Hydraulic Report

Driveway Culvert over an Unnamed Brook

at

76 Delaware Road, Easton, Connecticut

Prepared For:

Andrew Zolov, Property Owner
76 Delaware Road
Easton, CT 06612

Prepared By:

Justin Giorlando, P.E. #31422
Force Engineering & Construction
65 Kellers Farm Road
Easton, CT 06612

April 7, 2020

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Justin Giorlando, P.E.
Principal Engineer
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Introduction

This Hydraulic Report has been prepared in support of the replacement of a culvert carrying the driveway serving 76 Delaware Road in Easton, Connecticut. The culvert carries the driveway over an unnamed brook that is an upper reach of Morehouse Brook Pond. The tributary area for the culvert is approximately 153 acres consisting of rolling terrain in a generally developed portion of town consisting of one acre building lots.

The project, as proposed by the property owner's contractor, will consist of the removal of the existing culvert, installation of twin 48" HDPE pipe with a smooth barrel, culvert ends at the inlet and outlet, riprap aprons for inlet and outlet protection, water handling, and erosion and sedimentation controls. The site is located west of CT Route 59 between Delaware Road and Westwood Drive. The site is currently developed as a one acre single family lot with the unnamed brook traversing generally from north to south.

This report evaluates the hydraulic properties of the existing culvert and the culvert proposed by the property owner's contractor. No survey of the crossing is available. Relative elevations were obtained from field measurements. The structural adequacy of the culvert was not analyzed as part of this report.

Existing Conditions

The residence on the property was constructed in 1985. The driveway and culvert were likely built around the same time. The existing culvert is 20.5 feet long consisting of twin 42" asphalt lined corrugated metal pipes with a metal flared culvert end at the inlet and outlet. The culvert barrel is showing signs of deterioration and deficiencies. The asphalt lining has worn away from about the springline down and there is heavy rust apparent in the lower third. There is some inlet and outlet protection in which large stones are stacked retaining the immediate slope near the pipe. However, there are no signs of protection in the stream bed or on the embankments upstream or downstream. There are apparent signs of scour problems at the inlet and outlet that has exposed ledge and caused the separation of one culvert end at the outlet. Bank erosion upstream and downstream is apparent as well with a degrading streambed. The owner states heavy erosion and overtopping of the driveway was experienced during a heavy rainfall event in the fall of 2018. The driveway over the culvert is gravel and shows evidence of failure due to erosion related to the failure of the culvert outlet. The driveway has been undermined between the twin pipes at the outlet and has collapsed.

The brook is characterized by a small width of approximately 8 to 10 feet with perennial flow in a low relief valley setting. The FEMA Flood Insurance Study found this is an Area of Minimal Flood Hazard (Zone X.) There exists dense tree cover over the brook with a low degree of vegetation along the banks near the culvert and varying degrees of vegetation upstream and downstream. The brook is primarily cut into earth with some cobbles and large stones present throughout and ledge in the immediate vicinity of the outlet. No bank protection is present within a hundred feet of the culvert and there is evidence of severe erosion and scoured side slopes.

Hydrology

The Rational Method is used for determining the peak flow rates associated with the various design storms. The design storm used for this analysis is the 50-year return frequency storm. There are multiple culverts upstream of this structure that carry various roads over the brook. However, the analysis of each of these culverts is outside the scope of this report and it is conservatively assumed that the flow is unimpeded through the upstream culverts.

The watershed map used for this analysis is an excerpt from the 2018 USGS Westport Quadrangle, 7.5-Minute Series, and is found in Appendix A. The map shows the boundary of the study area as well as the route of water from the hydraulically most remote location in the watershed used in determining the time of concentration. Information about the hydrologic soil group for the watershed is based on the NRCS Web Soil Survey found in Appendix B. The area of this watershed is approximately 153 acres, of which 14 acres are expected to contain hydrologic soil group B, 97 acres are expected to contain hydrologic soil group C, and 42 acres are expected to contain hydrologic soil group C/D.

The majority of soils in the study area are expected to have a high runoff potential due to slow infiltration rates associated with hydrologic soil groups C and D. Due to this and the predominant suburban land use pattern, a coefficient of runoff of 0.41 is appropriate. The study area is generally fully developed under current zoning regulations in the Easton for single family homes on one acre lots.

The time of concentration (t_c) is the time required for water to flow from the hydraulically most remote point of the drainage area to the point under investigation and is approximately 40 minutes. The method used to determine t_c is based on the Federal Highway Administration's (FHWA) Hydraulic Design Series 2, 2nd Ed. See Appendix D for the Time of Concentration Calculations.

Hydrometeorological Design Studies Center is updating precipitation frequency estimates for various areas of the U.S. as Volumes of NOAA Atlas 14. The rainfall intensity for a 50-year design storm at this location, found in Volume 10 Version 3.0: Northeastern States, is 3.13 in/h. See Appendix E for the extracted data.

Hydrologic calculations were performed using the FHWA's Hydraulic Toolbox v. 4.4 computer application. The application utilizes the Rational Method to compute discharge rates. However, the application doesn't apply a frequency factor for higher order design storms typical for Connecticut analyses. The factor has been applied to the results derived from the application.

Peak Rate of Runoff for the 50-year Frequency Design Storm used for this analysis:

$$\mathbf{Q = CC_fIA = (0.41)*(1.2)*(3.13\ in/h)*(153\ acres) = 236\ ft^3/s}$$

where: Q = maximum rate of runoff, ft^3/s
C = runoff coefficient representing a ratio of runoff to rainfall
C_f = frequency factor for design storm (≤10-yr = 1.0; 25-yr = 1.1; 50-yr = 1.2; 100-yr = 1.25)
I = average rainfall intensity for a duration equal to the time of concentration, for a selected return period, in/h
A = drainage area tributary to the design location, acres

All design storms were analyzed and summarized in the following table:

Design Storm	C	C_f	T_c (min)	I (in/h)	A (acres)	Q (ft^3/s)
2-year	0.41	1.00	41	1.59	153	**100**
5-year	0.41	1.00	41	1.98	153	**124**
10-year	0.41	1.00	41	2.32	153	**146**
25-year	0.41	1.10	40	2.78	153	**192**
50-year	0.41	1.20	40	3.13	153	**236**
100-year	0.41	1.25	40	3.48	153	**273**

Existing Hydraulics

All design storms were analyzed and summarized in the following table for the existing conditions:

Design Storm	Total Discharge (ft^3/s)	Culvert Discharge (ft^3/s)	Headwater Elevation (ft)	Outlet Velocity (ft/s)	Driveway Overtopping
2-year	100	100.00	4.14	10.797	NO
5-year	124	124.00	4.62	11.38	NO
10-year	146	146.00	5.09	11.866	NO
25-year	192	162.95	5.49	12.215	**YES**
50-year	236	172.48	5.73	12.41	**YES**
100-year	273	179.01	5.90	12.547	**YES**

This analysis shows the existing culvert configuration overtopping the driveway in a storm slightly larger than the 10-year design storm at approximately 148 ft^3/s. This is consistent with the owners account of a major storm on September 25, 2018 in which the driveway was overtopped when rainfall rates of 2 to 3 in/h were observed and radar detected with rainfall totals of up to 4 to 7 inches according to the National Weather Service. This amount of rainfall is consistent with a magnitude of storm greater than the 10-year design storm values provided by NOAA.

Proposed Hydraulics

The owner stated that the project will install twin 48" HDPE smooth interior pipes with culvert ends at the inlet and outlet. Additionally, the elevation of the roadway would be raised one foot. The existing inlet elevation, outlet elevation and length of pipe are unchanged from the existing pipe. The brook cross sections at the inlet and outlet throughout the work area are to remain the same except that there will be intermediate riprap provided for inlet and outlet protection. The design of the inlet and outlet protection is not a part of this report.

All design storms were analyzed and summarized in the following table for the proposed conditions:

Design Storm	Total Discharge (ft^3/s)	Culvert Discharge (ft^3/s)	Headwater Elevation (ft)	Outlet Velocity (ft/s)	Driveway Overtopping
2-year	100	100.00	3.93	12.188	NO
5-year	124	124.00	4.34	12.705	NO
10-year	146	146.00	4.69	13.143	NO
25-year	192	192.00	5.46	14.005	NO
50-year	236	232.02	6.22	14.756	**YES**
100-year	273	244.56	6.48	14.994	**YES**

This analysis shows the proposed culvert configuration overtopping the driveway in a storm slightly smaller than the 50-year design storm at approximately 227 ft^3/s. It should be noted that the outlet velocities will increase due to the type of culvert chosen and appropriate outlet protection should be provided.

Temporary hydraulics for this site during construction should, at a minimum, be capable of conveying the Average Spring Flow. Outlet protection should be incorporated to prevent erosion for any temporary water diversion. Any water handling structures such as a cofferdam should be limited in elevation to the top of the structure to allow overtopping during any significant storm events. No materials or equipment should be left in an area of potential flooding during a storm event. Temporary hydraulic design for construction is not part of this report.

Average Spring Flow:

$$Q_{AS}(ft^3/s) = [A\ (mi^2)]^{0.988} * 3.62 = [0.24\ mi^2]^{0.988} * 3.62 = 0.88\ ft^3/s$$

Conclusion

The proposed culvert is significantly more hydraulically sufficient than the existing culvert. The existing culvert would create an overtopping situation at only 148 ft^3/s while the proposed culvert doesn't create an overtopping situation until a flow of approximately 227 ft^3/s is experienced. Additionally, providing

outlet protection will help reduce the effects of erosion on the stream banks, particularly at the outlet where the outlet velocity is 43%-59% greater than the velocity of the brook.

The hydraulic control for this culvert is the driveway it carries. The allowable headwater at the inlet should be 1 foot below this control during the design storm. However, due to the limiting site conditions and the pre-existing configuration, this would not be possible without extensive site work and expense. Therefore, the driveway and surrounding site should be capable of accommodating periodic overtopping during large storm events.

Multiple barrel culverts, as proposed, are more susceptible to clogging from debris. Periodic inspection of the site post-construction should be performed to ensure no debris is present that would restrict the flow of water into and through the culvert during a storm event.

The successful performance of HDPE depends upon proper bedding, backfill, and care during installation. Pipe strength evaluation is recommended due to the limited fill above the pipe crown of less than 3 feet and the pipes being subject to traffic loads. HDPE is relatively lightweight and more susceptible to buoyancy forces, particularly at the inlet where the expected headwater will rise above the crown of the pipe. Headwalls, endwalls, slope paving, or other means of anchoring to provide buoyancy protection is recommended.

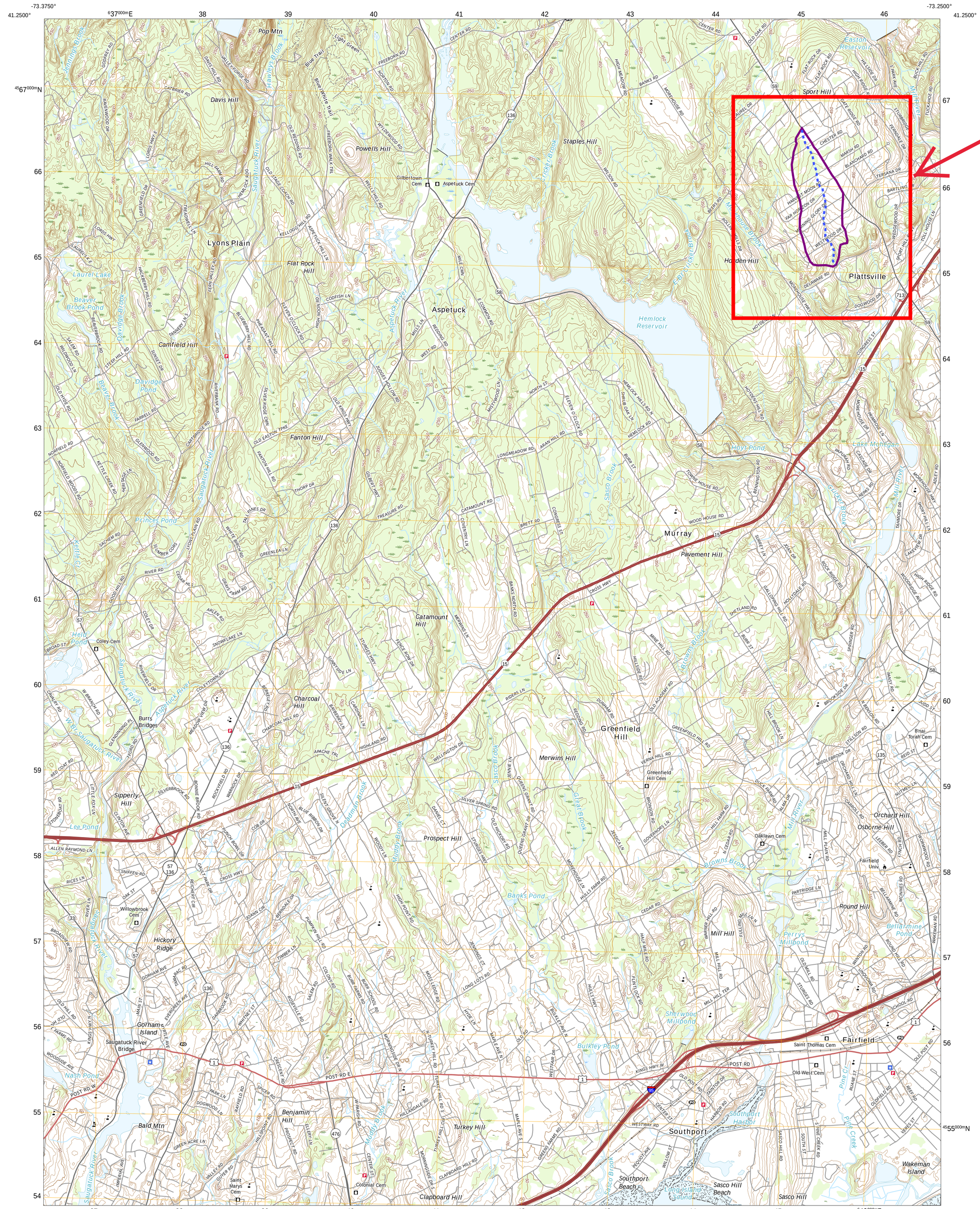
The evaluation of different culvert designs for this location was not a part of the scope of this report. However, it should be noted that there are many different types of culverts available that can convey the flows associated with this brook. Each of the various types of culverts have benefits and tradeoffs. Careful consideration of these tradeoffs, along with proper design, is important to ensure a long-lasting finished product that will safely accommodate the required design storm flows.

Appendix A – Watershed Map

U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

The National Map US Topo

WESTPORT QUADRANGLE
CONNECTICUT - FAIRFIELD COUNTY
7.5-MINUTE SERIES



Produced by the United States Geological Survey
North American Datum of 1983 (NAD83)
World Geodetic System of 1984 (WGS84). Projection and
1 000-meter grid:Universal Transverse Mercator, Zone 18T

This map is not a legal document. Boundaries may be generalized for this map scale. Private lands within government reservations may not be shown. Obtain permission before entering private lands.

Imagery.....NAIP, July 2016 - September 2016
Roads.....U.S. Census Bureau, 2016
Names.....GNIS, 1979 - 2017
Hydrography.....National Hydrography Dataset, 2004 - 2016
Contours.....National Elevation Dataset, 2012
Boundaries.....Multiple sources; see metadata file 2016 - 2017

Wetlands.....FWS National Wetlands Inventory 2010

MN
GN
13°22′
238 MILS
1°7′
20 MILS
UTM GRID AND 2017 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

U.S. National Grid
100,000 - m Square ID
XL
Grid Zone Designation
18T

SCALE 1:24 000
1 0.5 0 KILOMETERS 1 2
1000 500 0 METERS 1000 2000
1 0.5 0 1
MILES
1000 0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10000
FEET

CONTOUR INTERVAL 10 FEET
NORTH AMERICAN VERTICAL DATUM OF 1988

This map was produced to conform with the National Geospatial Program US Topo Product Standard, 2011.
A metadata file associated with this product is draft version 0.6.18

CONNECTICUT
QUADRANGLE LOCATION

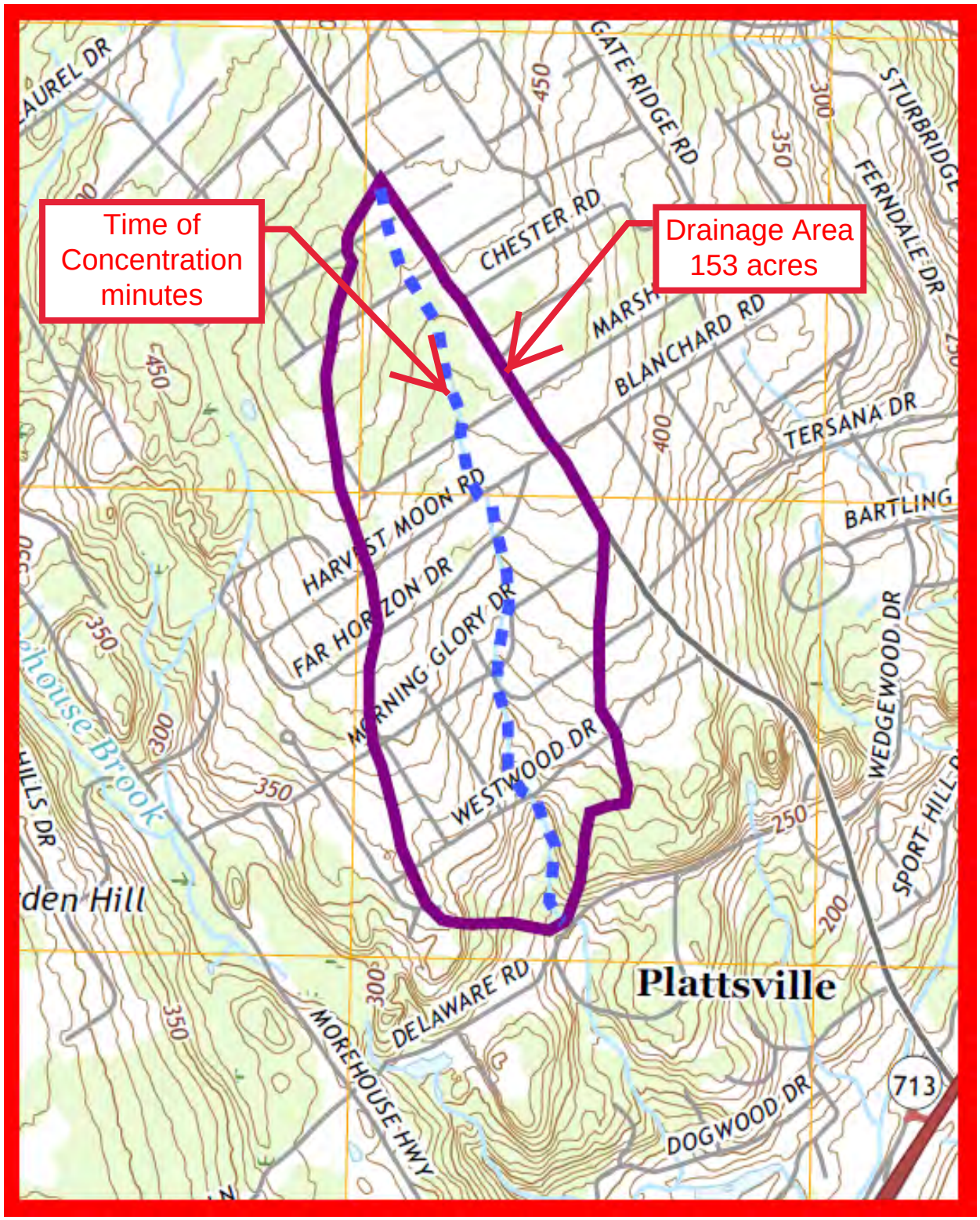
1	2	3
4		5
6	7	

ADJOINING QUADRANGLES
1 Bethel
2 Botsford
3 Long Hill
4 Norwalk North
5 Bridgeport
6 Norwalk South
7 Sherwood Point

ROAD CLASSIFICATION
Expressway
Secondary Hwy
Ramp
Local Connector
Local Road
4WD
Interstate Route
US Route
State Route

WESTPORT, CT
2018

NSN 7643016360177
NGA REF NO. USGSX24K484868


Time of Concentration minutes
Drainage Area 153 acres
CHESTER RD
BLANCHARD RD
TERSANA DR
HARVEST MOON RD
FAR HORIZON DR
MORNING GLORY DR
WESTWOOD DR
DELAWARE RD
MOREHOUSE HWY
DOGWOOD DR
BARTLING
WEDGEWOOD DR
FERNDALE DR
STURBRIDGE
GATE RIDGE RD
LAUREL DR
Plattsville
713

Appendix B – Soil Survey Map and Data

United States Department of Agriculture

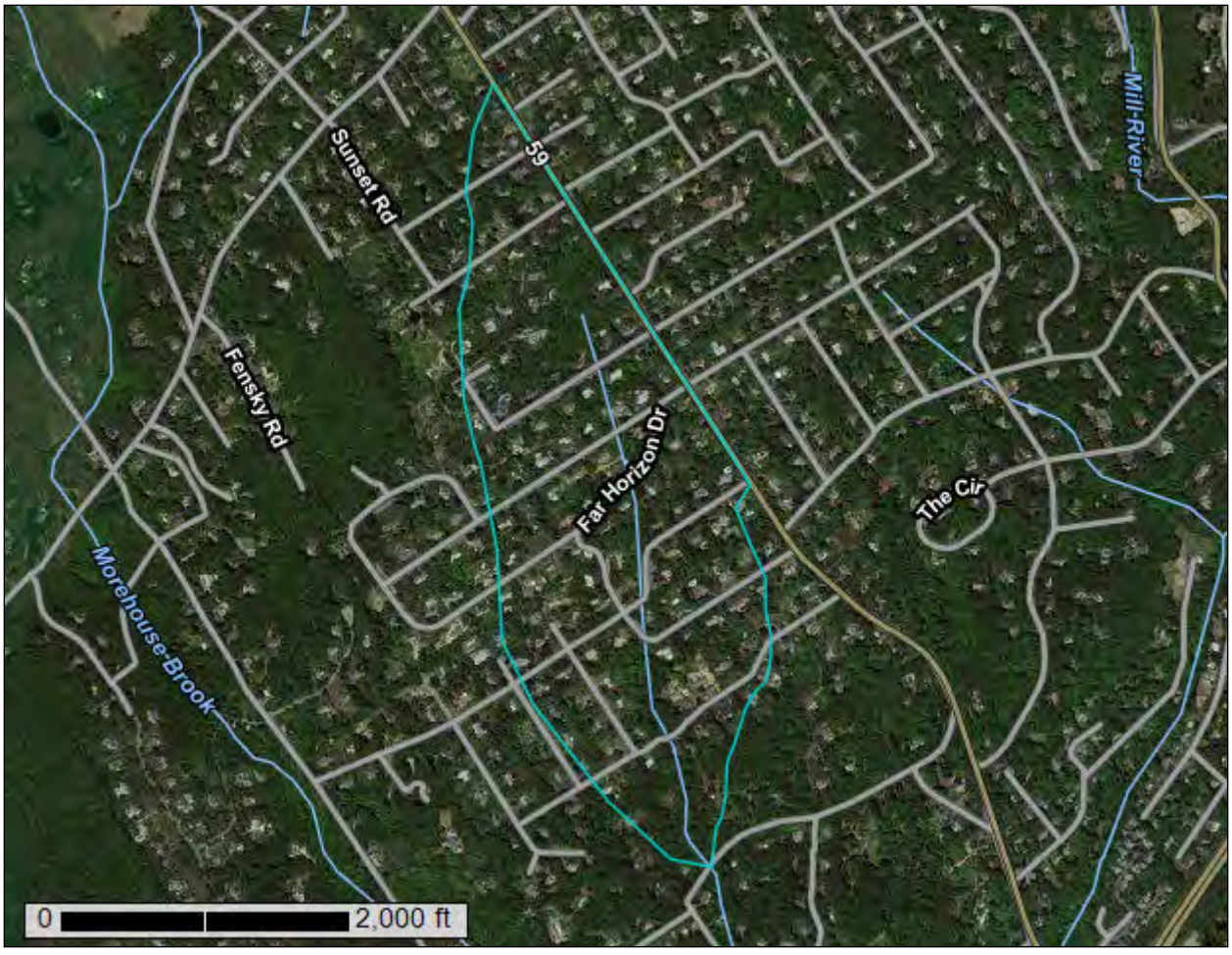
NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for State of Connecticut

Unnamed Brook at 76 Delaware Rd, Easton, CT



March 29, 2020

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require

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Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil

scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

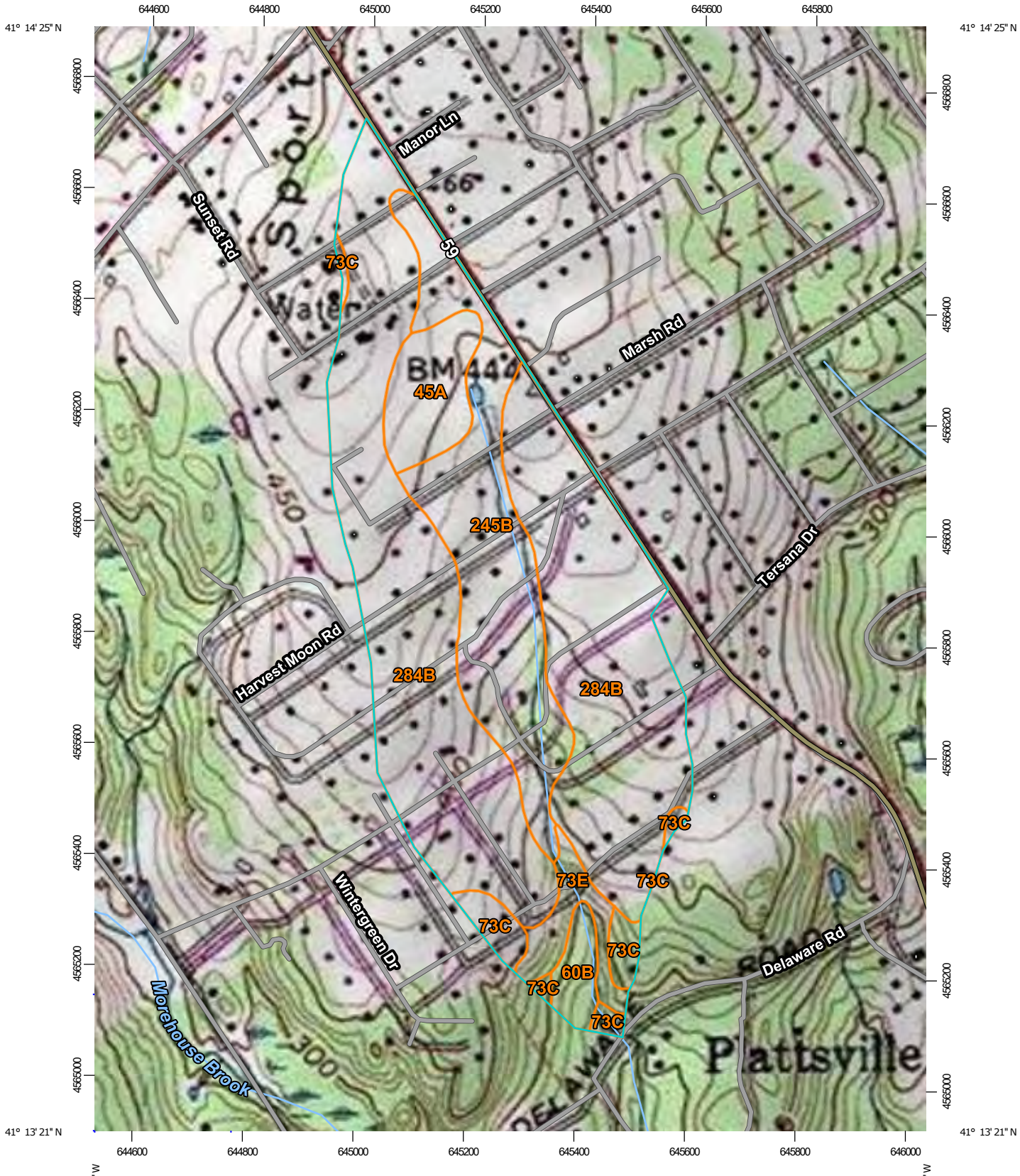
Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and

identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.


73° 16' 32" W
73° 15' 27" W
41° 14' 25" N
41° 13' 21" N
644600
644800
645000
645200
645400
645600
645800
646000
4566800
4566600
4566400
4566200
4566000
4565800
4565600
4565400
4565200
4565000
Manor Ln
Sunset Rd
59
Marsh Rd
Tersana Dr
Harvest Moon Rd
Wintergreen Dr
Delaware Rd
Morehouse Brook
Water
BM 442
Platts
ville
73C
45A
245B
284B
284B
73C
73E
73C
73C
73C
60B
73C
73C
Map Scale: 1:9,700 if printed on A portrait (8.5" x 11") sheet.
N
Meters
0 100 200 400 600
Feet
0 450 900 1800 2700
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 18N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

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

Background
- Topographic Map

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:12,000.

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 19, Sep 13, 2019

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

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
45A	Woodbridge fine sandy loam, 0 to 3 percent slopes	8.9	5.8%
60B	Canton and Charlton fine sandy loams, 3 to 8 percent slopes	3.4	2.2%
73C	Charlton-Chatfield complex, 0 to 15 percent slopes, very rocky	5.7	3.7%
73E	Charlton-Chatfield complex, 15 to 45 percent slopes, very rocky	5.2	3.4%
245B	Woodbridge-Urban land complex, 0 to 8 percent slopes	32.7	21.3%
284B	Paxton-Urban land complex, 3 to 8 percent slopes	97.4	63.5%
Totals for Area of Interest		**153.3**	**100.0%**

Map Unit Descriptions

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

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

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit

descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

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

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

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

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

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

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

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

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

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

State of Connecticut

45A—Woodbridge fine sandy loam, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: 2w686
Elevation: 0 to 1,420 feet
Mean annual precipitation: 36 to 71 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 140 to 240 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Woodbridge and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Woodbridge

Setting

Landform: Hills, ground moraines, drumlins
Landform position (two-dimensional): Footslope, summit
Landform position (three-dimensional): Crest
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Coarse-loamy lodgment till derived from gneiss, granite, and/or schist

Typical profile

Ap - 0 to 7 inches: fine sandy loam
Bw1 - 7 to 18 inches: fine sandy loam
Bw2 - 18 to 30 inches: fine sandy loam
Cd - 30 to 65 inches: gravelly fine sandy loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: 20 to 39 inches to densic material
Natural drainage class: Moderately well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.14 in/hr)
Depth to water table: About 18 to 30 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline (0.0 to 1.9 mmhos/cm)
Available water storage in profile: Low (about 4.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2w
Hydrologic Soil Group: C/D
Hydric soil rating: No

Minor Components

Paxton

Percent of map unit: 7 percent
Landform: Hills, ground moraines, drumlins
Landform position (two-dimensional): Summit, shoulder
Landform position (three-dimensional): Crest
Down-slope shape: Convex, linear
Across-slope shape: Convex
Hydric soil rating: No

Ridgebury

Percent of map unit: 6 percent
Landform: Ground moraines, depressions, drainageways, hills, drumlins
Landform position (two-dimensional): Toeslope, footslope
Landform position (three-dimensional): Base slope, head slope
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

Sutton

Percent of map unit: 1 percent
Landform: Hills, ground moraines
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Linear
Hydric soil rating: No

Whitman, extremely stony

Percent of map unit: 1 percent
Landform: Depressions, drainageways
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

60B—Canton and Charlton fine sandy loams, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: 2w81s
Elevation: 0 to 1,460 feet
Mean annual precipitation: 36 to 71 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 140 to 240 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Canton and similar soils: 50 percent
Charlton and similar soils: 35 percent
Minor components: 15 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Canton

Setting

Landform: Ridges, hills, moraines
Landform position (two-dimensional): Summit, shoulder, backslope
Landform position (three-dimensional): Side slope, nose slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Convex
Parent material: Coarse-loamy over sandy melt-out till derived from gneiss, granite, and/or schist

Typical profile

Ap - 0 to 7 inches: fine sandy loam
Bw1 - 7 to 15 inches: fine sandy loam
Bw2 - 15 to 26 inches: gravelly fine sandy loam
2C - 26 to 65 inches: gravelly loamy sand

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 19 to 39 inches to strongly contrasting textural stratification
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.14 to 14.17 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Very low (about 2.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2s
Hydrologic Soil Group: B
Hydric soil rating: No

Description of Charlton

Setting

Landform: Ground moraines, ridges, hills
Landform position (two-dimensional): Backslope, shoulder, summit
Landform position (three-dimensional): Side slope, crest
Down-slope shape: Linear, convex
Across-slope shape: Convex
Parent material: Coarse-loamy melt-out till derived from granite, gneiss, and/or schist

Typical profile

Ap - 0 to 7 inches: fine sandy loam
Bw - 7 to 22 inches: gravelly fine sandy loam
C - 22 to 65 inches: gravelly fine sandy loam

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained

Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.14 to 14.17 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline (0.0 to 1.9 mmhos/cm)
Available water storage in profile: Moderate (about 6.9 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: B
Hydric soil rating: No

Minor Components

Sutton
Percent of map unit: 5 percent
Landform: Ridges, ground moraines, hills
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Linear
Hydric soil rating: No

Chatfield
Percent of map unit: 5 percent
Landform: Ridges, hills
Landform position (two-dimensional): Backslope, shoulder, summit
Landform position (three-dimensional): Crest, side slope, nose slope
Down-slope shape: Convex
Across-slope shape: Linear, convex
Hydric soil rating: No

Leicester
Percent of map unit: 5 percent
Landform: Depressions, drainageways, hills, ground moraines
Landform position (two-dimensional): Toeslope, footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Linear, concave
Across-slope shape: Concave
Hydric soil rating: Yes

73C—Charlton-Chatfield complex, 0 to 15 percent slopes, very rocky

Map Unit Setting
National map unit symbol: 2w698
Elevation: 0 to 1,550 feet
Mean annual precipitation: 36 to 71 inches

Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 140 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition

Charlton, very stony, and similar soils: 50 percent
Chatfield, very stony, and similar soils: 30 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Charlton, Very Stony

Setting

Landform: Hills, ridges
Landform position (two-dimensional): Backslope, shoulder, summit
Landform position (three-dimensional): Crest, side slope, nose slope
Down-slope shape: Linear, convex
Across-slope shape: Convex
Parent material: Coarse-loamy melt-out till derived from granite, gneiss, and/or schist

Typical profile

Oe - 0 to 2 inches: moderately decomposed plant material
A - 2 to 4 inches: fine sandy loam
Bw - 4 to 27 inches: gravelly fine sandy loam
C - 27 to 65 inches: gravelly fine sandy loam

Properties and qualities

Slope: 3 to 15 percent
Percent of area covered with surface fragments: 1.6 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.14 to 14.17 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline (0.0 to 1.9 mmhos/cm)
Available water storage in profile: Moderate (about 8.7 inches)

Interpretive groups

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

Description of Chatfield, Very Stony

Setting

Landform: Hills, ridges
Landform position (two-dimensional): Backslope, summit, shoulder
Landform position (three-dimensional): Crest, side slope, nose slope
Down-slope shape: Convex
Across-slope shape: Linear, convex
Parent material: Coarse-loamy melt-out till derived from granite, gneiss, and/or schist

Typical profile

Oi - 0 to 1 inches: slightly decomposed plant material
A - 1 to 2 inches: fine sandy loam
Bw - 2 to 30 inches: gravelly fine sandy loam
2R - 30 to 40 inches: bedrock

Properties and qualities

Slope: 3 to 15 percent
Percent of area covered with surface fragments: 1.6 percent
Depth to restrictive feature: 20 to 41 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Very low (0.00 to 0.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline (0.0 to 1.9 mmhos/cm)
Available water storage in profile: Low (about 4.3 inches)

Interpretive groups

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

Minor Components

Sutton, very stony

Percent of map unit: 5 percent
Landform: Hills, ground moraines
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Linear
Hydric soil rating: No

Rock outcrop

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

Hollis, very stony

Percent of map unit: 5 percent
Landform: Ridges, hills
Landform position (two-dimensional): Backslope, shoulder, summit
Landform position (three-dimensional): Crest, side slope, nose slope
Down-slope shape: Convex
Across-slope shape: Linear, convex
Hydric soil rating: No

Leicester, very stony

Percent of map unit: 5 percent
Landform: Drainageways, depressions
Down-slope shape: Linear
Across-slope shape: Concave
Hydric soil rating: Yes

73E—Charlton-Chatfield complex, 15 to 45 percent slopes, very rocky

Map Unit Setting

National map unit symbol: 9lql
Elevation: 0 to 1,200 feet
Mean annual precipitation: 43 to 56 inches
Mean annual air temperature: 45 to 55 degrees F
Frost-free period: 140 to 185 days
Farmland classification: Not prime farmland

Map Unit Composition

Charlton and similar soils: 45 percent
Chatfield and similar soils: 30 percent
Minor components: 25 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Charlton

Setting

Landform: Hills
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Coarse-loamy melt-out till derived from granite and/or schist and/or gneiss

Typical profile

Ap - 0 to 4 inches: fine sandy loam
Bw1 - 4 to 7 inches: fine sandy loam
Bw2 - 7 to 19 inches: fine sandy loam
Bw3 - 19 to 27 inches: gravelly fine sandy loam
C - 27 to 65 inches: gravelly fine sandy loam

Properties and qualities

Slope: 15 to 45 percent
Percent of area covered with surface fragments: 1.6 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 5.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: B

Hydric soil rating: No

Description of Chatfield

Setting

Landform: Ridges, hills
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Coarse-loamy melt-out till derived from granite and/or schist and/or gneiss

Typical profile

Oa - 0 to 1 inches: highly decomposed plant material
A - 1 to 6 inches: gravelly fine sandy loam
Bw1 - 6 to 15 inches: gravelly fine sandy loam
Bw2 - 15 to 29 inches: gravelly fine sandy loam
2R - 29 to 80 inches: unweathered bedrock

Properties and qualities

Slope: 15 to 45 percent
Percent of area covered with surface fragments: 1.6 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Low to high (0.01 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 3.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: B
Hydric soil rating: No

Minor Components

Rock outcrop

Percent of map unit: 10 percent
Hydric soil rating: No

Leicester

Percent of map unit: 5 percent
Landform: Drainageways, depressions
Down-slope shape: Linear
Across-slope shape: Concave
Hydric soil rating: Yes

Sutton

Percent of map unit: 5 percent
Landform: Drainageways, depressions
Down-slope shape: Concave
Across-slope shape: Linear
Hydric soil rating: No

Hollis

Percent of map unit: 3 percent
Landform: Hills, ridges
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: No

Unnamed, sandy subsoil

Percent of map unit: 1 percent
Hydric soil rating: No

Unnamed, red parent material

Percent of map unit: 1 percent
Hydric soil rating: No

245B—Woodbridge-Urban land complex, 0 to 8 percent slopes

Map Unit Setting

National map unit symbol: 2w68d
Elevation: 0 to 970 feet
Mean annual precipitation: 36 to 71 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 145 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition

Woodbridge and similar soils: 43 percent
Urban land: 35 percent
Minor components: 22 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Woodbridge

Setting

Landform: Drumlins, hills, ground moraines
Landform position (two-dimensional): Backslope, footslope, summit
Landform position (three-dimensional): Side slope, crest
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Coarse-loamy lodgment till derived from gneiss, granite, and/or schist

Typical profile

Ap - 0 to 7 inches: fine sandy loam
Bw1 - 7 to 18 inches: fine sandy loam
Bw2 - 18 to 30 inches: fine sandy loam
Cd - 30 to 65 inches: gravelly fine sandy loam

Properties and qualities

Slope: 0 to 8 percent

Depth to restrictive feature: 20 to 39 inches to densic material
Natural drainage class: Moderately well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.14 in/hr)
Depth to water table: About 18 to 30 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline (0.0 to 1.9 mmhos/cm)
Available water storage in profile: Low (about 4.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2w
Hydrologic Soil Group: C/D
Hydric soil rating: No

Description of Urban Land

Typical profile

M - 0 to 10 inches: cemented material

Properties and qualities

Slope: 0 to 8 percent
Depth to restrictive feature: 0 inches to manufactured layer
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low (0.00 to 0.00 in/hr)
Available water storage in profile: Very low (about 0.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8
Hydrologic Soil Group: D
Hydric soil rating: Unranked

Minor Components

Paxton

Percent of map unit: 7 percent
Landform: Ground moraines, drumlins, hills
Landform position (two-dimensional): Summit, backslope, shoulder
Landform position (three-dimensional): Side slope, crest
Down-slope shape: Linear, convex
Across-slope shape: Convex
Hydric soil rating: No

Sutton

Percent of map unit: 5 percent
Landform: Hills, ground moraines
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Linear
Hydric soil rating: No

Ridgebury

Percent of map unit: 5 percent

Landform: Hills, ground moraines, drainageways, depressions, drumlins
Landform position (two-dimensional): Toeslope, footslope
Landform position (three-dimensional): Base slope, head slope
Down-slope shape: Concave, linear
Across-slope shape: Concave, linear
Hydric soil rating: Yes

Udorthents

Percent of map unit: 5 percent
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

284B—Paxton-Urban land complex, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: 2w67s
Elevation: 0 to 1,070 feet
Mean annual precipitation: 36 to 71 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 145 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition

Paxton and similar soils: 45 percent
Urban land: 35 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Paxton

Setting

Landform: Hills, ground moraines, drumlins
Landform position (two-dimensional): Backslope, shoulder, summit
Landform position (three-dimensional): Side slope, crest
Down-slope shape: Linear, convex
Across-slope shape: Convex
Parent material: Coarse-loamy lodgment till derived from gneiss, granite, and/or schist

Typical profile

Ap - 0 to 8 inches: fine sandy loam
Bw1 - 8 to 15 inches: fine sandy loam
Bw2 - 15 to 26 inches: fine sandy loam
Cd - 26 to 65 inches: gravelly fine sandy loam

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 20 to 39 inches to densic material
Natural drainage class: Well drained

Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.14 in/hr)
Depth to water table: About 18 to 37 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline (0.0 to 1.9 mmhos/cm)
Available water storage in profile: Low (about 4.1 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: C
Hydric soil rating: No

Description of Urban Land

Typical profile
M - 0 to 10 inches: cemented material

Properties and qualities
Slope: 3 to 8 percent
Depth to restrictive feature: 0 inches to manufactured layer
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low (0.00 to 0.00 in/hr)
Available water storage in profile: Very low (about 0.0 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8
Hydrologic Soil Group: D
Hydric soil rating: Unranked

Minor Components

Charlton
Percent of map unit: 7 percent
Landform: Hills
Landform position (two-dimensional): Shoulder, backslope, summit
Landform position (three-dimensional): Side slope, crest
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: No

Udorthents
Percent of map unit: 5 percent
Down-slope shape: Convex
Across-slope shape: Linear
Hydric soil rating: No

Woodbridge
Percent of map unit: 5 percent
Landform: Drumlins, hills, ground moraines
Landform position (two-dimensional): Backslope, summit, footslope
Landform position (three-dimensional): Side slope, crest
Down-slope shape: Concave
Across-slope shape: Linear

Hydric soil rating: No

Ridgebury

Percent of map unit: 3 percent
Landform: Hills, ground moraines, drumlins, depressions, drainageways
Landform position (two-dimensional): Toeslope, footslope
Landform position (three-dimensional): Base slope, head slope
Down-slope shape: Concave, linear
Across-slope shape: Concave, linear
Hydric soil rating: Yes

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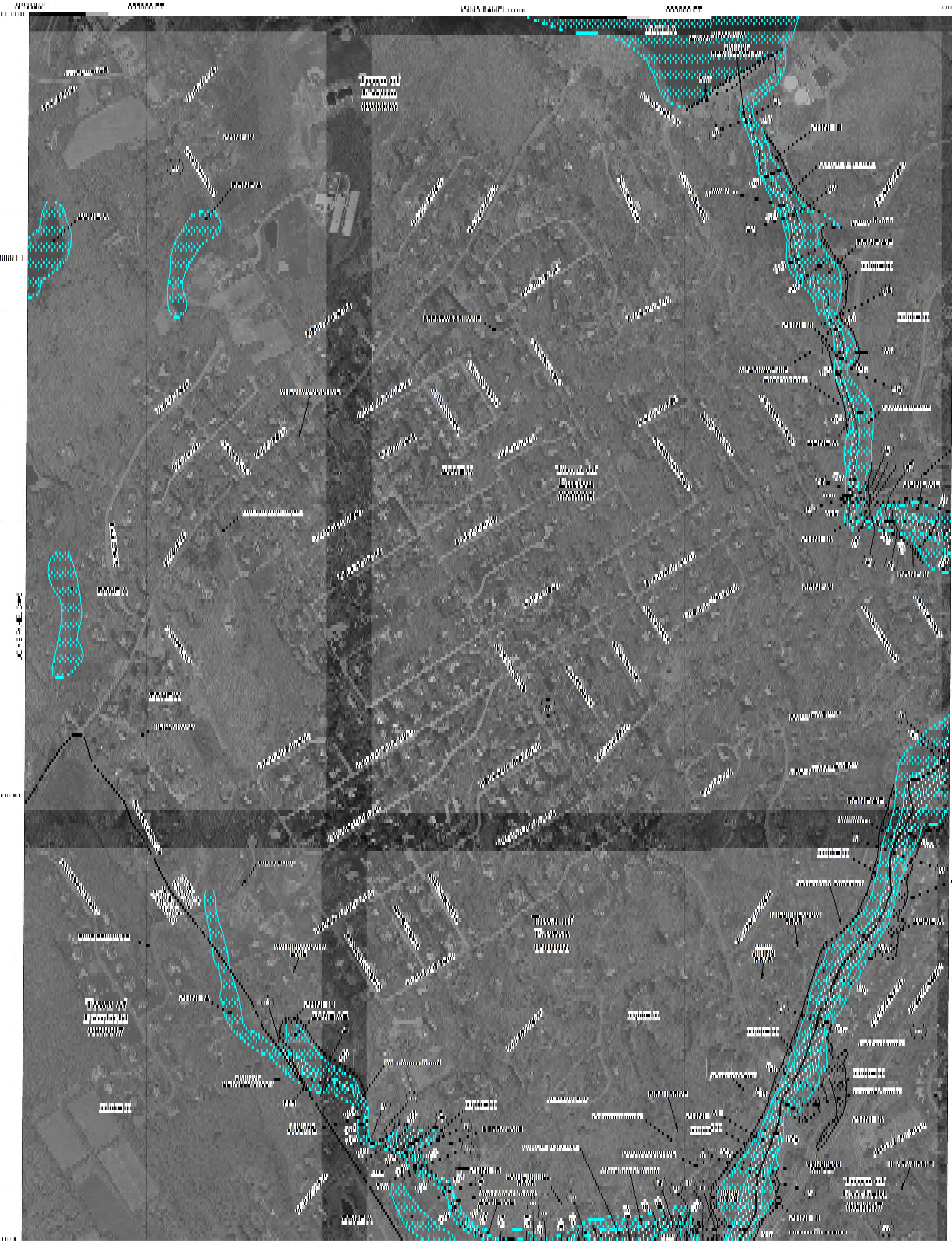
Appendix C – FEMA Flood Zone Map

NOTES TO USERS

LEGEND



FIRM

FLOOD INSURANCE RATE MAP

PANEL 407 OF 626

MAP NUMBER
09001C0407F

EFFECTIVE DATE
JUNE 18, 2010

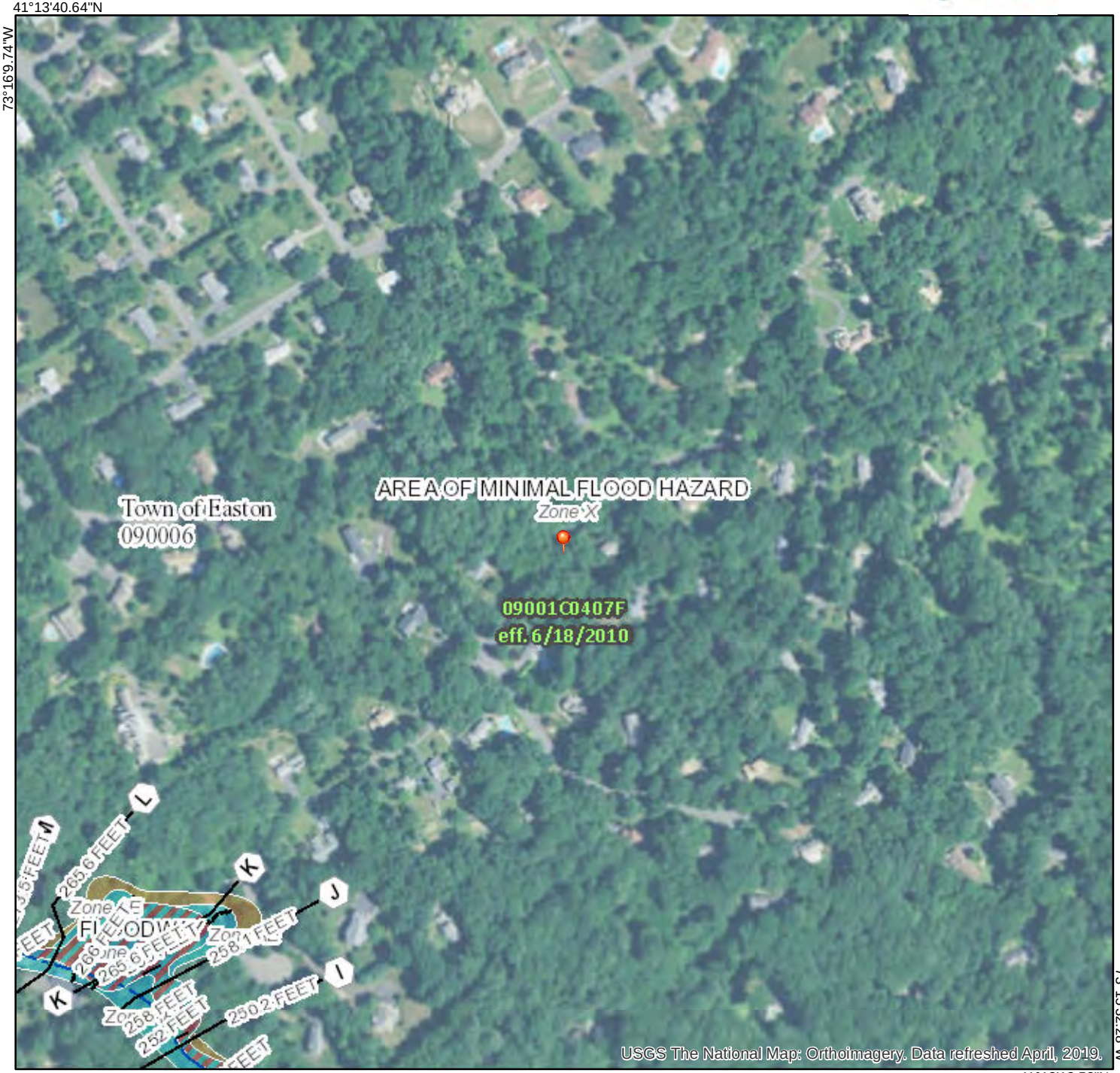
Federal Emergency Management Agency

National Flood Hazard Layer FIRMette

FEMA

41°13'40.64"N

73°16'9.74"W



73°15'32.28"W

41°13'13.58"N

Feet

0 250 500 1,000 1,500 2,000

1:6,000

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

OTHER AREAS OF FLOOD HAZARD
- 0.2% Annual Chance Flood Hazard, Areas 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
- NO SCREEN Area of Minimal Flood Hazard *Zone X*
- Effective LOMRs
- Area of Undetermined Flood Hazard *Zone D*

GENERAL STRUCTURES
- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

OTHER FEATURES
- 20.2 / 17.5 Cross Sections with 1% Annual Chance / Water Surface Elevation
- Coastal Transect
- Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature

MAP PANELS
- Digital Data Available
- No Digital Data Available
- Unmapped

N

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 3/29/2020 at 2:57:11 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.

Appendix D – Hydrology Report

Hydraulic Analysis Report

Project Data

Project Title: Project - 76 Delaware Road, Easton, CT

Designer: Justin Giorlando, P.E.

Project Date: Friday, April 3, 2020

Project Units: U.S. Customary Units

Notes:

Rational Analysis: Rational Method Analysis - 50-year Storm

Notes:

Rational Method Input Parameters

Runoff Coefficient: 0.41

Basin Area: 153.0000 acres

Rainfall Intensity: 3.13 in/hr

Time of Concentration: 40.29 minutes

Recurrence Year: 50 year

Rational Method Results

Flowrate: 197.7 cfs

IDF Input Parameters

User Supplied Data

2 year Recurrence, 5 min duration: 5.06 in/hr
2 year Recurrence, 10 min duration: 3.59 in/hr
2 year Recurrence, 15 min duration: 2.82 in/hr
2 year Recurrence, 30 min duration: 1.96 in/hr
2 year Recurrence, 60 min duration: 1.26 in/hr
5 year Recurrence, 5 min duration: 6.3 in/hr
5 year Recurrence, 10 min duration: 4.46 in/hr
5 year Recurrence, 15 min duration: 3.5 in/hr
5 year Recurrence, 30 min duration: 2.44 in/hr
5 year Recurrence, 60 min duration: 1.56 in/hr
10 year Recurrence, 5 min duration: 7.33 in/hr
10 year Recurrence, 10 min duration: 5.2 in/hr
10 year Recurrence, 15 min duration: 4.08 in/hr
10 year Recurrence, 30 min duration: 2.84 in/hr
10 year Recurrence, 60 min duration: 1.82 in/hr
25 year Recurrence, 5 min duration: 8.75 in/hr
25 year Recurrence, 10 min duration: 6.2 in/hr
25 year Recurrence, 15 min duration: 4.86 in/hr
25 year Recurrence, 30 min duration: 3.39 in/hr
25 year Recurrence, 60 min duration: 2.17 in/hr
50 year Recurrence, 5 min duration: 9.83 in/hr
50 year Recurrence, 10 min duration: 6.95 in/hr
50 year Recurrence, 15 min duration: 5.46 in/hr
50 year Recurrence, 30 min duration: 3.8 in/hr
50 year Recurrence, 60 min duration: 2.44 in/hr
100 year Recurrence, 5 min duration: 10.9 in/hr
100 year Recurrence, 10 min duration: 7.74 in/hr
100 year Recurrence, 15 min duration: 6.07 in/hr
100 year Recurrence, 30 min duration: 4.23 in/hr
100 year Recurrence, 60 min duration: 2.71 in/hr

IDF Results

50 year IDF equation: i = 31.4067 / (Tc + 1.55219)^0.61793

Intensity: 3.1261 in/hr

Time of Concentration Input Parameters

Computed Time of Concentration

Time of Concentration: 40.29 min

Sheet Flow Input Parameters

Top Elevation: 468.00 ft

Bottom Elevation: 465.00 ft

Length: 150.00 ft

Recommended length not to exceed 100'. Maximum length is 300'

Manning's n: 0.1500

See HDS-2 Table 2.1

2 yr, 24 hr precip: 3.5100 in

Sheet Flow Results

Slope: 0.0200 ft/ft

Time of Concentration: 12.94 min

Shallow Concentrated Flow Input Parameters

Top Elevation: 465.00 ft

Bottom Elevation: 440.00 ft

Length: 1300.00 ft

k: 0.2130

See HDS-2 Table 2.2

Shallow Concentrated Flow Results

Slope: 0.0192 ft/ft

Velocity: 0.9747 ft/s

HDS-2 equation 2.7

Time of Concentration: 22.23 min

Channel Flow Input Parameters

Define as: Channel Calculation

Channel Name: Local Channel Data

Top Elevation: 440.00 ft

Bottom Elevation: 205.00 ft

Length: 3000.00 ft

Manning's n: 0.0500

Channel Flow Results

Slope: 0.0783 ft/ft

Velocity: 9.7679 ft/s

Determined by Channel or Curb & Gutter Calculator

Time of Concentration: 5.12 min

Total Time of Concentration

Time of Concentration: 40.29 min

Final Iterated Solution

Report for channel used in Time of Concentration calculations

Channel Analysis: Channel Analysis

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Channel Width: 8.0000 ft

Longitudinal Slope: 0.0780 ft/ft

Manning's n: 0.0500

Flow: 197.7333 cfs

Result Parameters

Depth: 1.7579 ft

Area of Flow: 20.2432 ft^2

Wetted Perimeter: 15.8615 ft

Hydraulic Radius: 1.2763 ft

Average Velocity: 9.7679 ft/s

Top Width: 15.0315 ft

Froude Number: 1.4833

Critical Depth: 2.2032 ft

Critical Velocity: 7.2338 ft/s

Critical Slope: 0.0336 ft/ft

Critical Top Width: 16.81 ft

Calculated Max Shear Stress: 8.5559 lb/ft^2

Calculated Avg Shear Stress: 6.2118 lb/ft^2

Hydrograph - Rational Method Analysis - 50-year Storm - Rational Hydrograph Method

50 year recurrence Interval, Peak Discharge: 197.733 cfs, Time to Peak: 40.00 (min), Total Volume: 472913.56 ft^3

Time (minutes)	Flow cfs
0.00	0.00
1.00	4.91
2.00	9.82
3.00	14.72
4.00	19.63
5.00	24.54
6.00	29.45
7.00	34.36
8.00	39.27
9.00	44.17
10.00	49.08
11.00	53.99
12.00	58.90
13.00	63.81
14.00	68.71
15.00	73.62
16.00	78.53
17.00	83.44
18.00	88.35
19.00	93.25
20.00	98.16
21.00	103.07
22.00	107.98
23.00	112.89
24.00	117.80
25.00	122.70
26.00	127.61
27.00	132.52
28.00	137.43
29.00	142.34
30.00	147.24
31.00	152.15
32.00	157.06
33.00	161.97
34.00	166.88
35.00	171.79
36.00	176.69
37.00	181.60
38.00	186.51
39.00	191.42
40.00	197.73
41.00	192.79
42.00	187.85
43.00	182.90
44.00	177.96
45.00	173.02
46.00	168.07
47.00	163.13

48.00	158.19
49.00	153.24
50.00	148.30
51.00	143.36
52.00	138.41
53.00	133.47
54.00	128.53
55.00	123.58
56.00	118.64
57.00	113.70
58.00	108.75
59.00	103.81
60.00	98.87
61.00	93.92
62.00	88.98
63.00	84.04
64.00	79.09
65.00	74.15
66.00	69.21
67.00	64.26
68.00	59.32
69.00	54.38
70.00	49.43
71.00	44.49
72.00	39.55
73.00	34.60
74.00	29.66
75.00	24.72
76.00	19.77
77.00	14.83
78.00	9.89
79.00	4.94
80.00	0.00

Rational Analysis: Rational Method Analysis - 25-year Storm

Notes:

Rational Method Input Parameters

Runoff Coefficient: 0.41

Basin Area: 153.0000 acres

Rainfall Intensity: 2.78 in/hr

Time of Concentration: 40.47 minutes

Recurrence Year: 25 year

Rational Method Results

Flowrate: 175.6 cfs

IDF Results

25 year IDF equation: i = 28.3423 / (Tc + 1.63305)^0.621175

Intensity: 2.7763 in/hr

Time of Concentration Input Parameters

Computed Time of Concentration

Time of Concentration: 40.47 min

Sheet Flow Input Parameters

Top Elevation: 468.00 ft

Bottom Elevation: 465.00 ft

Length: 150.00 ft

Recommended length not to exceed 100'. Maximum length is 300'

Manning's n: 0.1500

See HDS-2 Table 2.1

2 yr, 24 hr precip: 3.5100 in

Sheet Flow Results

Slope: 0.0200 ft/ft

Time of Concentration: 12.94 min

Shallow Concentrated Flow Input Parameters

Top Elevation: 465.00 ft

Bottom Elevation: 440.00 ft

Length: 1300.00 ft

k: 0.2130

See HDS-2 Table 2.2

Shallow Concentrated Flow Results

Slope: 0.0192 ft/ft

Velocity: 0.9747 ft/s

HDS-2 equation 2.7

Time of Concentration: 22.23 min

Channel Flow Input Parameters

Define as: Channel Calculation

Channel Name: Local Channel Data

Top Elevation: 440.00 ft

Bottom Elevation: 205.00 ft

Length: 3000.00 ft

Manning's n: 0.0500

Channel Flow Results

Slope: 0.0783 ft/ft

Velocity: 9.4333 ft/s

Determined by Channel or Curb & Gutter Calculator

Time of Concentration: 5.30 min

Total Time of Concentration

Time of Concentration: 40.47 min

Final Iterated Solution

Report for channel used in Time of Concentration calculations

Channel Analysis: Channel Analysis

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Channel Width: 8.0000 ft

Longitudinal Slope: 0.0780 ft/ft

Manning's n: 0.0500

Flow: 197.7333 cfs

Result Parameters

Depth: 1.7579 ft

Area of Flow: 20.2432 ft^2

Wetted Perimeter: 15.8615 ft

Hydraulic Radius: 1.2763 ft

Average Velocity: 9.7679 ft/s

Top Width: 15.0315 ft

Froude Number: 1.4833

Critical Depth: 2.2032 ft

Critical Velocity: 7.2338 ft/s

Critical Slope: 0.0336 ft/ft

Critical Top Width: 16.81 ft

Calculated Max Shear Stress: 8.5559 lb/ft^2

Rational Analysis: Rational Method Analysis - 10-year Storm

Notes:

Rational Method Input Parameters

Runoff Coefficient: 0.41

Basin Area: 153.0000 acres

Rainfall Intensity: 2.32 in/hr

Time of Concentration: 40.76 minutes

Recurrence Year: 10 year

Rational Method Results

Flowrate: 146.6 cfs

IDF Results

10 year IDF equation: i = 23.9517 / (Tc + 1.68941)^0.623019

Intensity: 2.3181 in/hr

Time of Concentration Input Parameters

Computed Time of Concentration

Time of Concentration: 40.76 min

Sheet Flow Input Parameters

Top Elevation: 468.00 ft

Bottom Elevation: 465.00 ft

Length: 150.00 ft

Recommended length not to exceed 100'. Maximum length is 300'

Manning's n: 0.1500

See HDS-2 Table 2.1

2 yr, 24 hr precip: 3.5100 in

Sheet Flow Results

Slope: 0.0200 ft/ft

Time of Concentration: 12.94 min

Shallow Concentrated Flow Input Parameters

Top Elevation: 465.00 ft

Bottom Elevation: 440.00 ft

Length: 1300.00 ft

k: 0.2130

See HDS-2 Table 2.2

Shallow Concentrated Flow Results

Slope: 0.0192 ft/ft

Velocity: 0.9747 ft/s

HDS-2 equation 2.7

Time of Concentration: 22.23 min

Channel Flow Input Parameters

Define as: Channel Calculation

Channel Name: Local Channel Data

Top Elevation: 440.00 ft

Bottom Elevation: 205.00 ft

Length: 3000.00 ft

Manning's n: 0.0500

Channel Flow Results

Slope: 0.0783 ft/ft

Velocity: 8.9381 ft/s

Determined by Channel or Curb & Gutter Calculator

Time of Concentration: 5.59 min

Total Time of Concentration

Time of Concentration: 40.76 min

Final Iterated Solution

Report for channel used in Time of Concentration calculations

Channel Analysis: Channel Analysis

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Channel Width: 8.0000 ft

Longitudinal Slope: 0.0780 ft/ft

Manning's n: 0.0500

Flow: 197.7333 cfs

Result Parameters

Depth: 1.7579 ft

Area of Flow: 20.2432 ft^2

Wetted Perimeter: 15.8615 ft

Hydraulic Radius: 1.2763 ft

Average Velocity: 9.7679 ft/s

Top Width: 15.0315 ft

Froude Number: 1.4833

Critical Depth: 2.2032 ft

Critical Velocity: 7.2338 ft/s

Critical Slope: 0.0336 ft/ft

Critical Top Width: 16.81 ft

Calculated Max Shear Stress: 8.5559 lb/ft^2

Rational Analysis: Rational Method Analysis - 5-year Storm

Notes:

Rational Method Input Parameters

Runoff Coefficient: 0.41

Basin Area: 153.0000 acres

Rainfall Intensity: 1.98 in/hr

Time of Concentration: 41.03 minutes

Recurrence Year: 5 year

Rational Method Results

Flowrate: 125.3 cfs

IDF Results

5 year IDF equation: i = 20.4369 / (Tc + 1.63619)^0.621806

Intensity: 1.9806 in/hr

Time of Concentration Input Parameters

Computed Time of Concentration

Time of Concentration: 41.03 min

Sheet Flow Input Parameters

Top Elevation: 468.00 ft

Bottom Elevation: 465.00 ft

Length: 150.00 ft

Recommended length not to exceed 100'. Maximum length is 300'

Manning's n: 0.1500

See HDS-2 Table 2.1

2 yr, 24 hr precip: 3.5100 in

Sheet Flow Results

Slope: 0.0200 ft/ft

Time of Concentration: 12.94 min

Shallow Concentrated Flow Input Parameters

Top Elevation: 465.00 ft

Bottom Elevation: 440.00 ft

Length: 1300.00 ft

k: 0.2130

See HDS-2 Table 2.2

Shallow Concentrated Flow Results

Slope: 0.0192 ft/ft

Velocity: 0.9747 ft/s

HDS-2 equation 2.7

Time of Concentration: 22.23 min

Channel Flow Input Parameters

Define as: Channel Calculation

Channel Name: Local Channel Data

Top Elevation: 440.00 ft

Bottom Elevation: 205.00 ft

Length: 3000.00 ft

Manning's n: 0.0500

Channel Flow Results

Slope: 0.0783 ft/ft

Velocity: 8.5225 ft/s

Determined by Channel or Curb & Gutter Calculator

Time of Concentration: 5.87 min

Total Time of Concentration

Time of Concentration: 41.03 min

Final Iterated Solution

Report for channel used in Time of Concentration calculations

Channel Analysis: Channel Analysis

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Channel Width: 8.0000 ft

Longitudinal Slope: 0.0780 ft/ft

Manning's n: 0.0500

Flow: 197.7333 cfs

Result Parameters

Depth: 1.7579 ft

Area of Flow: 20.2432 ft^2

Wetted Perimeter: 15.8615 ft

Hydraulic Radius: 1.2763 ft

Average Velocity: 9.7679 ft/s

Top Width: 15.0315 ft

Froude Number: 1.4833

Critical Depth: 2.2032 ft

Critical Velocity: 7.2338 ft/s

Critical Slope: 0.0336 ft/ft

Critical Top Width: 16.81 ft

Calculated Max Shear Stress: 8.5559 lb/ft^2

Rational Analysis: Rational Method Analysis - 2-year Storm

Notes:

Rational Method Input Parameters

Runoff Coefficient: 0.41

Basin Area: 153.0000 acres

Rainfall Intensity: 1.59 in/hr

Time of Concentration: 41.45 minutes

Recurrence Year: 2 year

Rational Method Results

Flowrate: 100.4 cfs

IDF Results

2 year IDF equation: i = 16.4466 / (Tc + 1.66842)^0.621252

Intensity: 1.5869 in/hr

Time of Concentration Input Parameters

Computed Time of Concentration

Time of Concentration: 41.45 min

Sheet Flow Input Parameters

Top Elevation: 468.00 ft

Bottom Elevation: 465.00 ft

Length: 150.00 ft

Recommended length not to exceed 100'. Maximum length is 300'

Manning's n: 0.1500

See HDS-2 Table 2.1

2 yr, 24 hr precip: 3.5100 in

Sheet Flow Results

Slope: 0.0200 ft/ft

Time of Concentration: 12.94 min

Shallow Concentrated Flow Input Parameters

Top Elevation: 465.00 ft

Bottom Elevation: 440.00 ft

Length: 1300.00 ft

k: 0.2130

See HDS-2 Table 2.2

Shallow Concentrated Flow Results

Slope: 0.0192 ft/ft

Velocity: 0.9747 ft/s

HDS-2 equation 2.7

Time of Concentration: 22.23 min

Channel Flow Input Parameters

Define as: Channel Calculation

Channel Name: Local Channel Data

Top Elevation: 440.00 ft

Bottom Elevation: 205.00 ft

Length: 3000.00 ft

Manning's n: 0.0500

Channel Flow Results

Slope: 0.0783 ft/ft

Velocity: 7.9635 ft/s

Determined by Channel or Curb & Gutter Calculator

Time of Concentration: 6.28 min

Total Time of Concentration

Time of Concentration: 41.45 min

Final Iterated Solution

Report for channel used in Time of Concentration calculations

Channel Analysis: Channel Analysis

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Channel Width: 8.0000 ft

Longitudinal Slope: 0.0780 ft/ft

Manning's n: 0.0500

Flow: 197.7333 cfs

Result Parameters

Depth: 1.7579 ft

Area of Flow: 20.2432 ft^2

Wetted Perimeter: 15.8615 ft

Hydraulic Radius: 1.2763 ft

Average Velocity: 9.7679 ft/s

Top Width: 15.0315 ft

Froude Number: 1.4833

Critical Depth: 2.2032 ft

Critical Velocity: 7.2338 ft/s

Critical Slope: 0.0336 ft/ft

Critical Top Width: 16.81 ft

Calculated Max Shear Stress: 8.5559 lb/ft^2

Rational Analysis: Rational Method Analysis - 100-year Storm

Notes:

Rational Method Input Parameters

Runoff Coefficient: 0.41

Basin Area: 153.0000 acres

Rainfall Intensity: 3.48 in/hr

Time of Concentration: 40.13 minutes

Recurrence Year: 100 year

Rational Method Results

Flowrate: 220.4 cfs

IDF Results

100 year IDF equation: i = 35.6795 / (Tc + 1.7075)^0.623055

Intensity: 3.4843 in/hr

Time of Concentration Input Parameters

Computed Time of Concentration

Time of Concentration: 40.13 min

Sheet Flow Input Parameters

Top Elevation: 468.00 ft

Bottom Elevation: 465.00 ft

Length: 150.00 ft

Recommended length not to exceed 100'. Maximum length is 300'

Manning's n: 0.1500

See HDS-2 Table 2.1

2 yr, 24 hr precip: 3.5100 in

Sheet Flow Results

Slope: 0.0200 ft/ft

Time of Concentration: 12.94 min

Shallow Concentrated Flow Input Parameters

Top Elevation: 465.00 ft

Bottom Elevation: 440.00 ft

Length: 1300.00 ft

k: 0.2130

See HDS-2 Table 2.2

Shallow Concentrated Flow Results

Slope: 0.0192 ft/ft

Velocity: 0.9747 ft/s

HDS-2 equation 2.7

Time of Concentration: 22.23 min

Channel Flow Input Parameters

Define as: Channel Calculation

Channel Name: Local Channel Data

Top Elevation: 440.00 ft

Bottom Elevation: 205.00 ft

Length: 3000.00 ft

Manning's n: 0.0500

Channel Flow Results

Slope: 0.0783 ft/ft

Velocity: 10.0813 ft/s

Determined by Channel or Curb & Gutter Calculator

Time of Concentration: 4.96 min

Total Time of Concentration

Time of Concentration: 40.13 min

Final Iterated Solution

Report for channel used in Time of Concentration calculations

Channel Analysis: Channel Analysis

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Channel Width: 8.0000 ft

Longitudinal Slope: 0.0780 ft/ft

Manning's n: 0.0500

Flow: 197.7333 cfs

Result Parameters

Depth: 1.7579 ft

Area of Flow: 20.2432 ft^2

Wetted Perimeter: 15.8615 ft

Hydraulic Radius: 1.2763 ft

Average Velocity: 9.7679 ft/s

Top Width: 15.0315 ft

Froude Number: 1.4833

Critical Depth: 2.2032 ft

Critical Velocity: 7.2338 ft/s

Critical Slope: 0.0336 ft/ft

Critical Top Width: 16.81 ft

Calculated Max Shear Stress: 8.5559 lb/ft^2

Appendix E – NOAA ATLAS 14 Rainfall Data

NOAA Atlas 14, Volume 10, Version 3
Location name: Easton, Connecticut, USA*
Latitude: 41.2245°, Longitude: -73.2648°
Elevation: 263.63 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	**4.31** (3.34-5.47)	**5.06** (3.92-6.43)	**6.30** (4.86-8.03)	**7.33** (5.63-9.38)	**8.75** (6.50-11.6)	**9.83** (7.15-13.2)	**10.9** (7.72-15.1)	**12.1** (8.17-17.2)	**13.8** (8.96-20.1)	**15.2** (9.61-22.5)
10-min	**3.05** (2.36-3.88)	**3.59** (2.78-4.56)	**4.46** (3.44-5.69)	**5.20** (3.98-6.64)	**6.20** (4.60-8.20)	**6.95** (5.06-9.37)	**7.74** (5.47-10.7)	**8.60** (5.78-12.2)	**9.80** (6.35-14.3)	**10.8** (6.81-15.9)
15-min	**2.40** (1.86-3.04)	**2.82** (2.18-3.58)	**3.50** (2.70-4.46)	**4.08** (3.12-5.22)	**4.86** (3.61-6.43)	**5.46** (3.97-7.34)	**6.07** (4.29-8.41)	**6.74** (4.54-9.54)	**7.68** (4.98-11.2)	**8.44** (5.34-12.5)
30-min	**1.67** (1.29-2.11)	**1.96** (1.52-2.49)	**2.44** (1.88-3.11)	**2.84** (2.18-3.63)	**3.39** (2.51-4.48)	**3.80** (2.77-5.11)	**4.23** (2.98-5.84)	**4.68** (3.15-6.62)	**5.30** (3.44-7.72)	**5.79** (3.66-8.57)
60-min	**1.07** (0.827-1.35)	**1.26** (0.972-1.60)	**1.56** (1.21-1.99)	**1.82** (1.40-2.33)	**2.17** (1.61-2.87)	**2.44** (1.77-3.27)	**2.71** (1.91-3.74)	**3.00** (2.02-4.24)	**3.38** (2.19-4.92)	**3.68** (2.33-5.45)
2-hr	**0.690** (0.538-0.870)	**0.818** (0.638-1.03)	**1.03** (0.799-1.30)	**1.20** (0.929-1.53)	**1.44** (1.08-1.90)	**1.63** (1.19-2.18)	**1.82** (1.29-2.50)	**2.02** (1.37-2.84)	**2.31** (1.50-3.34)	**2.54** (1.61-3.74)
3-hr	**0.529** (0.414-0.665)	**0.631** (0.494-0.793)	**0.797** (0.621-1.00)	**0.935** (0.725-1.18)	**1.13** (0.844-1.48)	**1.27** (0.932-1.69)	**1.42** (1.01-1.95)	**1.59** (1.07-2.22)	**1.83** (1.19-2.63)	**2.02** (1.28-2.96)
6-hr	**0.334** (0.263-0.417)	**0.401** (0.315-0.500)	**0.510** (0.400-0.638)	**0.601** (0.468-0.755)	**0.725** (0.548-0.947)	**0.819** (0.606-1.09)	**0.917** (0.660-1.26)	**1.03** (0.700-1.43)	**1.20** (0.781-1.71)	**1.33** (0.849-1.94)
12-hr	**0.204** (0.162-0.253)	**0.247** (0.195-0.306)	**0.316** (0.249-0.392)	**0.373** (0.292-0.466)	**0.452** (0.343-0.586)	**0.510** (0.380-0.675)	**0.573** (0.415-0.783)	**0.646** (0.440-0.892)	**0.754** (0.494-1.07)	**0.844** (0.540-1.22)
24-hr	**0.120** (0.096-0.148)	**0.146** (0.117-0.180)	**0.190** (0.151-0.234)	**0.225** (0.178-0.280)	**0.275** (0.210-0.355)	**0.311** (0.234-0.410)	**0.351** (0.256-0.479)	**0.398** (0.272-0.547)	**0.470** (0.309-0.663)	**0.531** (0.341-0.762)
2-day	**0.067** (0.054-0.082)	**0.083** (0.067-0.102)	**0.109** (0.087-0.134)	**0.131** (0.104-0.162)	**0.161** (0.124-0.208)	**0.183** (0.139-0.241)	**0.208** (0.153-0.283)	**0.238** (0.163-0.324)	**0.285** (0.188-0.400)	**0.326** (0.210-0.464)
3-day	**0.048** (0.039-0.059)	**0.060** (0.048-0.073)	**0.079** (0.064-0.097)	**0.095** (0.076-0.117)	**0.117** (0.091-0.150)	**0.133** (0.101-0.175)	**0.151** (0.112-0.206)	**0.173** (0.119-0.235)	**0.208** (0.137-0.291)	**0.239** (0.154-0.339)
4-day	**0.039** (0.032-0.047)	**0.048** (0.039-0.059)	**0.064** (0.051-0.077)	**0.076** (0.061-0.093)	**0.093** (0.072-0.119)	**0.106** (0.081-0.139)	**0.120** (0.089-0.163)	**0.138** (0.095-0.186)	**0.165** (0.109-0.230)	**0.189** (0.122-0.267)
7-day	**0.027** (0.022-0.032)	**0.033** (0.026-0.039)	**0.042** (0.034-0.051)	**0.050** (0.040-0.061)	**0.060** (0.047-0.077)	**0.068** (0.052-0.088)	**0.077** (0.057-0.103)	**0.088** (0.061-0.118)	**0.104** (0.069-0.143)	**0.117** (0.076-0.165)
10-day	**0.022** (0.018-0.026)	**0.026** (0.021-0.031)	**0.033** (0.027-0.040)	**0.039** (0.031-0.047)	**0.047** (0.036-0.059)	**0.052** (0.040-0.067)	**0.059** (0.043-0.078)	**0.066** (0.046-0.089)	**0.077** (0.051-0.106)	**0.086** (0.056-0.121)
20-day	**0.015** (0.013-0.018)	**0.018** (0.015-0.021)	**0.022** (0.018-0.026)	**0.025** (0.020-0.030)	**0.029** (0.023-0.036)	**0.032** (0.025-0.041)	**0.036** (0.026-0.047)	**0.040** (0.028-0.053)	**0.045** (0.030-0.061)	**0.049** (0.032-0.068)
30-day	**0.013** (0.010-0.015)	**0.014** (0.012-0.017)	**0.017** (0.014-0.020)	**0.019** (0.016-0.023)	**0.022** (0.018-0.028)	**0.025** (0.019-0.031)	**0.027** (0.020-0.035)	**0.030** (0.021-0.039)	**0.033** (0.022-0.045)	**0.036** (0.023-0.050)
45-day	**0.011** (0.009-0.012)	**0.012** (0.010-0.014)	**0.014** (0.011-0.016)	**0.015** (0.012-0.018)	**0.017** (0.014-0.021)	**0.019** (0.015-0.024)	**0.021** (0.015-0.027)	**0.023** (0.016-0.030)	**0.025** (0.017-0.034)	**0.026** (0.017-0.036)
60-day	**0.009** (0.008-0.011)	**0.010** (0.008-0.012)	**0.012** (0.010-0.014)	**0.013** (0.011-0.015)	**0.015** (0.012-0.018)	**0.016** (0.012-0.020)	**0.017** (0.013-0.022)	**0.019** (0.013-0.024)	**0.020** (0.014-0.027)	**0.021** (0.014-0.030)

[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.

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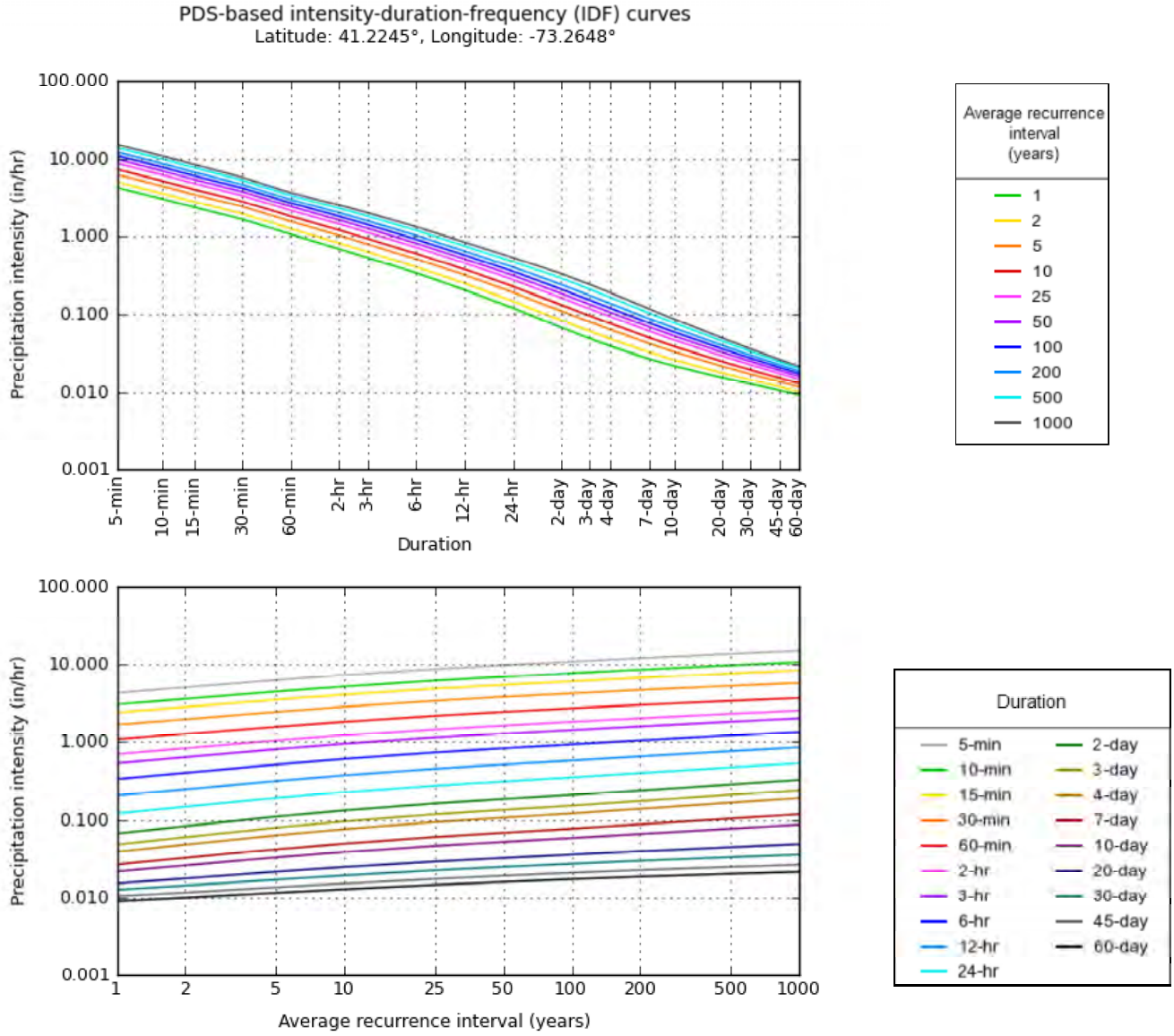
PF graphical



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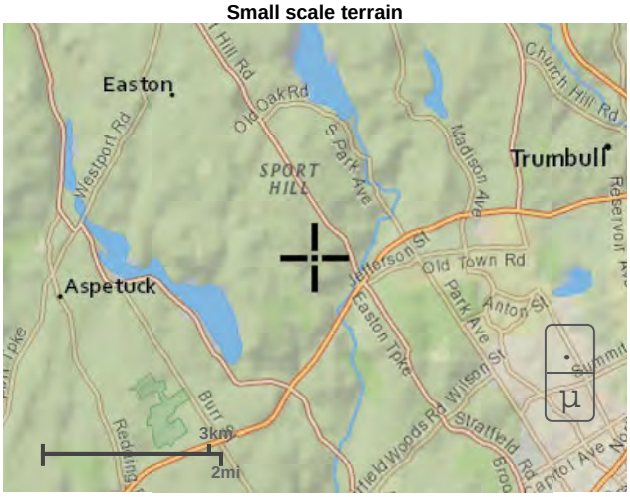
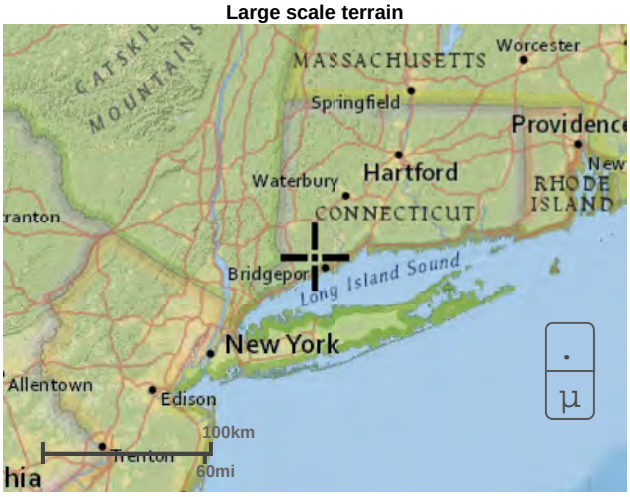


Large scale terrain



Large scale map

Large scale aerial

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

NOAA Atlas 14, Volume 10, Version 3
Location name: Easton, Connecticut, USA*
Latitude: 41.2245°, Longitude: -73.2648°
Elevation: 263.63 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	0.359 (0.278-0.456)	0.422 (0.327-0.536)	0.525 (0.405-0.669)	0.611 (0.469-0.782)	0.729 (0.542-0.965)	0.819 (0.596-1.10)	0.911 (0.643-1.26)	1.01 (0.681-1.43)	1.15 (0.747-1.68)	1.26 (0.801-1.87)
10-min	0.509 (0.394-0.646)	0.598 (0.463-0.760)	0.744 (0.574-0.948)	0.866 (0.664-1.11)	1.03 (0.767-1.37)	1.16 (0.844-1.56)	1.29 (0.911-1.79)	1.43 (0.964-2.03)	1.63 (1.06-2.38)	1.79 (1.14-2.65)
15-min	0.599 (0.464-0.760)	0.704 (0.545-0.894)	0.876 (0.676-1.12)	1.02 (0.781-1.30)	1.22 (0.903-1.61)	1.36 (0.993-1.84)	1.52 (1.07-2.10)	1.69 (1.13-2.38)	1.92 (1.24-2.80)	2.11 (1.34-3.12)
30-min	0.833 (0.645-1.06)	0.980 (0.758-1.24)	1.22 (0.941-1.55)	1.42 (1.09-1.82)	1.69 (1.26-2.24)	1.90 (1.38-2.56)	2.12 (1.49-2.92)	2.34 (1.58-3.31)	2.65 (1.72-3.86)	2.89 (1.83-4.29)
60-min	1.07 (0.827-1.35)	1.26 (0.972-1.60)	1.56 (1.21-1.99)	1.82 (1.40-2.33)	2.17 (1.61-2.87)	2.44 (1.77-3.27)	2.71 (1.91-3.74)	3.00 (2.02-4.24)	3.38 (2.19-4.92)	3.68 (2.33-5.45)
2-hr	1.38 (1.08-1.74)	1.64 (1.27-2.07)	2.06 (1.60-2.61)	2.41 (1.86-3.06)	2.89 (2.16-3.80)	3.25 (2.38-4.35)	3.63 (2.58-5.00)	4.04 (2.73-5.68)	4.62 (3.00-6.68)	5.08 (3.23-7.47)
3-hr	1.59 (1.24-2.00)	1.90 (1.48-2.38)	2.39 (1.87-3.02)	2.81 (2.18-3.56)	3.38 (2.54-4.43)	3.81 (2.80-5.09)	4.26 (3.04-5.86)	4.76 (3.22-6.67)	5.48 (3.57-7.89)	6.06 (3.86-8.88)
6-hr	2.00 (1.58-2.50)	2.40 (1.89-3.00)	3.05 (2.40-3.82)	3.60 (2.80-4.52)	4.34 (3.28-5.67)	4.90 (3.63-6.52)	5.49 (3.95-7.54)	6.17 (4.19-8.58)	7.16 (4.68-10.2)	7.97 (5.09-11.6)
12-hr	2.46 (1.95-3.05)	2.97 (2.35-3.68)	3.80 (3.00-4.73)	4.49 (3.52-5.61)	5.44 (4.13-7.06)	6.15 (4.58-8.13)	6.91 (5.00-9.44)	7.78 (5.31-10.8)	9.08 (5.95-12.9)	10.2 (6.50-14.7)
24-hr	2.88 (2.30-3.54)	3.51 (2.80-4.33)	4.55 (3.61-5.62)	5.41 (4.27-6.71)	6.59 (5.05-8.52)	7.47 (5.61-9.84)	8.42 (6.15-11.5)	9.56 (6.54-13.1)	11.3 (7.41-15.9)	12.7 (8.18-18.3)
2-day	3.22 (2.58-3.93)	3.99 (3.20-4.88)	5.25 (4.20-6.44)	6.30 (5.00-7.76)	7.74 (5.97-9.97)	8.80 (6.66-11.6)	9.97 (7.36-13.6)	11.4 (7.83-15.6)	13.7 (9.02-19.2)	15.7 (10.1-22.3)
3-day	3.49 (2.81-4.25)	4.33 (3.49-5.28)	5.72 (4.59-6.98)	6.86 (5.47-8.42)	8.44 (6.53-10.8)	9.60 (7.29-12.6)	10.9 (8.06-14.8)	12.5 (8.58-17.0)	15.0 (9.90-20.9)	17.2 (11.1-24.4)
4-day	3.75 (3.03-4.55)	4.64 (3.75-5.64)	6.10 (4.90-7.43)	7.31 (5.84-8.94)	8.97 (6.96-11.5)	10.2 (7.75-13.3)	11.5 (8.56-15.6)	13.2 (9.10-17.9)	15.8 (10.5-22.1)	18.1 (11.7-25.6)
7-day	4.49 (3.65-5.42)	5.46 (4.43-6.60)	7.04 (5.69-8.53)	8.36 (6.71-10.2)	10.2 (7.91-12.9)	11.5 (8.76-14.9)	12.9 (9.60-17.4)	14.7 (10.2-19.8)	17.4 (11.5-24.1)	19.7 (12.8-27.7)
10-day	5.22 (4.25-6.28)	6.23 (5.07-7.50)	7.89 (6.40-9.53)	9.27 (7.47-11.2)	11.2 (8.70-14.1)	12.6 (9.59-16.1)	14.1 (10.4-18.7)	15.9 (11.0-21.3)	18.5 (12.3-25.5)	20.8 (13.5-29.1)
20-day	7.39 (6.06-8.83)	8.51 (6.98-10.2)	10.3 (8.45-12.4)	11.9 (9.63-14.3)	14.0 (10.9-17.4)	15.5 (11.9-19.7)	17.2 (12.7-22.4)	19.0 (13.2-25.2)	21.5 (14.4-29.4)	23.5 (15.3-32.7)
30-day	9.18 (7.56-10.9)	10.4 (8.54-12.4)	12.3 (10.1-14.7)	14.0 (11.4-16.7)	16.2 (12.7-20.0)	17.9 (13.7-22.5)	19.6 (14.4-25.3)	21.4 (15.0-28.3)	23.9 (16.0-32.5)	25.8 (16.8-35.7)
45-day	11.4 (9.42-13.5)	12.7 (10.5-15.0)	14.8 (12.1-17.6)	16.5 (13.5-19.7)	18.9 (14.9-23.2)	20.8 (15.9-25.9)	22.6 (16.6-28.9)	24.4 (17.2-32.1)	26.8 (18.0-36.3)	28.6 (18.6-39.4)
60-day	13.2 (11.0-15.6)	14.6 (12.1-17.2)	16.8 (13.8-19.9)	18.6 (15.3-22.2)	21.1 (16.7-25.9)	23.1 (17.7-28.7)	25.0 (18.4-31.8)	26.9 (18.9-35.3)	29.2 (19.7-39.4)	30.9 (20.2-42.5)

[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.

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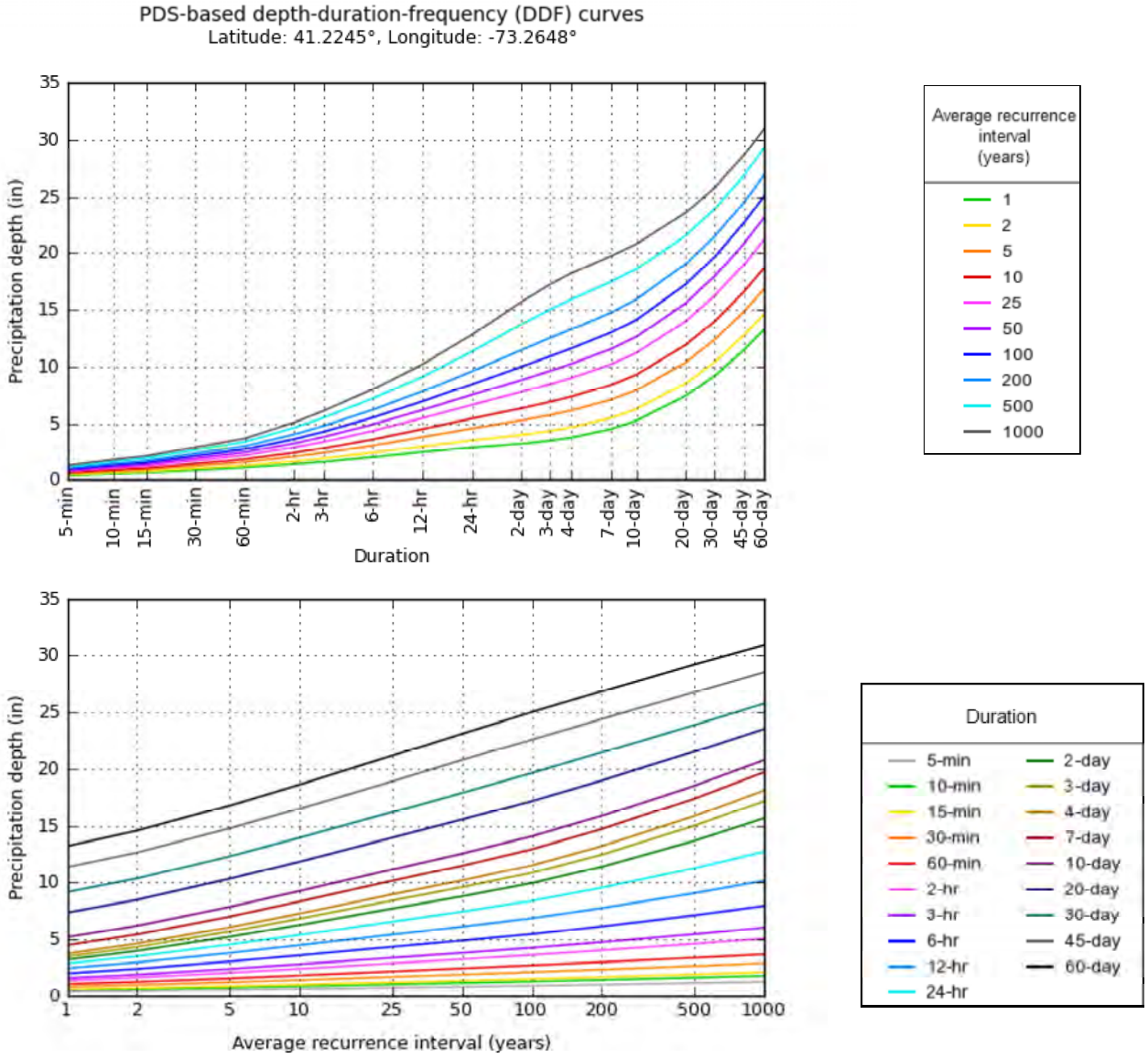
PF graphical



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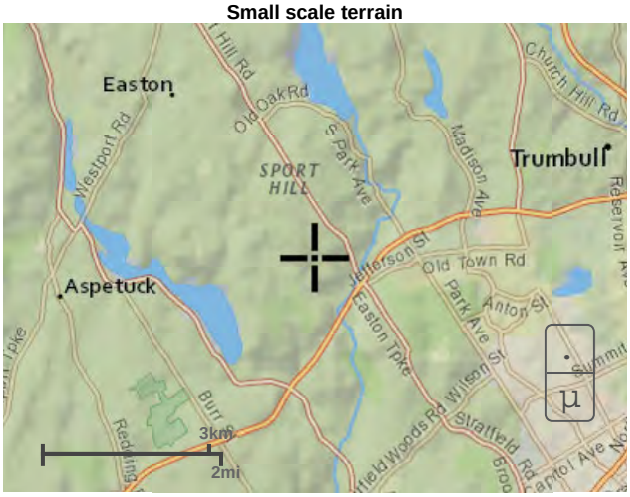

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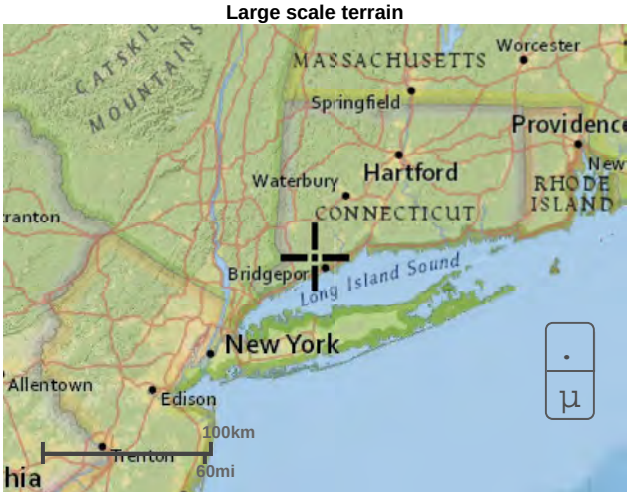

Large scale map

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Appendix F – Existing Hydraulic Calculations

HY-8 Culvert Analysis Report
EXISTING CONDITIONS

Table 1 - Summary of Culvert Flows at Crossing: Unnamed Brook at 76 Delaware Rd. (Existing)

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Existing Discharge (cfs)	Roadway Discharge (cfs)	Iterations
4.14	2 year	100.00	100.00	0.00	1
4.62	5 year	124.00	124.00	0.00	1
5.09	10 year	146.00	146.00	0.00	1
5.49	25 year	192.00	162.95	28.99	6
5.73	50 year	236.00	172.48	63.43	5
5.90	100 year	273.00	179.01	93.74	4
5.13	Overtopping	147.53	147.53	0.00	Overtopping

Rating Curve Plot for Crossing: Unnamed Brook at 76 Delaware Rd. (Existing)

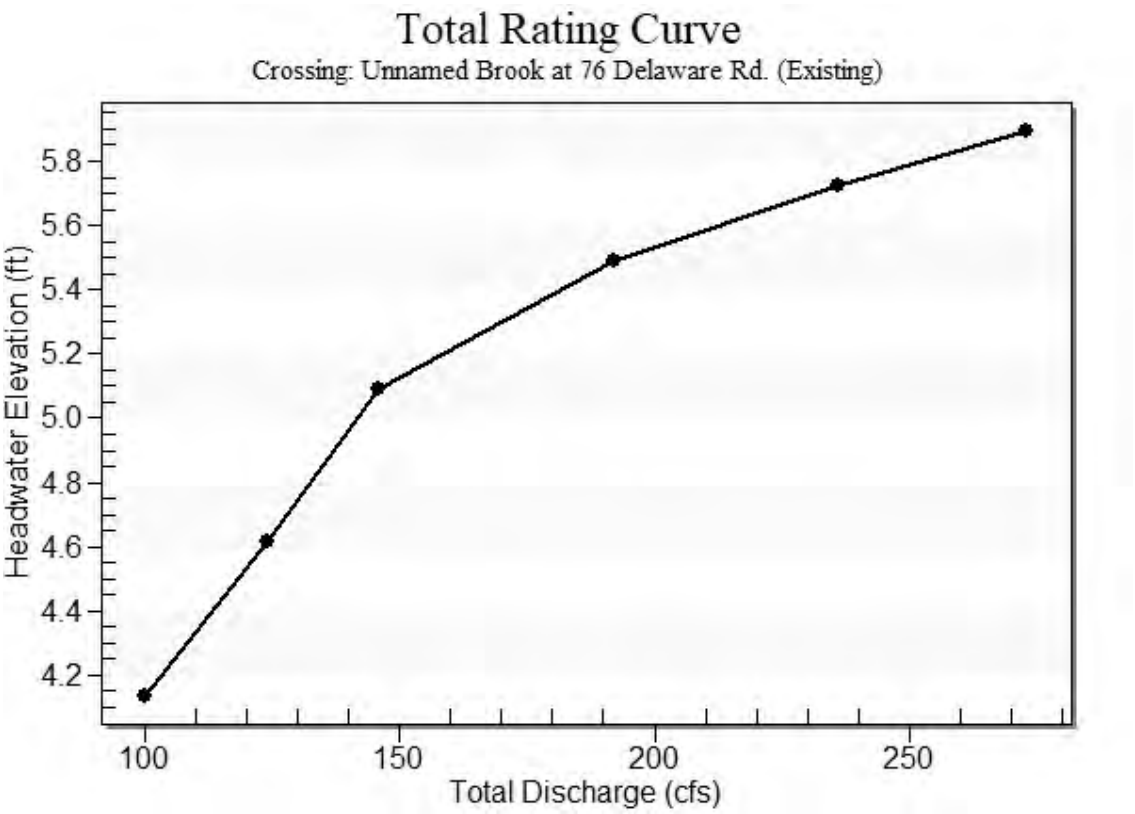


Table 2 - Culvert Summary Table: Existing

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
2 year	100.00	100.00	4.14	3.159	1.906	1-S2n	1.580	2.210	1.699	1.076	10.797	7.652
5 year	124.00	124.00	4.62	3.639	2.527	5-S2n	1.790	2.468	1.933	1.216	11.380	8.202
10 year	146.00	146.00	5.09	4.111	3.548	5-S2n	1.978	2.676	2.136	1.334	11.866	8.638
25 year	192.00	162.95	5.49	4.509	3.972	5-S2n	2.122	2.817	2.290	1.556	12.215	9.408
50 year	236.00	172.48	5.73	4.747	4.224	5-S2n	2.205	2.890	2.375	1.746	12.410	10.020
100 year	273.00	179.01	5.90	4.917	4.402	5-S2n	2.262	2.936	2.431	1.892	12.547	10.470

****

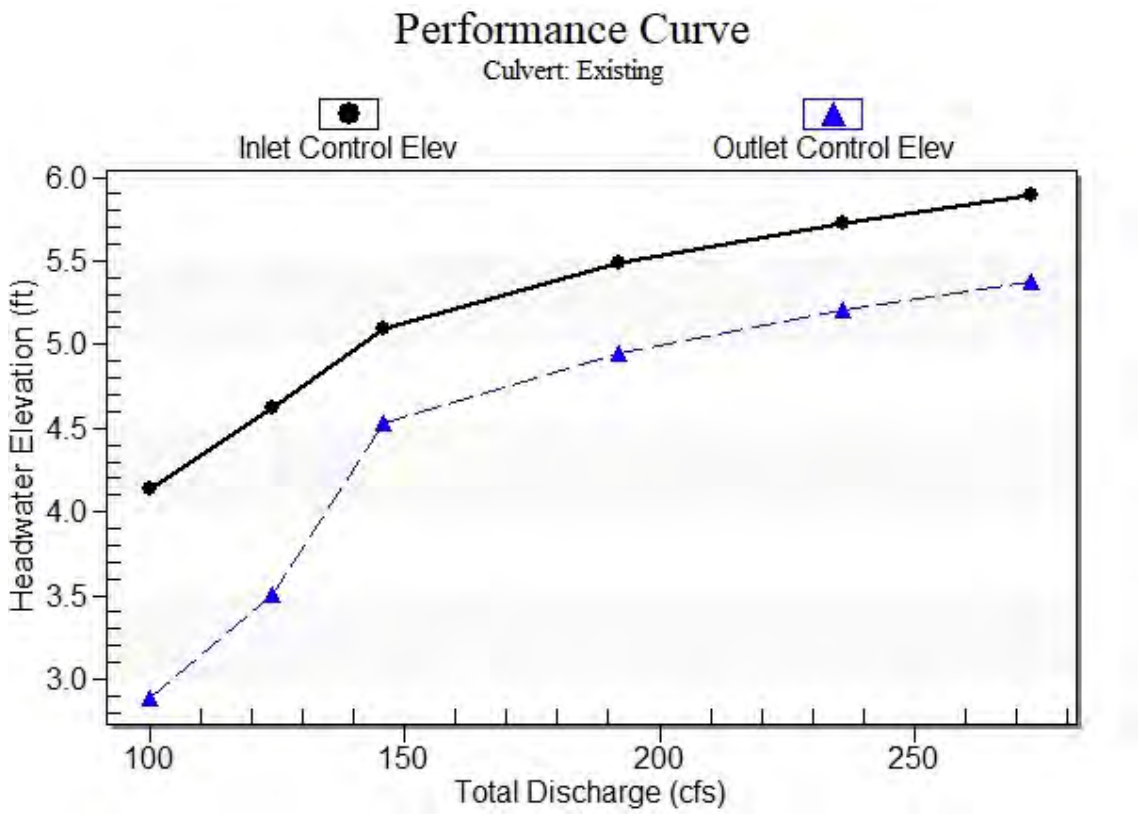
Straight Culvert

Inlet Elevation (invert): 0.98 ft, Outlet Elevation (invert): 0.00 ft

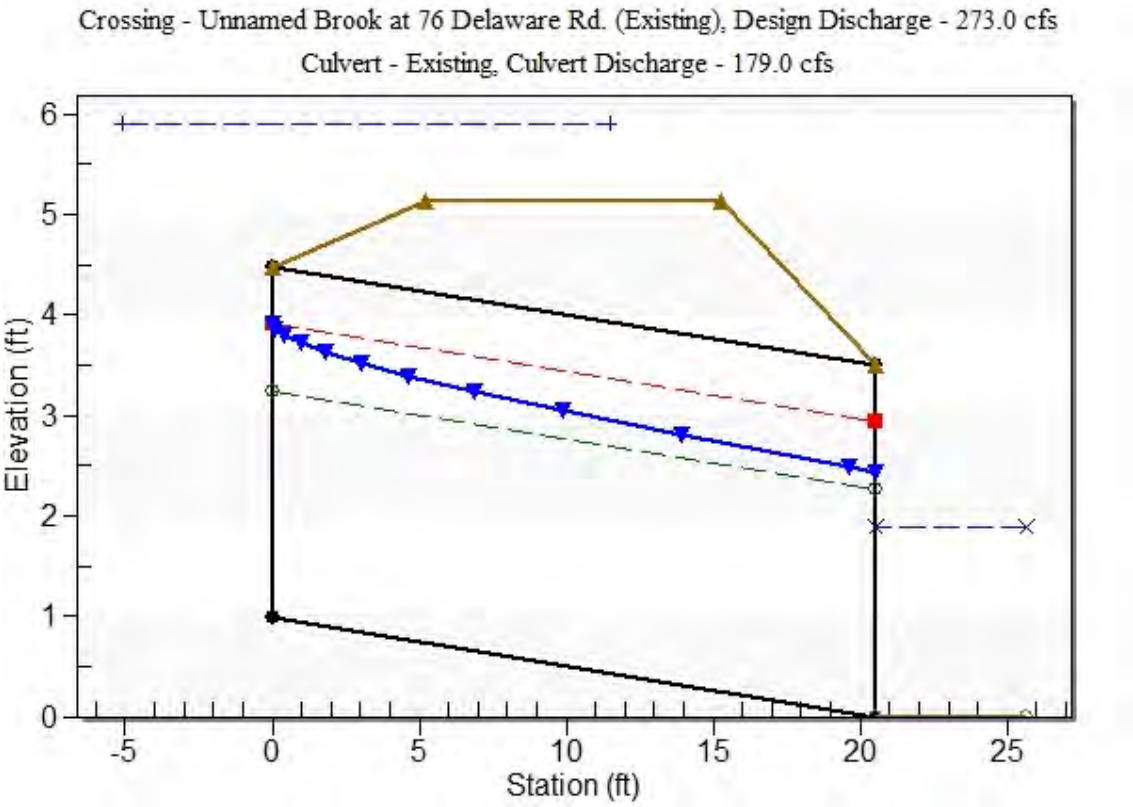
Culvert Length: 20.52 ft, Culvert Slope: 0.0478

****

Culvert Performance Curve Plot: Existing



Water Surface Profile Plot for Culvert: Existing



Site Data - Existing

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 0.98 ft

Outlet Station: 20.50 ft

Outlet Elevation: 0.00 ft

Number of Barrels: 2

Culvert Data Summary - Existing

Barrel Shape: Circular

Barrel Diameter: 3.50 ft

Barrel Material: Corrugated Steel

Embedment: 0.00 in

Barrel Manning's n: 0.0240

Culvert Type: Straight

Inlet Configuration: Beveled Edge (1.5:1)

Inlet Depression: None

Table 3 - Downstream Channel Rating Curve (Crossing: Unnamed Brook at 76 Delaware Rd. (Existing))

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
100.00	1.08	1.08	7.65	5.26	1.41
124.00	1.22	1.22	8.20	5.94	1.43
146.00	1.33	1.33	8.64	6.52	1.45
192.00	1.56	1.56	9.41	7.60	1.48
236.00	1.75	1.75	10.02	8.53	1.50
273.00	1.89	1.89	10.47	9.24	1.51

Tailwater Channel Data - Unnamed Brook at 76 Delaware Rd. (Existing)

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 10.00 ft

Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.0783

Channel Manning's n: 0.0500

Channel Invert Elevation: 0.00 ft

Roadway Data for Crossing: Unnamed Brook at 76 Delaware Rd. (Existing)

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 50.00 ft

Crest Elevation: 5.13 ft

Roadway Surface: Gravel

Roadway Top Width: 10.00 ft

Appendix G – Proposed Hydraulic Calculations

HY-8 Culvert Analysis Report
PROPOSED CONDITIONS

Table 1 - Summary of Culvert Flows at Crossing: Unnamed Brook at 76 Delaware Rd. (Proposed)

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Proposed Discharge (cfs)	Roadway Discharge (cfs)	Iterations
3.93	2 year	100.00	100.00	0.00	1
4.34	5 year	124.00	124.00	0.00	1
4.69	10 year	146.00	146.00	0.00	1
5.46	25 year	192.00	192.00	0.00	1
6.22	50 year	236.00	232.02	3.89	6
6.48	100 year	273.00	244.56	28.38	6
6.13	Overtopping	227.13	227.13	0.00	Overtopping

Rating Curve Plot for Crossing: Unnamed Brook at 76 Delaware Rd. (Proposed)

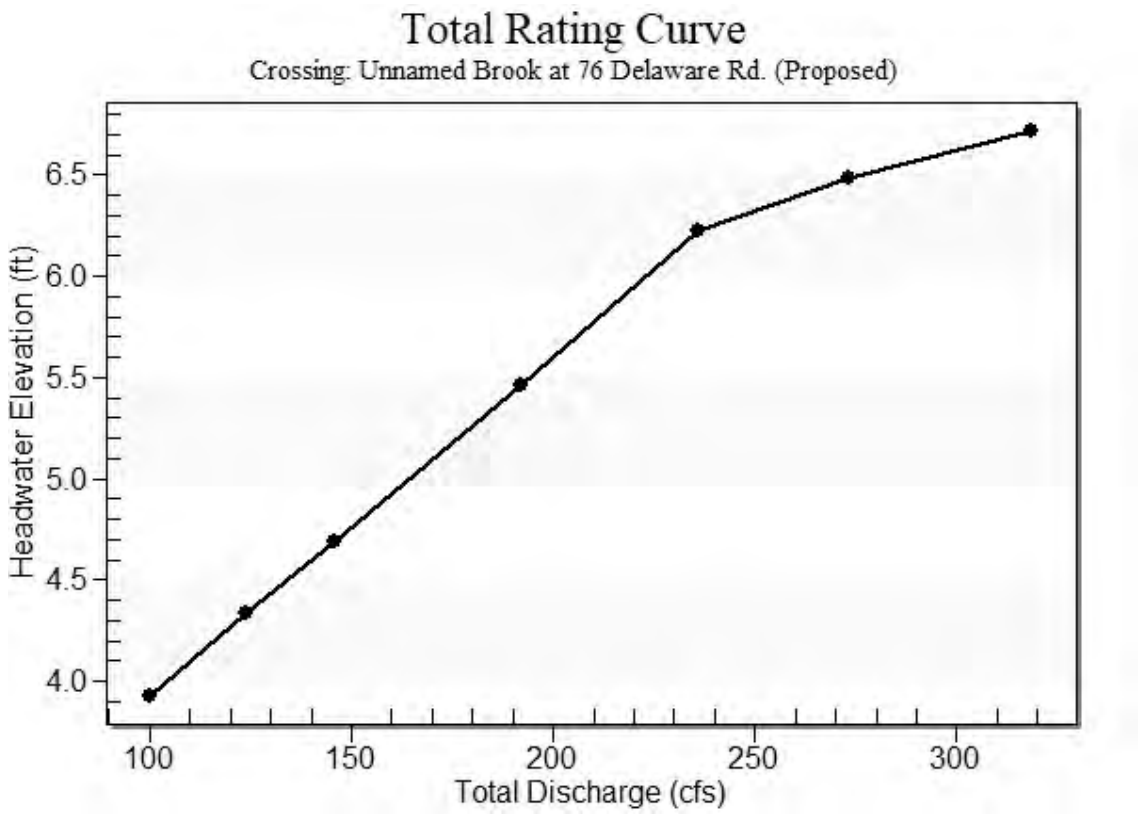


Table 2 - Culvert Summary Table: Proposed

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
2 year	100.00	100.00	3.93	2.953	1.458	1-S2n	1.035	2.121	1.448	1.076	12.188	7.652
5 year	124.00	124.00	4.34	3.358	1.881	1-S2n	1.155	2.374	1.647	1.216	12.705	8.202
10 year	146.00	146.00	4.69	3.713	2.279	1-S2n	1.257	2.584	1.818	1.334	13.143	8.638
25 year	192.00	192.00	5.46	4.484	3.156	5-S2n	1.452	2.970	2.143	1.556	14.005	9.408
50 year	236.00	232.02	6.22	5.244	4.347	5-S2n	1.609	3.249	2.397	1.746	14.756	10.020
100 year	273.00	244.56	6.48	5.504	4.574	5-S2n	1.656	3.325	2.473	1.892	14.994	10.470

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Straight Culvert

Inlet Elevation (invert): 0.98 ft, Outlet Elevation (invert): 0.00 ft

Culvert Length: 20.52 ft, Culvert Slope: 0.0478

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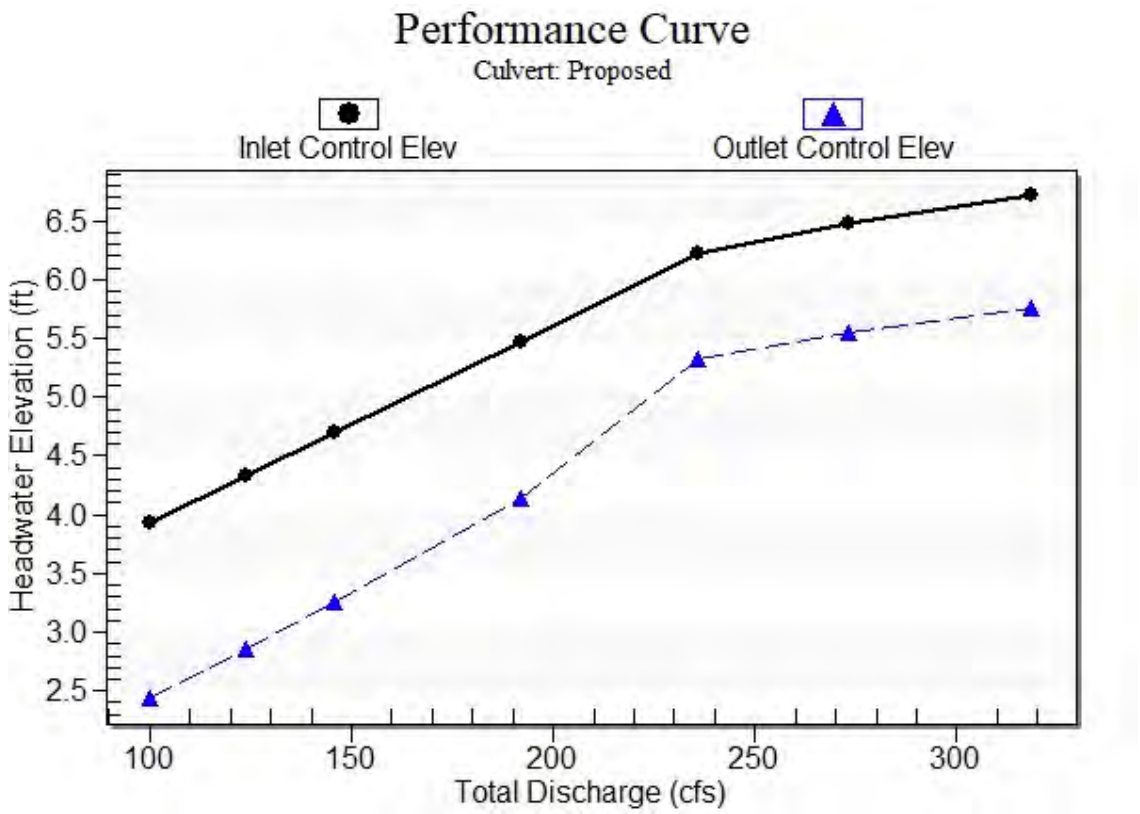
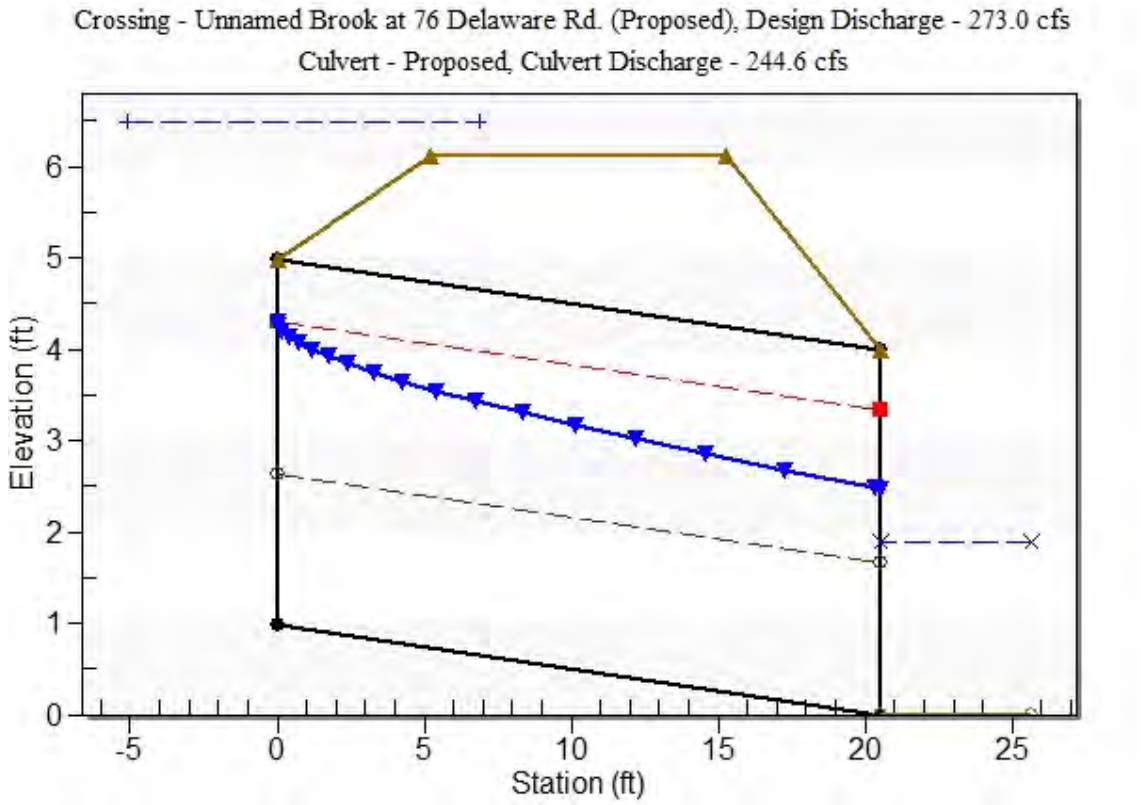
Culvert Performance Curve Plot: Proposed



Water Surface Profile Plot for Culvert: Proposed



Site Data - Proposed

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 0.98 ft

Outlet Station: 20.50 ft

Outlet Elevation: 0.00 ft

Number of Barrels: 2

Culvert Data Summary - Proposed

Barrel Shape: Circular

Barrel Diameter: 4.00 ft

Barrel Material: Smooth HDPE

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Beveled Edge (1.5:1)

Inlet Depression: None

Table 3 - Downstream Channel Rating Curve (Crossing: Unnamed Brook at 76 Delaware Rd. (Proposed))

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
100.00	1.08	1.08	7.65	5.26	1.41
124.00	1.22	1.22	8.20	5.94	1.43
146.00	1.33	1.33	8.64	6.52	1.45
192.00	1.56	1.56	9.41	7.60	1.48
236.00	1.75	1.75	10.02	8.53	1.50
273.00	1.89	1.89	10.47	9.24	1.51

Tailwater Channel Data - Unnamed Brook at 76 Delaware Rd. (Proposed)

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 10.00 ft

Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.0783

Channel Manning's n: 0.0500

Channel Invert Elevation: 0.00 ft

Roadway Data for Crossing: Unnamed Brook at 76 Delaware Rd. (Proposed)

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 50.00 ft

Crest Elevation: 6.13 ft

Roadway Surface: Gravel

Roadway Top Width: 10.00 ft

Appendix H – Site Photos

PHOTO 1 – Looking upstream from driveway turnaround at house

PHOTO 2 – Looking downstream towards the driveway culvert from turnaround at house

PHOTO 3 – Failure of driveway turnaround embankment at brook

PHOTO 4 – Looking upstream from culvert

PHOTO 5 – Looking upstream from culvert

PHOTO 6 – Looking upstream from culvert

PHOTO 7 – Culvert Inlet

PHOTO 8 – Upstream of culvert

PHOTO 9 – Culvert Inlet

PHOTO 10 – Driveway failure at outlet of culvert

PHOTO 11 – Driveway failure at outlet of culvert

PHOTO 12 – Culvert Outlet

PHOTO 13 – Looking downstream from culvert outlet

PHOTO 14 – Culvert Outlet

PHOTO 15 – Culvert end that dislodged at outlet due to scour