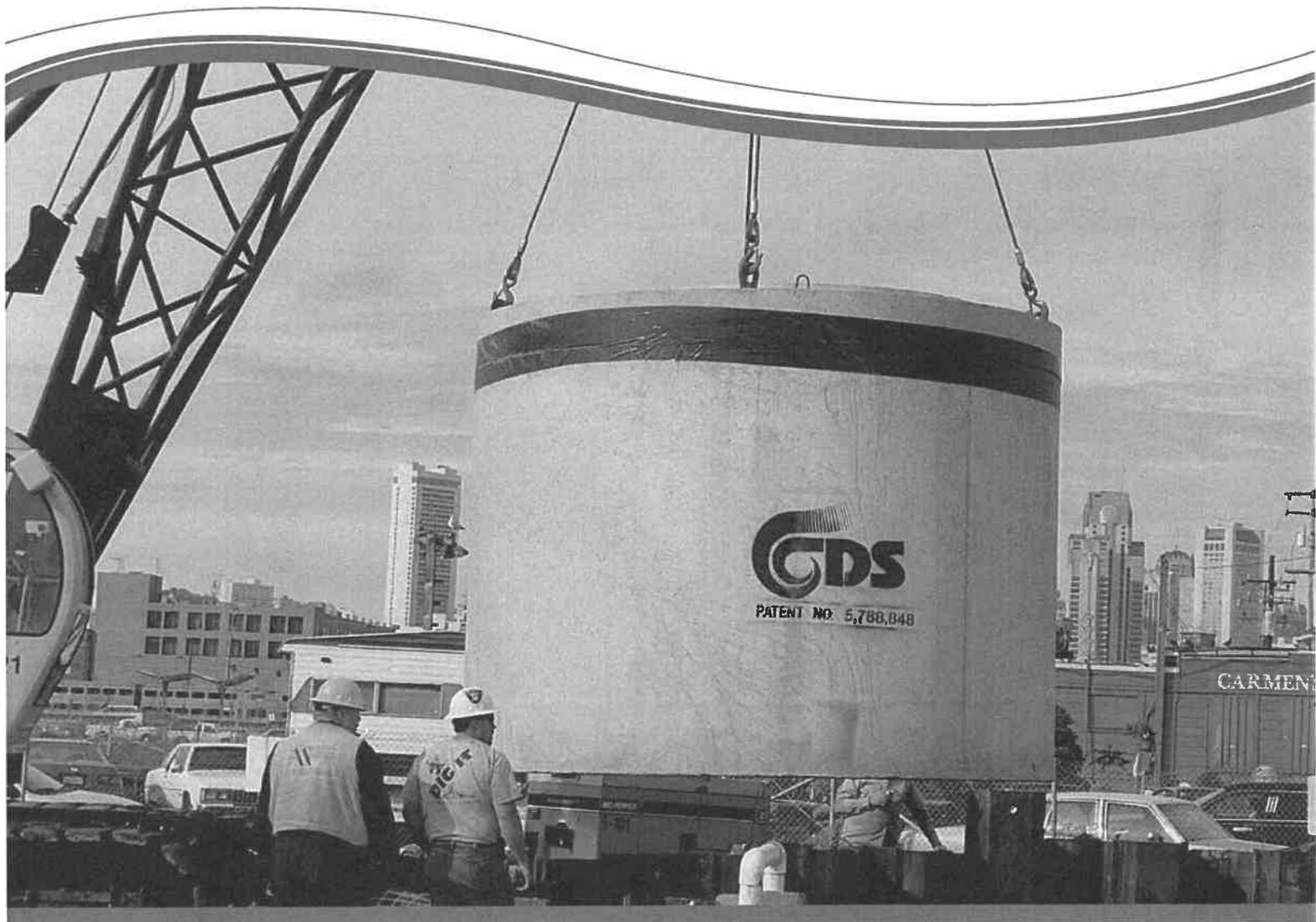
CDS®

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.
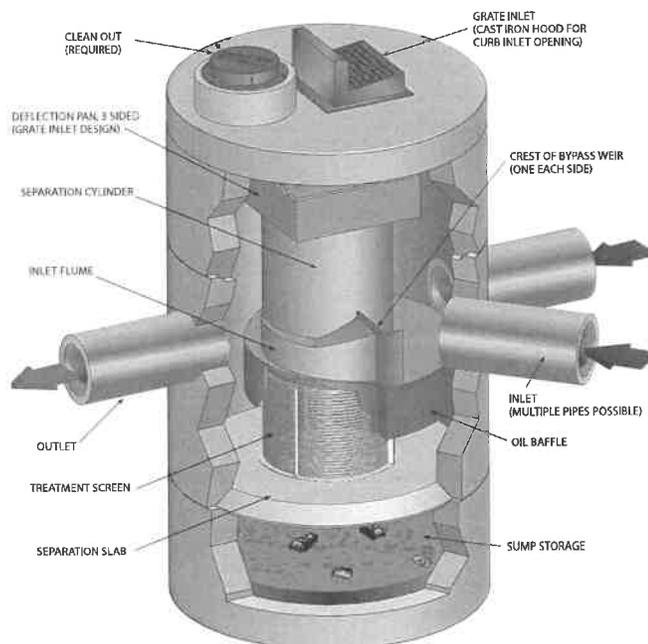
Operation Overview

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.
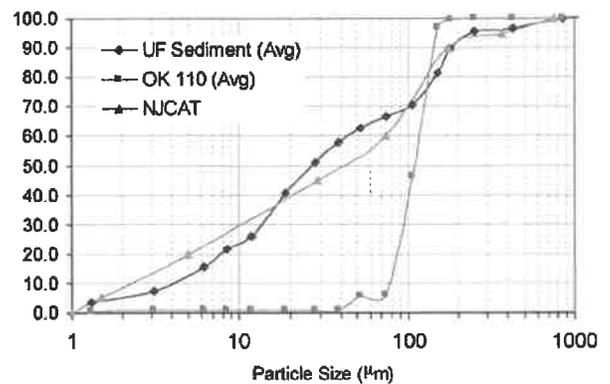
Figure 1. Particle size distributions

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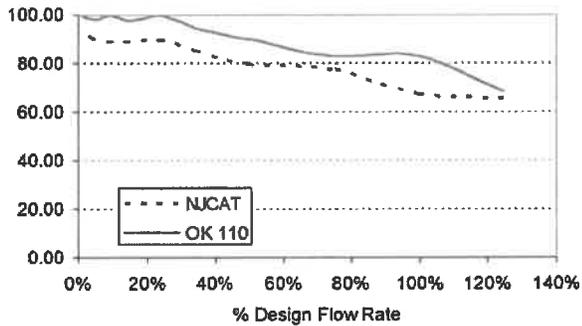
Figure 2. CDS stormwater treatment predictive performance for various particle gradations as a function of operating rate.

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 = $125\,\mu m$).
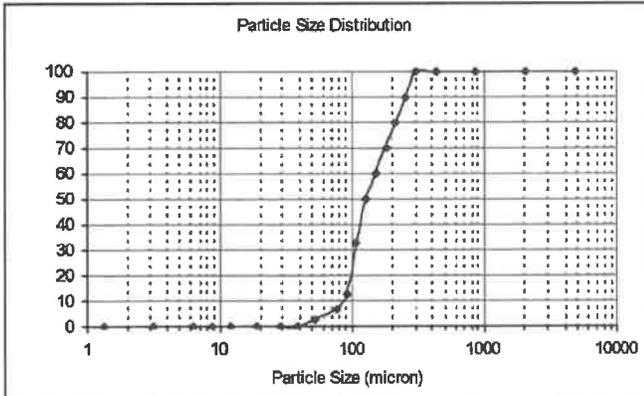
Figure 3. WASDOE PSD
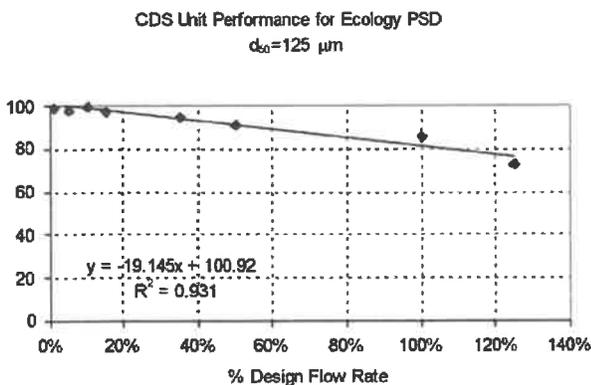
Figure 4. Modeled performance for WASDOE PSD.

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	y³	m³
CDS1515	3	0.9	3.0	0.9	0.5	0.4
CDS2015	4	1.2	3.0	0.9	0.9	0.7
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
CDS3025	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
CDS5640	10	3.0	6.3	1.9	8.7	6.7
CDS5653	10	3.0	7.7	2.3	8.7	6.7
CDS5668	10	3.0	9.3	2.8	8.7	6.7
CDS5678	10	3.0	10.3	3.1	8.7	6.7

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.

APPENDIX G

HYDROLOGIC ANALYSIS – INPUT COMPUTATIONS

Worksheet 2: Runoff curve number and runoff

Project: __Westside Elementary School__   By: __MCB__   Date: __06/18/19__
Location: __Groton, CT__   Checked: __FAB__   Date: _____
Circle one: ___Present___   Developed   Watershed: __WS 10 - Existing Conditions__

1.) Runoff curve number (CN)

Soil Name and Hydrologic Group (appendix A)	Cover Description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN Value [1]			Area Acres Sq. Ft. %	Product of CN x Area
		Table 2-2	Figure 2-3	Figure 2-4		
B soil	Woods - good condition	55			0.31	17.18
B soil	Open space - good condition	61			1.69	102.93
B soil	1/4 -acre residential	75			0.90	67.76
B soil	1/8 -acre residential	85			0.52	43.80
B soil	Gravel	85			0.05	4.53
N/A	Paved / impervious	98			1.71	167.39
N/A	Existing Building	98			0.01	1.30

[1] Use only one CN value source per line.

Totals = 5.19   404.89

(0.00811 sq mi)

$$CN \text{ (weighted)} = \frac{\text{total product}}{\text{total area}} = \frac{404.89}{5.19} \qquad \text{Use CN} = \boxed{78}$$

Worksheet 2: Runoff curve number and runoff

Project: Westside Elementary School   By: MCB   Date: 06/18/19
Location: Groton, CT   Checked: FAB   Date:
Circle one: **_Present_**   Developed   Watershed: WS 11 - Existing Conditions

1.) Runoff curve number (CN)

Soil Name and Hydrologic Group (appendix A)	Cover Description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN Value [1.]			Area Acres Sq. Ft. %	Product of CN x Area
		Table 2-2	Figure 2-3	Figure 2-4		
B soil	Woods - good condition	55			4.99	274.54
B soil	Open space - good condition	61			1.99	121.21
B soil	Bare Soil	86			0.08	6.50

[1.] Use only one CN value source per line.   Totals = 7.05   402.24

(0.01102 sq mi)

$$CN\ (weighted) = \frac{total\ product}{total\ area} = \frac{402.24}{7.05}$$ Use CN = 57

Milone & MacBroom Inc.

Worksheet 2: Runoff curve number and runoff

Project: Westside Elementary School   By: MCB   Date: 06/18/19
Location: Groton, CT   Checked: FAB   Date:
Circle one: *Present*   Developed   Watershed: WS 20 - Existing Conditions

1.) Runoff curve number (CN)

Soil Name and Hydrologic Group (appendix A)	Cover Description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN Value [1.]			Area (Acres) Sq. Ft. %	Product of CN x Area
		Table 2-2	Figure 2-3	Figure 2-4		
B soil	Open space - good condition	61			0.89	54.17
B soil	Gravel	85			0.01	0.85
N/A	Paved / Impervious	98			0.92	90.03
N/A	Existing Building	98			1.71	167.30

[1.] Use only one CN value source per line.

Totals =   3.52   312.35

(0.00551   sq mi)

$$CN \text{ (weighted)} = \frac{\text{total product}}{\text{total area}} = \frac{312.35}{3.52}$$ Use CN = 89

Milone & MacBroom Inc.

Worksheet 2: Runoff curve number and runoff

Project: Westside Elementary School   By: MCB   Date: 06/18/19
Location: Groton, CT   Checked: FAB   Date:
Circle one: **_Present_**   Developed   Watershed: WS 21 - Existing Conditions

1.) Runoff curve number (CN)

Soil Name and Hydrologic Group (appendix A)	Cover Description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN Value [1.]			Area Acres Sq. Ft. %	Product of CN x Area
		Table 2-2	Figure 2-3	Figure 2-4		
B soil	Woods - good condition	55			8.57	471.47
B soil	Open space - good condition	61			1.13	68.91
B soil	Bare Soil	86			0.10	8.91
N/A	Paved / Impervious	98			0.11	10.89

[1.] Use only one CN value source per line.   Totals =   9.92   560.18

(0.01549   sq mi)

$$\text{CN (weighted)} = \frac{\text{total product}}{\text{total area}} = \frac{560.18}{9.92} \qquad \text{Use CN} = \boxed{56}$$

Milone & MacBroom Inc.

Worksheet 2: Runoff curve number and runoff

Project: Westside Elementary School   By: MCB   Date: 06/18/19
Location: Groton, CT   Checked: FAB   Date:
Circle one: ***Present*** Developed Watershed: WS 30 - Existing Conditions

1.) Runoff curve number (CN)

Soil Name and Hydrologic Group (appendix A)	Cover Description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN Value [1.]			Area Acres Sq. Ft. %	Product of CN x Area
		Table 2-2	Figure 2-3	Figure 2-4		
B soil	Woods - good condition	55			0.73	39.95
B soil	Open space - good condition	61			0.23	13.97
N/A	Paved / Impervious	98			0.11	11.20

[1.] Use only one CN value source per line. Totals = 1.07 65.12

(0.00167 sq mi)

$$CN \text{ (weighted)} = \frac{\text{total product}}{\text{total area}} = \frac{65.12}{1.07}$$ Use CN = 61

Worksheet 2: Runoff curve number and runoff

Project: Westside Elementary School   By: MCB   Date: 06/18/19
Location: Groton, CT   Checked: FAB   Date:
Circle one: ***Present***   Developed   Watershed: WS 40 - Existing Conditions

1.) Runoff curve number (CN)

Soil Name and Hydrologic Group (appendix A)	Cover Description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN Value [1.]			Area Acres Sq. Ft. %	Product of CN x Area
		Table 2-2	Figure 2-3	Figure 2-4		
B soil	Woods - good condition	55			0.01	0.36
B soil	Open space - good condition	61			0.23	14.21
N/A	Paved / Impervious	98			0.19	18.42

[1.] Use only one CN value source per line.   Totals = 0.43   32.99

(0.00067   sq mi)

$$\text{CN (weighted)} = \frac{\text{total product}}{\text{total area}} = \frac{32.99}{0.43}$$ Use CN = 77

Worksheet 2: Runoff curve number and runoff

Project:	Westside Elementary School	By:	MCB	Date:	06/18/19
Location:	Groton, CT	Checked:	FAB	Date:	
Circle one:	Present *Developed*	Watershed:	WS 10 - Proposed Conditions		

1.) Runoff curve number (CN)

Soil Name and Hydrologic Group (appendix A)	Cover Description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN Value [1.]			Area (Acres) Sq. Ft. %	Product of CN x Area
		Table 2-2	Figure 2-3	Figure 2-4		
B soil	Woods - good condition	55			0.16	8.87
B soil	Open Space - good condition	61			1.19	72.70
B soil	1/4-acre residential	75			0.90	67.76
B Soil	1/8-acre residential	85			0.52	43.80
N/A	Paved / Impervious cover	98			1.09	107.18
N/A	Building	98			0.37	36.05

[1.] Use only one CN value source per line.   Totals =   4.23   336.36

(0.00661 sq mi)

$$CN \text{ (weighted)} = \frac{\text{total product}}{\text{total area}} = \frac{336.36}{4.23}$$

Use CN = **79**

Worksheet 2: Runoff curve number and runoff

Project: Westside Elementary School   By: MCB   Date: 06/18/19

Location: Groton, CT   Checked: FAB   Date:

Circle one: Present **_Developed_**   Watershed: WS 11 - Proposed Conditions

1.) Runoff curve number (CN)

Soil Name and Hydrologic Group (appendix A)	Cover Description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN Value [1]			Area (Acres) Sq. Ft. %	Product of CN x Area
		Table 2-2	Figure 2-3	Figure 2-4		
B soil	Woods - good condition	55			4.83	265.54
B soil	Open space - good condition	61			1.81	110.35
B soil	Bare Soil	86			0.09	7.57

[1] Use only one CN value source per line.   Totals = 6.73   383.46

(0.01051   sq mi)

$$CN \text{ (weighted)} = \frac{\text{total product}}{\text{total area}} = \frac{383.46}{6.73}$$

Use CN = 57

Worksheet 2: Runoff curve number and runoff

Project: Westside Elementary School   By: MCB   Date: 06/18/19

Location: Groton, CT   Checked: FAB   Date:

Circle one: Present ***Developed***   Watershed: WS 20 - Proposed Conditions

1.) Runoff curve number (CN)

Soil Name and Hydrologic Group (appendix A)	Cover Description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN Value [1]			Area (Acres) Sq. Ft. %	Product of CN x Area
		Table 2-2	Figure 2-3	Figure 2-4		
B soil	Open space - good condition	61			2.77	169.20
B soil	Gravel	85			0.04	3.80
N/A	Paved / Impervious	98			3.57	350.09
N/A	Proposed Building	98			0.63	61.36

[1] Use only one CN value source per line.   Totals = 7.02   584.45

(0.01096 sq mi)

$$\text{CN (weighted)} = \frac{\text{total product}}{\text{total area}} = \frac{584.45}{7.02} \qquad \text{Use CN} = \boxed{83}$$

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Worksheet 2: Runoff curve number and runoff

Project: Westside Elementary School

Location: Groton, CT

Circle one: Present   ***Developed***

By: MCB   Date: 06/18/19

Checked: FAB   Date:

Watershed: WS 21 - Proposed Conditions

1.) Runoff curve number (CN)

Soil Name and Hydrologic Group (appendix A)	Cover Description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN Value [1.]			Area Acres Sq. Ft. %	Product of CN x Area
		Table 2-2	Figure 2-3	Figure 2-4		
B soil	Woods - good condition	55			7.03	386.39
B soil	Open space - good condition	61			1.15	70.12
B soil	Bare Soil	86			0.09	7.85
N/A	Paved / Impervious	98			0.01	0.93

[1.] Use only one CN value source per line.

Totals =   8.28   465.29

(0.01293   sq mi)

$$CN \text{ (weighted)} = \frac{\text{total product}}{\text{total area}} = \frac{465.29}{8.28}$$

Use CN =   56

Worksheet 2: Runoff curve number and runoff

Project: Westside Elementary School   By: MCB   Date: 06/18/19
Location: Groton, CT   Checked: FAB   Date:
Circle one: Present   *Developed*   Watershed: WS 30 - Proposed Conditions

1.) Runoff curve number (CN)

Soil Name and Hydrologic Group (appendix A)	Cover Description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN Value [1.]			Area Acres Sq. Ft. %	Product of CN x Area
		Table 2-2	Figure 2-3	Figure 2-4		
B soil	Woods - good condition	55			0.69	37.78
B soil	Open space - good condition	61			0.11	6.92

[1.] Use only one CN value source per line.   Totals =   0.80   44.70

(0.00125   sq mi)

$$CN \text{ (weighted)} = \frac{\text{total product}}{\text{total area}} = \frac{44.70}{0.80} \qquad \text{Use CN} = \boxed{56}$$

Worksheet 2: Runoff curve number and runoff

Project: Westside Elementary School   By: MCB   Date: 06/18/19

Location: Groton, CT   Checked: FAB   Date:

Circle one: Present   *Developed*   Watershed: WS 40 - Proposed Conditions

1.) Runoff curve number (CN)

Soil Name and Hydrologic Group (appendix A)	Cover Description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN Value [1]			Area (Acres) Sq. Ft. %	Product of CN x Area
		Table 2-2	Figure 2-3	Figure 2-4		
B soil	Open space - good condition	61			0.09	5.25
N/A	Paved / Impervious	98			0.05	4.65

[1]. Use only one CN value source per line.

Totals =   0.13   9.91

(0.00021   sq mi)

$$CN \text{ (weighted)} = \frac{\text{total product}}{\text{total area}} = \frac{9.91}{0.13}$$

Use CN = 74

Time of Concentration (T_c) or Travel Time (T_t) Worksheet

Project: __Westside Elementary School__ By: __MCB__ Date: __06/18/19__
Location: __Groton, CT__ Checked: _____ Date: _____
Circle one: _**Present**_ Developed Watershed: __WS 10 - Existing Conditions__
Circle one: _**T_c**_ T_t Subwatershed: _____

Sheet flow (applicable to T_c only)

		Segment ID	A-B
1.	Surface description (Table 3-1)		GRASS
2.	Manning's roughness coeff. for sheet flow, n (Table 3-1)		0.240
3.	Flow Length, L (< 300ft)	ft.	83.7
4.	Two-year 24-hr rainfall, P_2	in.	3.43
5.	Land slope, s	ft./ft.	0.020
6.	$T_t = \dfrac{0.007\,(nL)^{0.8}}{P_2^{0.5}(s^{0.4})}$	hr.	0.199

= 0.199

Shallow concentrated flow (assume hyd. radius = depth of flow)

		Segment ID	B-C			
7.	Surface description		BIT			
8.	Manning's roughness coeff., n		0.015			
9.	Paved or unpaved		PVD			
10.	Depth of flow, d (default values: d=.4 unpaved, d=.2 paved)	ft.	0.20			
11.	Flow Length, L	ft.	311.8			
12.	Watercourse slope, s	ft./ft.	0.021			
13.	Average velocity, $V = \dfrac{1.49}{n}(d^{\frac{2}{3}})(s^{\frac{1}{2}})$	fps.	4.92			
14.	$T_t = \dfrac{L}{3600*V}$	hr.	0.018	+	+	+

= 0.018

Channel flow

		Segment ID	C-D	D-E	E-F	F-G
15.	Channel Bottom width, b	ft.	12" RCP	15" RCP	24" RCP	36" RCP
16.	Horizontal side slope component, z (z horiz:1 vert)	ft.	--	--	--	--
17.	Depth of flow, d	ft.	FULL	FULL	FULL	FULL
18.	Cross sectional flow area, A (assume trapazoidal)	ft.^{2}	0.79	1.23	3.14	7.07
19.	Wetted perimeter, P_w	ft.	3.14	3.93	6.28	9.42
20.	Hydraulic Radius, $R = \dfrac{A}{P_w}$	ft.	0.25	0.31	0.50	0.75
21.	Channel slope, s	ft./ft.	0.008	0.099	0.029	0.008
22.	Manning's roughness coeff., n		0.013	0.013	0.013	0.013
23.	$V = \dfrac{1.49}{n}(R^{\frac{2}{3}})(s^{\frac{1}{2}})$	fps.	4.07	16.58	12.30	8.47
24.	Flow length, L	ft.	40.1	416.6	171.9	48
25.	$T_t = \dfrac{L}{3600*V}$	hr.	0.003	0.007	0.004	0.002

+ + + = 0.015

26. Watershed or subarea T_c or T_t (add T_t in steps 6, 14 & 25)   hr.   0.232

Time of Concentration (T$_c$) or Travel Time (T$_t$) Worksheet

Project: __Westside Elementary School__   By: MCB   Date: 06/18/19

Location: __Groton, CT__   Checked: ____   Date: ____

Circle one: **_Present_**   Developed   Watershed: WS 11 - Existing Conditions

Circle one: **_T$_c$_**   T$_t$ Subwatershed: ____

Sheet flow (applicable to T$_c$ only)

		Segment ID	**A-B**
1. Surface description (Table 3-1)			GRASS
2. Manning's roughness coeff. for sheet flow, n (Table 3-1)			0.240
3. Flow Length, L (< 300ft)		ft.	100.0
4. Two-year 24-hr rainfall, P$_2$		in.	3.43
5. Land slope, s		ft./ft.	0.020

6. $T_t = \dfrac{0.007\,(nL)^{0.8}}{P_2^{0.5}(s^{0.4})}$ hr. | 0.230 | = | 0.230

Shallow concentrated flow (assume hyd. radius = depth of flow)

		Segment ID	**B-C**	**C-D**		
7. Surface description			GRASS	WOODS		
8. Manning's roughness coeff., n			0.080	0.100		
9. Paved or unpaved			UNPVD	UNPVD		
10. Depth of flow, d (default values: d=.4 unpaved, d=.2 paved)	ft.		0.40	0.40		
11. Flow Length, L		ft.	80.0	480.0		
12. Watercourse slope, s		ft./ft.	0.038	0.145		
13. Average velocity, $V = \dfrac{1.49}{n}(d^{2/3})(s^{1/2})$		fps.	1.97	3.08		
14. $T_t = \dfrac{L}{3600*V}$		hr.	0.011 +	0.043 +	+	+ = 0.055

Channel flow

		Segment ID				
15. Channel Bottom width, b		ft.				
16. Horizontal side slope component, z (z horiz:1 vert)	ft.					
17. Depth of flow, d		ft.				
18. Cross sectional flow area, A (assume trapazoidal)	ft.^{2}					
19. Wetted perimeter, P$_w$		ft.				
20. Hydraulic Radius, $R = \dfrac{A}{P_w}$		ft.				
21. Channel slope, s		ft./ft.				
22. Manning's roughness coeff., n						
23. $V = \dfrac{1.49}{n}(R^{2/3})(s^{1/2})$		fps.				
24. Flow length, L		ft.				
25. $T_t = \dfrac{L}{3600*V}$		hr.	+	+	+	= 0.000

26. Watershed or subarea T$_c$ or T$_t$ (add T$_t$ in steps 6, 14 & 25)   hr.   0.284

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Time of Concentration (T_c) or Travel Time (T_t) Worksheet

Project: __Westside Elementary School__   By: MCB   Date: 06/18/19
Location: __Groton, CT__   Checked: _____   Date: _____
Circle one: **_Present_**   Developed   Watershed: WS 20 - Existing Conditions
Circle one: **_T_c_** T_t Subwatershed: _____

Sheet flow (applicable to T_c only)

		Segment ID	**A-B**	
1.	Surface description (Table 3-1)		GRASS	
2.	Manning's roughness coeff. for sheet flow, n (Table 3-1)		0.240	
3.	Flow Length, L (< 300ft)	ft.	70.0	
4.	Two-year 24-hr rainfall, P_2	in.	3.43	
5.	Land slope, s	ft./ft.	0.070	
6.	$T_t = \dfrac{0.007\,(nL)^{0.8}}{P_2^{0.5}(s^{0.4})}$	hr.	0.105	= 0.105

Shallow concentrated flow (assume hyd. radius = depth of flow)

		Segment ID	**B-C**			
7.	Surface description		BIT			
8.	Manning's roughness coeff., n		0.015			
9.	Paved or unpaved		PVD			
10.	Depth of flow, d (default values: d=.4 unpaved, d=.2 paved)	ft.	0.20			
11.	Flow Length, L	ft.	80.0			
12.	Watercourse slope, s	ft./ft.	0.050			
13.	Average velocity, $V = \dfrac{1.49}{n}(d^{2/3})(s^{1/2})$	fps.	7.60			
14.	$T_t = \dfrac{L}{3600 * V}$	hr.	0.003	+ + +	=	0.003

Channel flow

		Segment ID	**C-D**	**D-E**		
15.	Channel Bottom width, b	ft.	15" RCP	18" RCP		
16.	Horizontal side slope component, z (z horiz:1 vert)	ft.	--	--		
17.	Depth of flow, d	ft.	FULL	FULL		
18.	Cross sectional flow area, A (assume trapazoidal)	ft.^{2}	1.23	3.14		
19.	Wetted perimeter, P_w	ft.	3.93	6.28		
20.	Hydraulic Radius, $R = \dfrac{A}{P_w}$	ft.	0.31	0.50		
21.	Channel slope, s	ft./ft.	0.021	0.170		
22.	Manning's roughness coeff., n		0.013	0.013		
23.	$V = \dfrac{1.49}{n}(R^{2/3})(s^{1/2})$	fps.	7.66	29.77		
24.	Flow length, L	ft.	375.0	100		
25.	$T_t = \dfrac{L}{3600 * V}$	hr.	0.014	+ 0.001	+ +	= 0.015
26.	Watershed or subarea T_c or T_t (add T_t in steps 6, 14 & 25)	hr.				0.122

Time of Concentration (T$_c$) or Travel Time (T$_t$) Worksheet

Project: __Westside Elementary School__   By: __MCB__   Date: __06/18/19__

Location: __Groton, CT__   Checked: ____   Date: ____

Circle one: **_Present_**   Developed   Watershed: WS 21 - Existing Conditions

Circle one: **_T$_c$_**   T$_t$ Subwatershed: ____

Sheet flow (applicable to T$_c$ only)

	Segment ID	A-B
1. Surface description (Table 3-1)		GRASS
2. Manning's roughness coeff. for sheet flow, n (Table 3-1)		0.240
3. Flow Length, L (< 300ft)	ft.	95.0
4. Two-year 24-hr rainfall, P$_2$	in.	3.43
5. Land slope, s	ft./ft.	0.028

6. $T_t = \dfrac{0.007\,(nL)^{0.8}}{P_2^{0.5}\,(s^{0.4})}$ hr. | 0.193   =   0.193

Shallow concentrated flow (assume hyd. radius = depth of flow)

	Segment ID	B-C	C-D		
7. Surface description		GRASS	WOODS		
8. Manning's roughness coeff., n		0.080	0.100		
9. Paved or unpaved		UNPVD	UNPVD		
10. Depth of flow, d (default values: d=.4 unpaved, d=.2 paved)	ft.	0.40	0.40		
11. Flow Length, L	ft.	55.0	600.0		
12. Watercourse slope, s	ft./ft.	0.200	0.114		

13. Average velocity, $V = \dfrac{1.49}{n}(d^{2/3})(s^{1/2})$ fps. | 4.52 | 2.73

14. $T_t = \dfrac{L}{3600*V}$ hr. | 0.003 + 0.061 + + = 0.064

Channel flow

	Segment ID				
15. Channel Bottom width, b	ft.				
16. Horizontal side slope component, z (z horiz:1 vert)	ft.				
17. Depth of flow, d	ft.				
18. Cross sectional flow area, A (assume trapazoidal)	ft.^{2}				
19. Wetted perimeter, P$_w$	ft.				

20. Hydraulic Radius, $R = \dfrac{A}{P_w}$ ft.

21. Channel slope, s   ft./ft.

22. Manning's roughness coeff., n

23. $V = \dfrac{1.49}{n}(R^{2/3})(s^{1/2})$ fps.

24. Flow length, L   ft.

25. $T_t = \dfrac{L}{3600*V}$ hr. | + + + = 0.000

26. Watershed or subarea T$_c$ or T$_t$ (add T$_t$ in steps 6, 14 & 25)   hr. | 0.257

Time of Concentration (T$_c$) or Travel Time (T$_t$) Worksheet

Project: __Westside Elementary School__   By: __MCB__   Date: __06/18/19__
Location: __Groton, CT__   Checked: _____   Date: _____
Circle one: **_Present_**   Developed   Watershed: __WS 30 - Existing Conditions__
Circle one: **_T$_c$_**   T$_t$ Subwatershed: _____

Sheet flow (applicable to T$_c$ only)

	Segment ID	**A-B**	
1. Surface description (Table 3-1)		WOODS	
2. Manning's roughness coeff. for sheet flow, n (Table 3-1)		0.400	
3. Flow Length, L (< 300ft)	ft.	100.0	
4. Two-year 24-hr rainfall, P$_2$	in.	3.43	
5. Land slope, s	ft./ft.	0.030	
6. $T_t = \dfrac{0.007\,(nL)^{0.8}}{P_2^{0.5}(s^{0.4})}$	hr.	0.294	= 0.294

Shallow concentrated flow (assume hyd. radius = depth of flow)

	Segment ID	**B-C**				
7. Surface description		WOODS				
8. Manning's roughness coeff., n		0.100				
9. Paved or unpaved		UNPVD				
10. Depth of flow, d (default values: d=.4 unpaved, d=.2 paved)	ft.	0.40				
11. Flow Length, L	ft.	146.7				
12. Watercourse slope, s	ft./ft.	0.075				
13. Average velocity, $V = \dfrac{1.49}{n}(d^{\frac{2}{3}})(s^{\frac{1}{2}})$	fps.	2.22				
14. $T_t = \dfrac{L}{3600*V}$	hr.	0.018	+	+	+	= 0.018

Channel flow

	Segment ID					
15. Channel Bottom width, b	ft.					
16. Horizontal side slope component, z (z horiz:1 vert)	ft.					
17. Depth of flow, d	ft.					
18. Cross sectional flow area, A (assume trapazoidal)	ft.^{2}					
19. Wetted perimeter, P$_w$	ft.					
20. Hydraulic Radius, $R = \dfrac{A}{P_w}$	ft.					
21. Channel slope, s	ft./ft.					
22. Manning's roughness coeff., n						
23. $V = \dfrac{1.49}{n}(R^{\frac{2}{3}})(s^{\frac{1}{2}})$	fps.					
24. Flow length, L	ft.					
25. $T_t = \dfrac{L}{3600*V}$	hr.		+	+	+	= 0.000
26. Watershed or subarea T$_c$ or T$_t$ (add T$_t$ in steps 6, 14 & 25)	hr.					0.312

Time of Concentration (T$_c$) or Travel Time (T$_t$) Worksheet

Project: __Westside Elementary School__   By: __MCB__   Date: __06/18/19__
Location: __Groton, CT__   Checked: _____   Date: _____
Circle one: ***Present***   Developed   Watershed: __WS 40 - Existing Conditions__
Circle one: __T$_c$__   T$_t$ Subwatershed: _____

Sheet flow (applicable to T$_c$ only)

	Segment ID	**A-B**	
1. Surface description (Table 3-1)		GRASS	
2. Manning's roughness coeff. for sheet flow, n (Table 3-1)		0.240	
3. Flow Length, L (< 300ft)	ft.	56.4	
4. Two-year 24-hr rainfall, P$_2$	in.	3.43	
5. Land slope, s	ft./ft.	0.018	
6. $T_t = \dfrac{0.007\,(nL)^{0.8}}{P_2^{0.5}(s^{0.4})}$	hr.	0.152	= 0.152

Shallow concentrated flow (assume hyd. radius = depth of flow)

	Segment ID	**B-C**			
7. Surface description		BIT			
8. Manning's roughness coeff., n		0.015			
9. Paved or unpaved		PVD			
10. Depth of flow, d (default values: d=.4 unpaved, d=.2 paved)	ft.	0.20			
11. Flow Length, L	ft.	50.9			
12. Watercourse slope, s	ft./ft.	0.010			
13. Average velocity, $V = \dfrac{1.49}{n}(d^{2/3})(s^{1/2})$	fps.	3.40			
14. $T_t = \dfrac{L}{3600*V}$	hr.	0.004	+ + +	=	0.004

Channel flow

	Segment ID				
15. Channel Bottom width, b	ft.				
16. Horizontal side slope component, z (z horiz:1 vert)	ft.				
17. Depth of flow, d	ft.				
18. Cross sectional flow area, A (assume trapazoidal)	ft.^{2}				
19. Wetted perimeter, P$_w$	ft.				
20. Hydraulic Radius, $R = \dfrac{A}{P_w}$	ft.				
21. Channel slope, s	ft./ft.				
22. Manning's roughness coeff., n					
23. $V = \dfrac{1.49}{n}(R^{2/3})(s^{1/2})$	fps.				
24. Flow length, L	ft.				
25. $T_t = \dfrac{L}{3600*V}$	hr.		+ + +	=	0.000

26. Watershed or subarea T$_c$ or T$_t$ (add T$_t$ in steps 6, 14 & 25)   hr.   0.156

Time of Concentration (T_c) or Travel Time (T_t) Worksheet

Project: __Westside Elementary School__   By: __MCB__   Date: __06/18/19__
Location: __Groton, CT__   Checked: _____   Date: _____
Circle one: Present   ***Developed***   Watershed: __WS 10 - Proposed Conditions__
Circle one: $\boldsymbol{T_c}$ T_t Subwatershed: _____

Sheet flow (applicable to T_c only)

	Segment ID	**A-B**
1. Surface description (Table 3-1)		GRASS
2. Manning's roughness coeff. for sheet flow, n (Table 3-1)		0.240
3. Flow Length, L (< 300ft)	ft.	83.7
4. Two-year 24-hr rainfall, P_2	in.	3.43
5. Land slope, s	ft./ft.	0.020

6. $T_t = \dfrac{0.007\,(nL)^{0.8}}{P_2^{0.5}\,(s^{0.4})}$ hr. | 0.199 | = | 0.199 |

Shallow concentrated flow (assume hyd. radius = depth of flow)

	Segment ID	**B-C**			
7. Surface description		BIT			
8. Manning's roughness coeff., n		0.015			
9. Paved or unpaved		PVD			
10. Depth of flow, d (default values: d=.4 unpaved, d=.2 paved)	ft.	0.20			
11. Flow Length, L	ft.	311.8			
12. Watercourse slope, s	ft./ft.	0.021			
13. Average velocity, $V = \dfrac{1.49}{n}(d^{\frac{2}{3}})(s^{\frac{1}{2}})$	fps.	4.92			
14. $T_t = \dfrac{L}{3600*V}$	hr.	0.018	+	+	+	= 0.018

Channel flow

	Segment ID	**C-D**	**D-E**	**F-G**	**G-H**
15. Channel Bottom width, b	ft.	12" RCP	15" HDPE	24" RCP	36" RCP
16. Horizontal side slope component, z (z horiz:1 vert)	ft.	--	--	--	--
17. Depth of flow, d	ft.	FULL	FULL	FULL	FULL
18. Cross sectional flow area, A (assume trapazoidal)	ft.^{2}	0.79	1.23	3.14	7.07
19. Wetted perimeter, P_w	ft.	3.14	3.93	6.28	9.42
20. Hydraulic Radius, $R = \dfrac{A}{P_w}$	ft.	0.25	0.31	0.50	0.75
21. Channel slope, s	ft./ft.	0.008	0.047	0.041	0.008
22. Manning's roughness coeff., n		0.013	0.012	0.013	0.013
23. $V = \dfrac{1.49}{n}(R^{\frac{2}{3}})(s^{\frac{1}{2}})$	fps.	4.07	12.41	14.57	8.47
24. Flow length, L	ft.	40.1	448.5	131.6	48
25. $T_t = \dfrac{L}{3600*V}$	hr.	0.003	0.010	0.003	0.002	= 0.017

26. Watershed or subarea T_c or T_t (add T_t in steps 6, 14 & 25)   hr. | 0.234 |

Milone & MacBroom Inc.

Time of Concentration (T_c) or Travel Time (T_t) Worksheet

Project: Westside Elementary School   By: MCB   Date: 06/18/19

Location: Groton, CT   Checked: Date:

Circle one: Present **_Developed_**   Watershed: WS 11 - Proposed Conditions

Circle one: **_T_c_** T_t Subwatershed:

Sheet flow (applicable to T_c only)

		Segment ID	**A-B**	
1.	Surface description (Table 3-1)		GRASS	
2.	Manning's roughness coeff. for sheet flow, n (Table 3-1)		0.240	
3.	Flow Length, L (< 300ft)	ft.	100.0	
4.	Two-year 24-hr rainfall, P_2	in.	3.43	
5.	Land slope, s	ft./ft.	0.020	
6.	$T_t = \dfrac{0.007\,(nL)^{0.8}}{P_2^{0.5}(s^{0.4})}$	hr.	0.230	= 0.230

Shallow concentrated flow (assume hyd. radius = depth of flow)

			Segment ID	**B-C**	**C-D**			
7.	Surface description			GRASS	WOODS			
8.	Manning's roughness coeff., n			0.080	0.100			
9.	Paved or unpaved			UNPVD	UNPVD			
10.	Depth of flow, d (default values: d=.4 unpaved, d=.2 paved)	ft.		0.40	0.40			
11.	Flow Length, L		ft.	80.0	480.0			
12.	Watercourse slope, s		ft./ft.	0.038	0.145			
13.	Average velocity, $V = \dfrac{1.49}{n}(d^{2/3})(s^{1/2})$		fps.	1.97	3.08			
14.	$T_t = \dfrac{L}{3600*V}$		hr.	0.011	+ 0.043	+	+	= 0.055

Channel flow

			Segment ID				
15.	Channel Bottom width, b	ft.					
16.	Horizontal side slope component, z (z horiz:1 vert)	ft.					
17.	Depth of flow, d	ft.					
18.	Cross sectional flow area, A (assume trapazoidal)	ft.^{2}					
19.	Wetted perimeter, P_w	ft.					
20.	Hydraulic Radius, $R = \dfrac{A}{P_w}$	ft.					
21.	Channel slope, s	ft./ft.					
22.	Manning's roughness coeff., n						
23.	$V = \dfrac{1.49}{n}(R^{2/3})(s^{1/2})$	fps.					
24.	Flow length, L	ft.					
25.	$T_t = \dfrac{L}{3600*V}$	hr.		+	+	+	= 0.000

26. Watershed or subarea T_c or T_t (add T_t in steps 6, 14 & 25)   hr.   0.284

Time of Concentration (T_c) or Travel Time (T_t) Worksheet

Project: __Westside Elementary School__   By: __MCB__   Date: __06/18/19__
Location: __Groton, CT__   Checked: _____   Date: _____
Circle one: Present   _**Developed**_   Watershed: __WS 20 - Proposed Conditions__
Circle one: **_T_c_** T_t Subwatershed: _____

Sheet flow (applicable to T_c only)

		Segment ID	**A-B**		
1.	Surface description (Table 3-1)		GRASS		
2.	Manning's roughness coeff. for sheet flow, n (Table 3-1)		0.240		
3.	Flow Length, L (< 300ft)	ft.	95.0		
4.	Two-year 24-hr rainfall, P_2	in.	3.43		
5.	Land slope, s	ft./ft.	0.030		
6.	$T_t = \dfrac{0.007\,(nL)^{0.8}}{P_2^{0.5}(s^{0.4})}$	hr.	0.187	=	0.187

Shallow concentrated flow (assume hyd. radius = depth of flow)

		Segment ID	**B-C**				
7.	Surface description		BIT				
8.	Manning's roughness coeff., n		0.015				
9.	Paved or unpaved		PVD				
10.	Depth of flow, d (default values: d=.4 unpaved, d=.2 paved)	ft.	0.20				
11.	Flow Length, L	ft.	73.0				
12.	Watercourse slope, s	ft./ft.	0.030				
13.	Average velocity, $V = \dfrac{1.49}{n}(d^{2/3})(s^{1/2})$	fps.	5.88				
14.	$T_t = \dfrac{L}{3600*V}$	hr.	0.003	+	+	+	= 0.003

Channel flow

		Segment ID	**C-D**	**E-F**		
15.	Channel Bottom width, b	ft.	5" HDPE	24" HDPE		
16.	Horizontal side slope component, z (z horiz:1 vert)	ft.	--	--		
17.	Depth of flow, d	ft.	FULL	FULL		
18.	Cross sectional flow area, A (assume trapazoidal)	ft.^{2}	1.23	3.14		
19.	Wetted perimeter, P_w	ft.	3.93	6.28		
20.	Hydraulic Radius, $R = \dfrac{A}{P_w}$	ft.	0.31	0.50		
21.	Channel slope, s	ft./ft.	0.041	0.068		
22.	Manning's roughness coeff., n		0.012	0.012		
23.	$V = \dfrac{1.49}{n}(R^{2/3})(s^{1/2})$	fps.	11.59	20.41		
24.	Flow length, L	ft.	446.0	65.9		
25.	$T_t = \dfrac{L}{3600*V}$	hr.	0.011	+ 0.001	+ +	= 0.012
26.	Watershed or subarea T_c or T_t (add T_t in steps 6, 14 & 25)	hr.				0.203

Time of Concentration (T_c) or Travel Time (T_t) Worksheet

Project: __Westside Elementary School__   By: MCB   Date: 06/18/19
Location: __Groton, CT__   Checked: _____   Date: _____
Circle one: Present   ***Developed***   Watershed: WS 21 - Proposed Conditions
Circle one: ***T_c*** T_t Subwatershed: _____

Sheet flow (applicable to T_c only)

	Segment ID	A-B
1. Surface description (Table 3-1)		GRASS
2. Manning's roughness coeff. for sheet flow, n (Table 3-1)		0.240
3. Flow Length, L (< 300ft)	ft.	95.0
4. Two-year 24-hr rainfall, P_2	in.	3.43
5. Land slope, s	ft./ft.	0.028
6. $T_t = \dfrac{0.007\,(nL)^{0.8}}{P_2^{0.5}\,(s^{0.4})}$	hr.	0.193

= 0.193

Shallow concentrated flow (assume hyd. radius = depth of flow)

	Segment ID	B-C	C-D		
7. Surface description		GRASS	WOODS		
8. Manning's roughness coeff., n		0.080	0.100		
9. Paved or unpaved		UNPVD	UNPVD		
10. Depth of flow, d (default values: d=.4 unpaved, d=.2 paved)	ft.	0.40	0.40		
11. Flow Length, L	ft.	55.0	600.0		
12. Watercourse slope, s	ft./ft.	0.200	0.114		
13. Average velocity, $V = \dfrac{1.49}{n}(d^{2/3})(s^{1/2})$	fps.	4.52	2.73		
14. $T_t = \dfrac{L}{3600 * V}$	hr.	0.003	0.061		

0.003 + 0.061 + + = 0.064

Channel flow

	Segment ID				
15. Channel Bottom width, b	ft.				
16. Horizontal side slope component, z (z horiz:1 vert)	ft.				
17. Depth of flow, d	ft.				
18. Cross sectional flow area, A (assume trapazoidal)	ft.^{2}				
19. Wetted perimeter, P_w	ft.				
20. Hydraulic Radius, $R = \dfrac{A}{P_w}$	ft.				
21. Channel slope, s	ft./ft.				
22. Manning's roughness coeff., n					
23. $V = \dfrac{1.49}{n}(R^{2/3})(s^{1/2})$	fps.				
24. Flow length, L	ft.				
25. $T_t = \dfrac{L}{3600 * V}$	hr.				

+ + + = 0.000

26. Watershed or subarea T_c or T_t (add T_t in steps 6, 14 & 25)   hr.   0.257

Milone & MacBroom Inc.

Time of Concentration (T_c) or Travel Time (T_t) Worksheet

Project: __Westside Elementary School__   By: __MCB__   Date: __06/18/19__
Location: __Groton, CT__   Checked: _____   Date: _____
Circle one: Present   ***Developed***   Watershed: __WS 30 - Proposed Conditions__
Circle one: ***T_c*** T_t Subwatershed: _____

Sheet flow (applicable to T_c only)

	Segment ID	A-B	
1. Surface description (Table 3-1)		WOODS	
2. Manning's roughness coeff. for sheet flow, n (Table 3-1)		0.400	
3. Flow Length, L (< 300ft)	ft.	100.0	
4. Two-year 24-hr rainfall, P_2	in.	3.43	
5. Land slope, s	ft./ft.	0.040	
6. $T_t = \dfrac{0.007\,(nL)^{0.8}}{P_2^{0.5}(s^{0.4})}$	hr.	0.262	= 0.262

Shallow concentrated flow (assume hyd. radius = depth of flow)

	Segment ID	B-C			
7. Surface description		WOODS			
8. Manning's roughness coeff., n		0.100			
9. Paved or unpaved		UNPVD			
10. Depth of flow, d (default values: d=.4 unpaved, d=.2 paved)	ft.	0.40			
11. Flow Length, L	ft.	105.5			
12. Watercourse slope, s	ft./ft.	0.085			
13. Average velocity, $V = \dfrac{1.49}{n}(d^{2/3})(s^{1/2})$	fps.	2.36			
14. $T_t = \dfrac{L}{3600*V}$	hr.	0.012	+ + +	= 0.012

Channel flow

	Segment ID				
15. Channel Bottom width, b	ft.				
16. Horizontal side slope component, z (z horiz:1 vert)	ft.				
17. Depth of flow, d	ft.				
18. Cross sectional flow area, A (assume trapazoidal)	ft.^{2}				
19. Wetted perimeter, P_w	ft.				
20. Hydraulic Radius, $R = \dfrac{A}{P_w}$	ft.				
21. Channel slope, s	ft./ft.				
22. Manning's roughness coeff., n					
23. $V = \dfrac{1.49}{n}(R^{2/3})(s^{1/2})$	fps.				
24. Flow length, L	ft.				
25. $T_t = \dfrac{L}{3600*V}$	hr.		+ + +	= 0.000

26. Watershed or subarea T_c or T_t (add T_t in steps 6, 14 & 25)   hr.   0.274

Milone & MacBroom Inc.

Time of Concentration (T$_c$) or Travel Time (T$_t$) Worksheet

Project: __Westside Elementary School__   By: __MCB__   Date: __06/18/19__

Location: __Groton, CT__   Checked: _____   Date: _____

Circle one: Present   ***Developed***   Watershed: __WS 40 - Proposed Conditions__

Circle one: ***T$_c$***   T$_t$ Subwatershed: _____

Sheet flow (applicable to T$_c$ only)

	Segment ID	**A-B**
1. Surface description (Table 3-1)		GRASS
2. Manning's roughness coeff. for sheet flow, n (Table 3-1)		0.240
3. Flow Length, L (< 300ft)	ft.	70.0
4. Two-year 24-hr rainfall, P$_2$	in.	3.43
5. Land slope, s	ft./ft.	0.026

6. $T_t = \dfrac{0.007\,(nL)^{0.8}}{P_2^{0.5}(s^{0.4})}$ hr. 0.155 = 0.155

Shallow concentrated flow (assume hyd. radius = depth of flow)

	Segment ID	**B-C**			
7. Surface description		BIT			
8. Manning's roughness coeff., n		0.015			
9. Paved or unpaved		PVD			
10. Depth of flow, d (default values: d=.4 unpaved, d=.2 paved)	ft.	0.20			
11. Flow Length, L	ft.	15.0			
12. Watercourse slope, s	ft./ft.	0.037			

13. Average velocity, $V = \dfrac{1.49}{n}(d^{2/3})(s^{1/2})$ fps. 6.53

14. $T_t = \dfrac{L}{3600 * V}$ hr. 0.001 + + + = 0.001

Channel flow

	Segment ID				
15. Channel Bottom width, b	ft.				
16. Horizontal side slope component, z (z horiz:1 vert)	ft.				
17. Depth of flow, d	ft.				
18. Cross sectional flow area, A (assume trapazoidal)	ft.^{2}				
19. Wetted perimeter, P$_w$	ft.				

20. Hydraulic Radius, $R = \dfrac{A}{P_w}$ ft.

21. Channel slope, s   ft./ft.

22. Manning's roughness coeff., n

23. $V = \dfrac{1.49}{n}(R^{2/3})(s^{1/2})$ fps.

24. Flow length, L   ft.

25. $T_t = \dfrac{L}{3600 * V}$ hr.   + + + = 0.000

26. Watershed or subarea T$_c$ or T$_t$ (add T$_t$ in steps 6, 14 & 25)   hr.   0.156

NOAA Atlas 14, Volume 10, Version 2
Location name: Groton, Connecticut, USA*
Latitude: 41.3384°, Longitude: -72.0671°
Elevation: 120.53 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sandra Pavlovic, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Orlan Wilhite

NOAA, National Weather Service, Silver Spring, Maryland

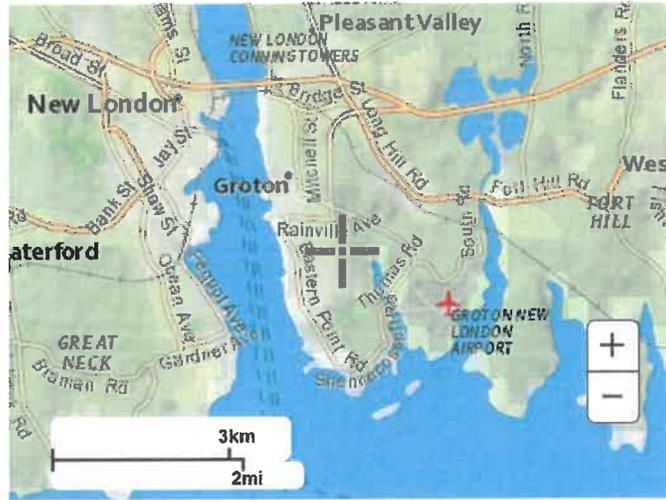PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

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

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.336 (0.256-0.438)	0.402 (0.306-0.524)	0.509 (0.387-0.666)	0.599 (0.452-0.785)	0.722 (0.531-0.976)	0.816 (0.590-1.12)	0.911 (0.643-1.28)	1.04 (0.693-1.47)	1.20 (0.776-1.74)	1.33 (0.839-1.95)
10-min	0.476 (0.363-0.620)	0.569 (0.433-0.742)	0.722 (0.548-0.943)	0.848 (0.641-1.11)	1.02 (0.752-1.38)	1.16 (0.836-1.59)	1.29 (0.911-1.82)	1.47 (0.982-2.08)	1.70 (1.10-2.47)	1.88 (1.19-2.76)
15-min	0.560 (0.427-0.730)	0.669 (0.510-0.873)	0.849 (0.644-1.11)	0.998 (0.754-1.31)	1.20 (0.884-1.63)	1.36 (0.983-1.87)	1.52 (1.07-2.14)	1.73 (1.16-2.45)	2.00 (1.29-2.90)	2.21 (1.40-3.25)
30-min	0.796 (0.607-1.04)	0.950 (0.723-1.24)	1.20 (0.911-1.57)	1.41 (1.06-1.85)	1.70 (1.25-2.29)	1.92 (1.39-2.63)	2.14 (1.51-3.01)	2.43 (1.63-3.45)	2.82 (1.82-4.09)	3.11 (1.97-4.57)
60-min	1.03 (0.787-1.35)	1.23 (0.936-1.60)	1.55 (1.18-2.03)	1.82 (1.38-2.39)	2.19 (1.61-2.96)	2.47 (1.79-3.39)	2.76 (1.95-3.89)	3.13 (2.10-4.44)	3.63 (2.35-5.27)	4.01 (2.54-5.89)
2-hr	1.35 (1.04-1.74)	1.61 (1.24-2.08)	2.04 (1.57-2.63)	2.39 (1.83-3.10)	2.88 (2.14-3.85)	3.26 (2.38-4.42)	3.63 (2.59-5.06)	4.13 (2.78-5.79)	4.78 (3.11-6.86)	5.27 (3.36-7.67)
3-hr	1.57 (1.22-2.00)	1.87 (1.45-2.39)	2.37 (1.83-3.03)	2.78 (2.14-3.57)	3.34 (2.50-4.44)	3.78 (2.78-5.09)	4.22 (3.02-5.83)	4.78 (3.24-6.67)	5.53 (3.62-7.90)	6.10 (3.90-8.83)
6-hr	1.99 (1.57-2.51)	2.37 (1.87-2.99)	2.99 (2.35-3.79)	3.51 (2.74-4.46)	4.22 (3.19-5.53)	4.77 (3.54-6.35)	5.32 (3.84-7.27)	6.02 (4.12-8.32)	6.96 (4.58-9.84)	7.67 (4.93-11.0)
12-hr	2.46 (1.96-3.06)	2.92 (2.33-3.64)	3.68 (2.93-4.60)	4.32 (3.41-5.41)	5.18 (3.97-6.71)	5.85 (4.39-7.70)	6.52 (4.76-8.83)	7.39 (5.10-10.1)	8.54 (5.66-12.0)	9.41 (6.09-13.4)
24-hr	2.87 (2.32-3.52)	3.43 (2.77-4.21)	4.34 (3.50-5.35)	5.10 (4.09-6.31)	6.15 (4.77-7.87)	6.95 (5.28-9.06)	7.76 (5.73-10.4)	8.85 (6.15-12.0)	10.3 (6.87-14.3)	11.4 (7.42-16.0)
2-day	3.18 (2.61-3.85)	3.83 (3.14-4.65)	4.91 (4.01-5.97)	5.81 (4.71-7.09)	7.03 (5.53-8.92)	7.98 (6.15-10.3)	8.93 (6.69-11.9)	10.3 (7.20-13.8)	12.1 (8.12-16.6)	13.4 (8.81-18.7)
3-day	3.42 (2.83-4.12)	4.13 (3.41-4.97)	5.28 (4.34-6.37)	6.23 (5.09-7.55)	7.54 (5.97-9.49)	8.55 (6.63-11.0)	9.57 (7.20-12.7)	11.0 (7.75-14.7)	12.9 (8.73-17.7)	14.4 (9.47-19.9)
4-day	3.66 (3.04-4.38)	4.39 (3.65-5.25)	5.58 (4.62-6.70)	6.57 (5.41-7.92)	7.94 (6.31-9.93)	8.99 (7.00-11.5)	10.0 (7.59-13.2)	11.5 (8.14-15.3)	13.5 (9.14-18.4)	15.0 (9.89-20.7)
7-day	4.34 (3.65-5.13)	5.12 (4.30-6.06)	6.40 (5.35-7.59)	7.46 (6.20-8.89)	8.92 (7.15-11.0)	10.0 (7.88-12.6)	11.2 (8.48-14.5)	12.7 (9.03-16.7)	14.7 (10.0-19.8)	16.2 (10.8-22.3)
10-day	5.01 (4.25-5.89)	5.83 (4.93-6.85)	7.16 (6.03-8.43)	8.26 (6.92-9.78)	9.78 (7.89-12.0)	11.0 (8.63-13.7)	12.1 (9.22-15.6)	13.6 (9.75-17.8)	15.6 (10.7-20.9)	17.1 (11.4-23.3)
20-day	7.11 (6.12-8.24)	7.99 (6.86-9.26)	9.42 (8.06-11.0)	10.6 (9.01-12.4)	12.2 (9.99-14.7)	13.5 (10.7-16.5)	14.8 (11.3-18.5)	16.1 (11.7-20.8)	17.9 (12.4-23.7)	19.3 (12.9-26.0)
30-day	8.87 (7.69-10.2)	9.80 (8.48-11.3)	11.3 (9.75-13.0)	12.6 (10.8-14.6)	14.3 (11.7-17.0)	15.6 (12.5-18.9)	17.0 (13.0-21.0)	18.2 (13.2-23.3)	19.8 (13.8-26.1)	21.1 (14.2-28.3)
45-day	11.1 (9.66-12.6)	12.0 (10.5-13.7)	13.7 (11.9-15.6)	15.0 (13.0-17.3)	16.9 (14.0-19.9)	18.3 (14.7-21.9)	19.8 (15.1-24.2)	20.9 (15.3-26.5)	22.4 (15.6-29.3)	23.5 (15.8-31.3)
60-day	12.9 (11.3-14.6)	13.9 (12.2-15.8)	15.7 (13.7-17.8)	17.1 (14.9-19.5)	19.1 (15.9-22.4)	20.6 (16.6-24.5)	22.2 (17.0-26.9)	23.2 (17.1-29.3)	24.6 (17.3-32.1)	25.7 (17.4-34.1)

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

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.
Please refer to NOAA Atlas 14 document for more information.

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Large scale terrain

Large scale map

Large scale aerial

APPENDIX H

HYDROLOGIC ANALYSIS – COMPUTER MODEL RESULTS

Hydrographs Peak Flowrate Summary (cfs)
Existing vs. Proposed

Storm Event	2yr		10yr		25yr		50yr		100yr	
	Exist	**Prop**	**Exist**	**Prop**	**Exist**	**Prop**	**Exist**	**Prop**	**Exist**	**Prop**
Point of Analysis A	7.5	6.5	18.4	16.1	26.3	23.1	32.6	28.7	39.3	34.6
Point of Analysis B	8.5	5.8	18.2	14.8	25.6	22.4	31.6	28.6	38.0	37.8
Point of Analysis C	0.4	0.1	1.2	0.6	1.8	1.0	2.3	1.4	2.9	1.7
Point of Analysis D	0.6	0.2	1.2	0.3	1.6	0.4	1.9	0.5	2.2	0.6
DET 200 W.S. Elev. (ft) Top of Berm = 90.0	---	86.55	---	87.53	---	88.06	---	88.40	---	88.67

Study Area   **Description**

A	Intermittent Watercourse and Wetland (Northeast)
B	Intermittent Watercourse and Wetland (Southeast)
C	Southern Property Boundary
D	Brandegee Avenue

Watershed Model Schematic

1 - EXWS-10

2 - EXWS-11

4 - EXWS-20

5 - EXWS-21

8 - EXWS-30 / C

9 - EXWS-40 / D

3 - POA_A

6 - POA_B

7 - A + B

12 - PRWS-20

10 - PRWS-10

15 - PRWS-30 / C

16 - PRWS-40 / D

11 - PRWS-11

13 - PRWS-21

14 - DET 200

17 - POA_A

18 - POA_B

19 - A+B
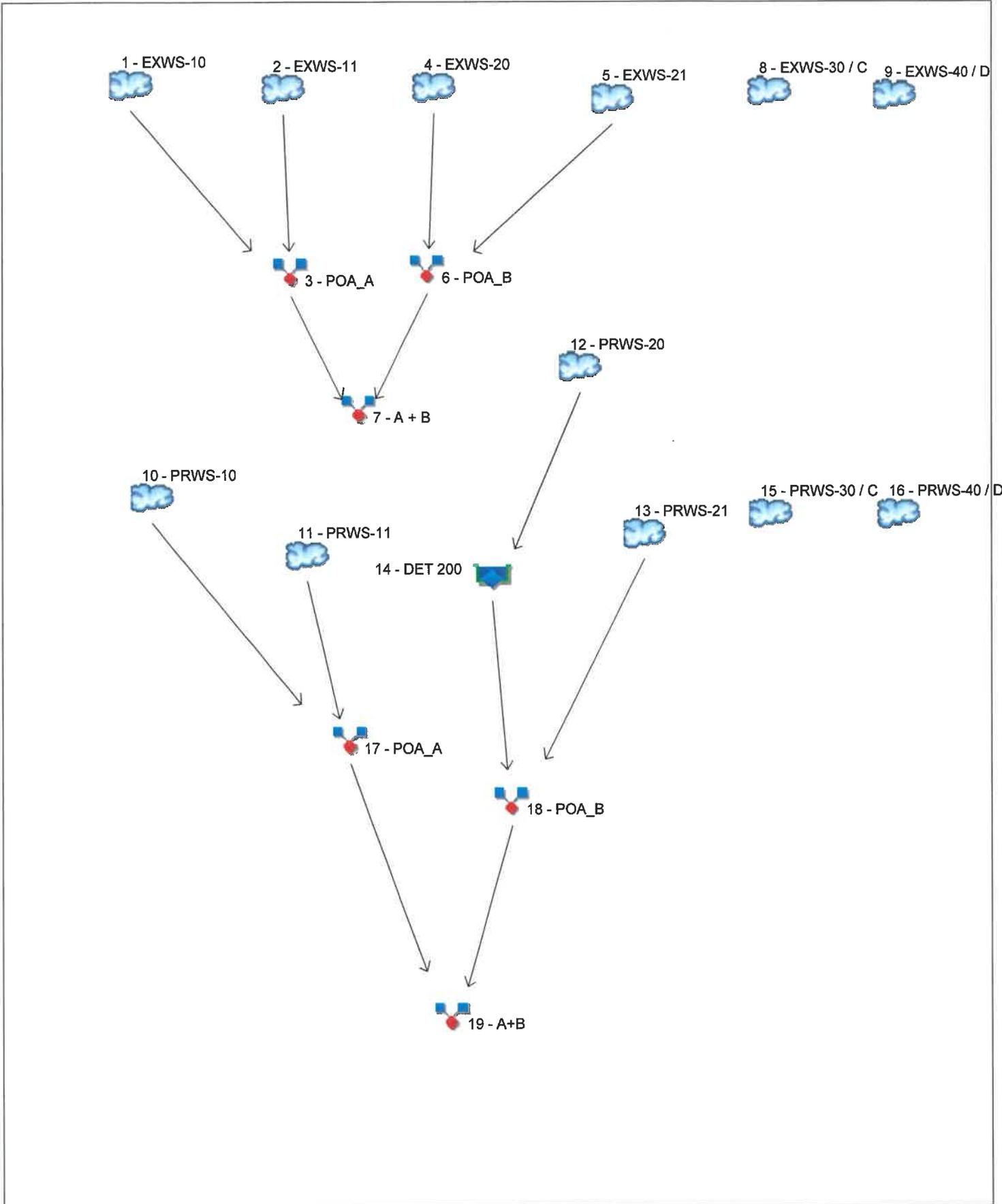
Hydraflow Table of Contents

Hydrograph Return Period Recap

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)								Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	-------	6.794	-------	--------	13.40	17.76	21.13	24.57	EXWS-10
2	SCS Runoff	------	-------	1.388	-------	-------	5.846	9.608	12.74	16.10	EXWS-11
3	Combine	1, 2	-------	7.512	-------	-------	18.40	26.28	32.62	39.25	POA_A
4	SCS Runoff	------	-------	8.156	-------	-------	13.44	16.75	19.26	21.78	EXWS-20
5	SCS Runoff	------	-------	1.665	-------	-------	7.610	12.74	17.05	21.69	EXWS-21
6	Combine	4, 5	-------	8.505	-------	-------	18.16	25.59	31.60	38.03	POA_B
7	Combine	3, 6	-------	15.09	-------	-------	35.87	51.39	63.94	77.15	A + B
8	SCS Runoff	------	-------	0.355	-------	-------	1.172	1.800	2.314	2.858	EXWS-30 / C
9	SCS Runoff	------	-------	0.597	-------	-------	1.191	1.586	1.892	2.203	EXWS-40 / D
10	SCS Runoff	------	-------	5.825	-------	-------	11.28	14.86	17.62	20.42	PRWS-10
11	SCS Runoff	------	-------	1.325	-------	-------	5.581	9.172	12.16	15.37	PRWS-11
12	SCS Runoff	------	-------	11.65	-------	-------	21.06	27.10	31.72	36.38	PRWS-20
13	SCS Runoff	------	-------	1.390	-------	-------	6.352	10.63	14.23	18.10	PRWS-21
14	Reservoir	12	-------	4.466	-------	-------	8.967	12.62	15.66	21.28	DET 200
15	SCS Runoff	------	-------	0.134	-------	-------	0.614	1.027	1.375	1.749	PRWS-30 / C
16	SCS Runoff	------	-------	0.153	-------	-------	0.324	0.441	0.531	0.625	PRWS-40 / D
17	Combine	10, 11,	-------	6.513	-------	-------	16.10	23.07	28.68	34.57	POA_A
18	Combine	13, 14,	-------	5.829	-------	-------	14.82	22.35	28.63	37.75	POA_B
19	Combine	17, 18	-------	10.95	-------	-------	29.01	43.06	54.80	67.44	A+B

Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (acft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (acft)	Hydrograph Description
1	SCS Runoff	6.794	3	729	0.625	------	------	------	EXWS-10
2	SCS Runoff	1.388	3	744	0.236	------	------	------	EXWS-11
3	Combine	7.512	3	732	0.861	1, 2	------	------	POA_A
4	SCS Runoff	8.156	3	726	0.630	------	------	------	EXWS-20
5	SCS Runoff	1.665	3	747	0.303	------	------	------	EXWS-21
6	Combine	8.505	3	726	0.933	4, 5	------	------	POA_B
7	Combine	15.09	3	729	1.794	3, 6	------	------	A + B
8	SCS Runoff	0.355	3	741	0.050	------	------	------	EXWS-30 / C
9	SCS Runoff	0.597	3	726	0.046	------	------	------	EXWS-40 / D
10	SCS Runoff	5.825	3	729	0.533	------	------	------	PRWS-10
11	SCS Runoff	1.325	3	744	0.225	------	------	------	PRWS-11
12	SCS Runoff	11.65	3	729	1.053	------	------	------	PRWS-20
13	SCS Runoff	1.390	3	747	0.253	------	------	------	PRWS-21
14	Reservoir	4.466	3	750	1.053	12	86.55	0.331	DET 200
15	SCS Runoff	0.134	3	747	0.024	------	------	------	PRWS-30 / C
16	SCS Runoff	0.153	3	726	0.012	------	------	------	PRWS-40 / D
17	Combine	6.513	3	732	0.758	10, 11,	------	------	POA_A
18	Combine	5.829	3	747	1.306	13, 14,	------	------	POA_B
19	Combine	10.95	3	735	2.064	17, 18	------	------	A+B

WS-Hydro02 - WQV.gpw	Return Period: 2 Year	Wednesday, 06 / 12 / 2019

Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (acft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (acft)	Hydrograph Description
1	SCS Runoff	13.40	3	729	1.210	------	------	------	EXWS-10
2	SCS Runoff	5.846	3	735	0.702	------	------	------	EXWS-11
3	Combine	18.40	3	732	1.911	1, 2	------	------	POA_A
4	SCS Runoff	13.44	3	726	1.064	------	------	------	EXWS-20
5	SCS Runoff	7.610	3	738	0.932	------	------	------	EXWS-21
6	Combine	18.16	3	726	1.996	4, 5	------	------	POA_B
7	Combine	35.87	3	729	3.907	3, 6	------	------	A + B
8	SCS Runoff	1.172	3	735	0.131	------	------	------	EXWS-30 / C
9	SCS Runoff	1.191	3	726	0.091	------	------	------	EXWS-40 / D
10	SCS Runoff	11.28	3	729	1.018	------	------	------	PRWS-10
11	SCS Runoff	5.581	3	735	0.670	------	------	------	PRWS-11
12	SCS Runoff	21.06	3	729	1.910	------	------	------	PRWS-20
13	SCS Runoff	6.352	3	738	0.778	------	------	------	PRWS-21
14	Reservoir	8.967	3	747	1.910	12	87.53	0.580	DET 200
15	SCS Runoff	0.614	3	738	0.075	------	------	------	PRWS-30 / C
16	SCS Runoff	0.324	3	726	0.025	------	------	------	PRWS-40 / D
17	Combine	16.10	3	732	1.688	10, 11,	------	------	POA_A
18	Combine	14.82	3	741	2.688	13, 14,	------	------	POA_B
19	Combine	29.01	3	735	4.376	17, 18	------	------	A+B

WS-Hydro02 - WQV.gpw   Return Period: 10 Year   Wednesday, 06 / 12 / 2019

Hydrograph Summary Report
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (acft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (acft)	Hydrograph Description
1	SCS Runoff	17.76	3	729	1.605	------	------	------	EXWS-10
2	SCS Runoff	9.608	3	735	1.071	------	------	------	EXWS-11
3	Combine	26.28	3	732	2.676	1, 2	------	------	POA_A
4	SCS Runoff	16.75	3	726	1.342	------	------	------	EXWS-20
5	SCS Runoff	12.74	3	735	1.437	------	------	------	EXWS-21
6	Combine	25.59	3	726	2.779	4, 5	------	------	POA_B
7	Combine	51.39	3	729	5.456	3, 6	------	------	A + B
8	SCS Runoff	1.800	3	735	0.194	------	------	------	EXWS-30 / C
9	SCS Runoff	1.586	3	726	0.121	------	------	------	EXWS-40 / D
10	SCS Runoff	14.86	3	729	1.344	------	------	------	PRWS-10
11	SCS Runoff	9.172	3	735	1.022	------	------	------	PRWS-11
12	SCS Runoff	27.10	3	729	2.475	------	------	------	PRWS-20
13	SCS Runoff	10.63	3	735	1.199	------	------	------	PRWS-21
14	Reservoir	12.62	3	744	2.475	12	88.06	0.724	DET 200
15	SCS Runoff	1.027	3	735	0.116	------	------	------	PRWS-30 / C
16	SCS Runoff	0.441	3	726	0.034	------	------	------	PRWS-40 / D
17	Combine	23.07	3	732	2.367	10, 11,	------	------	POA_A
18	Combine	22.35	3	741	3.674	13, 14,	------	------	POA_B
19	Combine	43.06	3	735	6.041	17, 18	------	------	A+B

WS-Hydro02 - WQV.gpw	Return Period: 25 Year	Wednesday, 06 / 12 / 2019

Hydrograph Summary Report
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (acft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (acft)	Hydrograph Description
1	SCS Runoff	21.13	3	729	1.916	------	------	------	EXWS-10
2	SCS Runoff	12.74	3	735	1.381	------	------	------	EXWS-11
3	Combine	32.62	3	732	3.297	1, 2	------	------	POA_A
4	SCS Runoff	19.26	3	726	1.556	------	------	------	EXWS-20
5	SCS Runoff	17.05	3	735	1.863	------	------	------	EXWS-21
6	Combine	31.60	3	726	3.420	4, 5	------	------	POA_B
7	Combine	63.94	3	729	6.717	3, 6	------	------	A + B
8	SCS Runoff	2.314	3	735	0.245	------	------	------	EXWS-30 / C
9	SCS Runoff	1.892	3	726	0.145	------	------	------	EXWS-40 / D
10	SCS Runoff	17.62	3	729	1.600	------	------	------	PRWS-10
11	SCS Runoff	12.16	3	735	1.319	------	------	------	PRWS-11
12	SCS Runoff	31.72	3	729	2.914	------	------	------	PRWS-20
13	SCS Runoff	14.23	3	735	1.555	------	------	------	PRWS-21
14	Reservoir	15.66	3	744	2.913	12	88.40	0.828	DET 200
15	SCS Runoff	1.375	3	735	0.150	------	------	------	PRWS-30 / C
16	SCS Runoff	0.531	3	726	0.041	------	------	------	PRWS-40 / D
17	Combine	28.68	3	732	2.919	10, 11,	------	------	POA_A
18	Combine	28.63	3	738	4.469	13, 14,	------	------	POA_B
19	Combine	54.80	3	735	7.387	17, 18	------	------	A+B

WS-Hydro02 - WQV.gpw	Return Period: 50 Year	Wednesday, 06 / 12 / 2019

Hydrograph Summary Report

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (acft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (acft)	Hydrograph Description
1	SCS Runoff	24.57	3	729	2.236	------	------	------	EXWS-10
2	SCS Runoff	16.10	3	735	1.716	------	------	------	EXWS-11
3	Combine	39.25	3	732	3.952	1, 2	------	------	POA_A
4	SCS Runoff	21.78	3	726	1.774	------	------	------	EXWS-20
5	SCS Runoff	21.69	3	735	2.325	------	------	------	EXWS-21
6	Combine	38.03	3	729	4.099	4, 5	------	------	POA_B
7	Combine	77.15	3	729	8.051	3, 6	------	------	A + B
8	SCS Runoff	2.858	3	735	0.300	------	------	------	EXWS-30 / C
9	SCS Runoff	2.203	3	726	0.170	------	------	------	EXWS-40 / D
10	SCS Runoff	20.42	3	729	1.863	------	------	------	PRWS-10
11	SCS Runoff	15.37	3	735	1.638	------	------	------	PRWS-11
12	SCS Runoff	36.38	3	729	3.363	------	------	------	PRWS-20
13	SCS Runoff	18.10	3	735	1.940	------	------	------	PRWS-21
14	Reservoir	21.28	3	741	3.363	12	88.67	0.912	DET 200
15	SCS Runoff	1.749	3	735	0.187	------	------	------	PRWS-30 / C
16	SCS Runoff	0.625	3	726	0.048	------	------	------	PRWS-40 / D
17	Combine	34.57	3	732	3.501	10, 11,	------	------	POA_A
18	Combine	37.75	3	741	5.303	13, 14,	------	------	POA_B
19	Combine	67.44	3	735	8.804	17, 18	------	------	A+B

WS-Hydro02 - WQV.gpw	Return Period: 100 Year	Wednesday, 06 / 12 / 2019

Pond Report

Wednesday, 06 / 12 / 2019

Pond No. 1 - DET 200
Pond Data
Contours -User-defined contour areas. Conic method used for volume calculation. Begining Elevation = 85.00 ft

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (acft)	Total storage (acft)
0.00	85.00	8,100	0.000	0.000
1.00	86.00	9,525	0.202	0.202
2.00	87.00	11,025	0.236	0.438
3.00	88.00	12,575	0.271	0.708
3.50	88.50	13,375	0.149	0.857
4.00	89.00	14,175	0.158	1.015
5.00	90.00	15,825	0.344	1.359

Culvert / Orifice Structures

	[A]	[B]	[C]	[PrfRsr]
Rise (in)	= 24.00	8.00	0.00	0.00
Span (in)	= 24.00	8.00	0.00	0.00
No. Barrels	= 1	2	0	0
Invert El. (ft)	= 81.00	85.00	0.00	0.00
Length (ft)	= 174.00	0.00	0.00	0.00
Slope (%)	= 2.87	0.00	0.00	n/a
N-Value	= .012	.013	.013	n/a
Orifice Coeff.	= 0.60	0.60	0.60	0.60
Multi-Stage	= n/a	Yes	No	No

Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	= 12.00	0.00	0.00	0.00
Crest El. (ft)	= 88.50	85.50	0.00	0.00
Weir Coeff.	= 3.33	0.68	3.33	3.33
Weir Type	= 1	30 degV	---	---
Multi-Stage	= Yes	Yes	No	No
Exfil.(in/hr)	= 0.000 (by Wet area)			
TW Elev. (ft)	= 0.00			

Note: Culvert/Orifice outflows are analyzed under inlet (ic) and outlet (oc) control. Weir risers checked for orifice conditions (ic) and submergence (s).

Stage / Storage / Discharge Table

Stage ft	Storage acft	Elevation ft	Clv A cfs	Clv B cfs	Clv C cfs	PrfRsr cfs	Wr A cfs	Wr B cfs	Wr C cfs	Wr D cfs	Exfil cfs	User cfs	Total cfs
0.00	0.000	85.00	0.00	0.00	---	---	0.00	---	---	---	---	---	0.000
1.00	0.202	86.00	26.20 ic	2.74 ic	---	---	0.00	0.12	---	---	---	---	2.865
2.00	0.438	87.00	26.20 ic	4.34 ic	---	---	0.00	1.88	---	---	---	---	6.216
3.00	0.708	88.00	26.20 ic	5.49 ic	---	---	0.00	6.73	---	---	---	---	12.22
3.50	0.857	88.50	26.20 ic	5.98 ic	---	---	0.00	10.62	---	---	---	---	16.60
4.00	1.015	89.00	33.20 ic	4.96 ic	---	---	14.13	14.11 s	---	---	---	---	33.20
5.00	1.359	90.00	42.44 ic	1.19 ic	---	---	32.68 s	8.58 s	---	---	---	---	42.44

APPENDIX I
WATERSHED MAPS

LEGEND

▬▬▬	WATERSHED BOUNDARY
WS 10	WATERSHED LABEL
DET 200	DETENTION BASIN LABEL
B	HYDROLOGIC SOIL-TYPE LABEL
▬ · ▬ · ▬	TIME OF CONCENTRATION PATH
Ⓐ	ANALYSIS POINT LABEL

WS 11

WS 21

WS 30

WS 20

WS 40

WS 10

Inland-Wetlands Limit
(See Note 12)

Grass Field

Basketball Court

Bit Parking Lot

Courtyard

BRANDEGEE AVENUE

LITTON AVE

HYNES AVENUE

MORSE AVENUE

FREY ST

SUTTON PLACE

Intermittent Watercourse
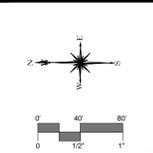
DESCRIPTION | DATE | BY

WATERSHED MAP - EXISTING CONDITIONS

WESTSIDE ELEMENTARY SCHOOL

250 BRANDEGEE AVENUE
GROTON, CONNECTICUT

FAB	MCB	FAB
DESIGNED	DRAWN	CHECKED

SCALE
1"=80'

DATE
JUNE 18, 2019

PROJECT NO.
1777-39

SHEET NO.
1 OF 2

SHEET NAME
EXWS

(A)

(B)

(C)

(D)

WS 11

WS 21

DET 200

WS 30

WS 20

WS 30

WS 10

WS 40

N/F Town of Groton

N/F Birch Plain Properties, LLC

LITTON AVE

HYNES AVENUE

BRANDEGEE AVENUE

MORSE AVE

SUTTON PL

FREY ST

esri