CT 11934
Access Road Drainage Report

SBA Bridgewater
Wewaka Brook Road
Bridgewater, CT 06752

CHA Project Number: 15363.1054.30000

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1.0 INTRODUCTION

The project site is located off Wewaka Brook Road in the town of Bridgewater, CT. The site spans two properties. The first parcel is owned by Edward R. and Cynthia S. Bennet. The second parcel is owned by Mary Allen. The subject parcels are bounded by Wewaka Brook Road to the East, and residential parcels to the North, South and West. Site access comes from an existing residential asphalt driveway off Wewaka Brook Road.

The proposed work includes the installation of a fenced gravel compound for a telecommunications tower, construction of a gravel access drive to the tower site (2,215 linear feet), and installation of a stormwater collection system consisting of rock lined drainage swales, and storm drain culverts. Replacement of the existing residential driveway and accompanying existing bridge is also associated with this project but has not been analyzed as part of this report.

This report addresses the design of drainage swales and storm drain culverts to protect the access road from washout, safely convey stormwater flows, and protect outfall locations from erosion. This report does not address the design of groundwater controls or slope stabilization, as site geotechnical information was not available at the time of this report.

Refer to the proposed Certificate Drawings submission, dated 10-27-10, under a separate cover, for specific site details.

2.0 HYDROLOGIC EVALUATION

Existing Watershed Characteristics

The Connecticut United States Geological Survey (USGS) Roxbury Quandrangle Map indicates that the project improvements are located between an existing topographic ridge to the west, and Wewaka Brook Road to the east. Topography is varied between these features and includes small topographic ridges, natural swales, flatlands, and wetlands in the surrounding area. Existing topography contributing to site drainage consists of elevations ranging from 670' above mean sea level (AMSL) along Stuart Road to the north to 482' AMSL at an existing culvert to be replaced. Existing slopes vary from flat to very steep ranging (+/- 25%) (See Figure 1 – USGS Map).

Aerial photography and a site field visit indicate that the existing land use at the site consists primarily of forested area, with the exception of the existing residential asphalt driveway off Wewaka Brook Road and adjacent lawn area (See Figure 2 – Aerial Map).

Project site soil characteristics were determined using the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Web Soil Survey. The site is primarily comprised of soils belonging to Hydrologic Soil Groups (HSG) B and C, with small pockets of HSG D (See Appendix A). A summary of the soil composition is shown in Table 1 on the following page.

Below is a brief description of the hydrologic soil groups present within site drainage areas:

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

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

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

Table 1 - Soil Analysis Summary

Unit Symbol – Unit Name	Hydrologic Soil Group	Percent of Drainage Areas
2 – Ridgebury fine sandy loam	D	2.2
3 – Ridgebury, Leicester, and Whitman soils, extremely stony	D	4.9
34A – Merrimac sandy loam, 0 to 3 percent slopes	B	0.1
50B – Sutton fine sandy loam, 3 to 8 percent slopes	B	1.2
60C – Canton and Charlton soils, 8 to 15 percent slopes	B	0.4
73C – Charlton-Chatfield complex, 3 to 15 percent slopes, very rocky	B	48.7
75C – Hollis-Chatfield-Rock outcrop complex, 3 to 15 percent slopes	D	3.5
75E – Hollis-Chatfield-Rock Outcrop complex, 15 to 45 percent slopes	D	4.6
84B – Paxton and Montauk fine sandy loams, 3 to 8 percent slopes	C	20.9
84C – Paxton and Montauk fine sandy loams, 8 to 15 percent slopes	C	6.4
85B – Paxton and Montauk fine sandy loams, 3 to 8 percent slopes, extremely stony	C	3.1
86D – Paxton and Montauk fine sandy loams, 15 to 35 percent slopes, extremely stony	C	3.9

Design Methodology

In order to design the proposed swales and culverts, peak flows (Q) for the 10-, 25-, and 50-year design storms were calculated using the Rational Method (Q=CIA). Composite runoff coefficients (C) were developed from an analysis of existing land use and typical C-values provided in Tables 6-3 and 6-5 of the Connecticut Department of Transportation (ConnDOT) Drainage Manual, dated October 2000 (See Appendix C). Times of concentration (T_c) were computed using standard NRCS TR-55 Methodology (See Appendix D). Rainfall intensities (I) were determined from Table B-2.1 of the ConnDOT Drainage Manual and the computed T_c values. A frequency factor (C_f) was used to refine the calculated peak flow for the 25- and 50-year design storms as prescribed in Table 6-2 in Section 6.9.5 of the ConnDOT Drainage Manual.

Proposed Condition Hydrology

For the purposes of the proposed condition analysis, eleven (11) drainage areas (DA) were developed to quantify the peak stormwater runoff rates to the proposed swales. Additionally, two separate design points (DP) were generated to quantify the peak stormwater runoff rates to the proposed culvert locations.

Drainage areas were determined through review of the existing topographic survey of the site (See Certificate Drawing submission) and the Connecticut USGS Roxbury Quadrangle Map.

A summary of the results for the proposed condition hydrologic analysis is shown in Table 2 and Table 3 below (See Figures 3A through 3D for site drainage areas).

Table 2 – Hydrologic Analysis Summary (Drainage Areas)

Drainage Area/ Design Point	Area (acres)	Runoff Coefficient (C)	Tc (min)[2]	Rainfall Intensity (I) (in/hr)			Peak Discharge (Q) (cfs)		
				10 year	25 year	50 year	10 year	25 year[1]	50 year[1]
DA 1	67.56	0.27	48	2.20	2.60	2.90	39.9	51.8	63.1
DA 1.1	0.36	0.30	10	4.80	5.50	6.00	0.5	0.6	0.8
DA 1.2	0.17	0.29	13	4.30	5.00	5.40	0.2	0.3	0.3
DA 2	0.22	0.27	17	3.80	4.40	4.90	0.2	0.3	0.4
DA 3	0.38	0.33	11	4.70	5.30	5.80	0.6	0.7	0.9
DA 4	0.40	0.33	10	4.80	5.50	6.00	0.6	0.8	1.0
DA 5	6.09	0.24	24	3.30	3.80	4.20	4.8	6.1	7.3
DA 5.1	0.25	0.40	10	4.80	5.50	6.00	0.5	0.6	0.7
DA 5.2	0.07	0.23	10	4.80	5.50	6.00	0.1	0.1	0.1
DA 6	0.05	0.45	10	4.80	5.50	6.00	0.1	0.1	0.1
DA 7	0.09	0.42	10	4.80	5.50	6.00	0.2	0.2	0.3

[1]Frequency Factor for 25-year recurrence interval is 1.1. Frequency factor for 50-year recurrence interval is 1.2 (Table 6-2 of ConnDOT Drainage Manual)
[2]Per section 6.9.6 of the ConnDOT Drainage Manual, the minimum T_C used for design purposes shall be 10 minutes for grass areas.

Table 3 – Hydrologic Analysis Summary (Design Points)

Drainage Area/ Design Point	Area (acres)	Runoff Coefficient (C)	Tc (min)[4]	Rainfall Intensity (I) (in/hr)			Peak Discharge (Q) (cfs)		
				10 year	25 year	50 year	10 year	25 year[3]	50 year[3]
DP 1[1]	68.09	0.27	48	2.20	2.60	2.90	40.2[5]	52.3[5]	63.6[5]
DP 5[2]	6.41	0.24	24	3.30	3.80	4.20	5.2[5]	6.5[5]	7.9[5]

[1]DP 1 consists of DA 1, DA 1.1 and DA 1.2
[2]DP5 consists of DA 5, DA 5.1 and DA 5.2
[3]Frequency Factor for 25-year recurrence interval is 1.1. Frequency factor for 50-year recurrence interval is 1.2 (Table 6-2 of ConnDOT Drainage Manual)
[4]Per section 6.9.6 of the ConnDOT Drainage Manual, the minimum T_C used for design purposes shall be 10 minutes for grass areas.
[5]Due to variable T_c, the sum of individual subarea peak flow rates may not necessarily equal the overall design point peak flow rate

3.0 HYDRAULIC EVALUATION

3.1 CULVERTS

Basis of Design

In accordance with the design criteria and procedures set forth in Section 8.3 of the ConnDOT Drainage Manual, the Connecticut Department of Environmental Protection Stream Crossing Guidelines and guidelines established by the Army Corps of Engineers, culverts shall be designed to:

- Allow for continuous flow and safe conveyance of the 50-year design storm peak flow.
- Have a HW/D ratio less than 1.5 (The hydraulic performance of a culvert is commonly expressed as a ratio of headwater depth (HW), which equals the depth of water measured from the invert of the culvert, to the culvert diameter (D) as HW/D).
- Have a minimum diameter of 18 inches.
- Have a gradient that is not steeper than the streambed gradient immediately upstream or downstream of the culvert.
- Have inverts that are set to greater than or equal to 12 inches below the elevation of the streambed.
- Be backfilled with natural substrate material matching the upstream and downstream steambed substrate.

Design Methodology

The proposed culverts were analyzed using Haestad Methods CulvertMaster Computer Software (Version 3.1). This program was utilized to compute the headwater elevation and discharge velocity of the culverts (evaluating both inlet and outlet control equations) (See Appendix E).

The pipe flow capacity was calculated using:

- Manning's Equation for velocity (V) using equation 7.6 of the ConnDOT Drainage Manual.
- The Continuity Equation for flow capacity (Q) using equation 7.5 of the ConnDOT Drainage Manual.

See Appendix F for culvert capacity calculations.

Design Summary

The access road design required two (2) culvert locations (one at DP 1, the other at DP 5) for stormwater conveyance (See Figures 4A through 4D for locations). The culvert at DP 1 will be a 3-foot high x 6-foot wide x 42-foot long concrete box culvert set at a slope of approximately 2.4 percent, with an invert set 12 inches below the streambed elevation. The culverts at DP 5 will be 24-inch RCP culverts, 35 feet in length, set at a slope of approximately 8.5% (to match existing channel slope), with inverts set 12 inches below the streambed elevation. Three culverts have been utilized at this location in an attempt to maintain the existing drainage channel width and flow characteristics, and to minimize impact to wetlands. These culverts will be backfilled with free draining material to create a french mattress as recommended by the Wetland Impact Assessment prepared for this project by VHB, Inc., dated 11/11/2011 (See Figure 5 for drainage details).

See Table 4 below for a summary of the results of the culvert analysis

Table 4 – Culvert Analysis

Culvert	Length (ft)	Slope (%)	Size (ft)	Manning's n[1] (unitless)	50-year Peak Design Flow (cfs)	Provided Flow Capacity[2] (cfs)	Computed HW (ft)	HW/D Ratio (ft/ft)
DP 1	42	2.4	3 x 6	0.013	63.6	240.8	1.41	0.71
DP 5	35	7.9	2 (3x)	0.013	7.9	99.0	0.62	0.62

[1]Manning's n referenced from CulvertMaster.
[2]See Appendix E for culvert capacity calculations.

Based on the analysis, a 6 foot x 3 foot box culvert at DP 1will allow for continuous passage of the 50-year frequency design storm, with a calculated HW/D ratio less than 1.5. Additionally, three (3) 24" diameter RCP culverts at DP 5 will safely convey peak flows from the 50-year frequency design storm, with a calculated HW/D ratio less than 1.5.

3.2 SWALES

Basis of Design

In accordance with the design criteria and procedures set forth in Sections 7.3 and 7.6 of the ConnDOT Drainage Manual, roadway swales shall be designed:

- To safely convey the 10-year frequency design storm peak flow without causing erosive damage.
- With a lining that is sufficient to resist the shear forces created from the transportation of storm flows (The permissible or critical shear stress in a swale defines the force required to initiate movement of the channel bed or lining).

Additionally, in accordance with Chapter 5, Section 6, Permanent Lined Waterway, of the 2002 Connecticut Guidelines for Soil Erosion and Sediment Control by The Connecticut Council on Soil and Water Conservation in Cooperation with the Connecticut Department of Environmental Protection (CTDEP), swales shall be designed with a minimum freeboard of 0.25 feet if no out-of-bank damage would be expected.

Design Methodology

Flow capacity of the swales was determined from the following:

- Velocity (V) – Equation 7.6 of the ConnDOT Drainage Manual (Manning's Equation)
- Flow capacity (Q) – Equation 7.5 of the ConnDOT Drainage Manual (The Continuity Equation).

See Appendix H for swale sizing calculations.

Swale lining was determined by the following:

- Average Shear Stress (τ) – Equation 7.11 of the ConnDOT Drainage Manual
- Maximum Shear Stress (τ_d) – Equation 7.12 of the ConnDOT Drainage Manual
- Lining Category (Material) and Type– Table 7-4 of the ConnDOT Drainage Manual

See Appendix I for shear stress calculations.

Design Summary

For ease of construction, one swale type (size) was designed which meets the dimensional requirements at all swale locations. (See Figures 4A through 4D for proposed swale locations and Figure 5 for drainage details). The swale selected is a 1-foot deep, 1-foot wide flat bottom swale with 2:1 side slopes.

See Table 5 on the following page for a summary of the results of the swale analysis.

Table 5 – Swale Hydraulic Analysis

Swale	Slope (ft/ft)	Manning's n[1] (unitless)	Velocity (ft/sec)	10-yr Peak Design Flow (cfs)	Provided Flow Capacity (cfs)	Provided Freeboard @ 10-yr Peak Flow (ft)
DA 1.1	0.20	0.078	2.24	0.51	9.11	0.82
DA 1. 2	0.01	0.088	0.52	0.21	1.65	0.72
DA 2	0.08	0.088	1.14	0.23	4.94	0.84
DA 3	0.17	0.079	2.15	0.59	8.27	0.80
DA 4	0.14	0.080	2.05	0.64	7.30	0.77
DA 5.1	0.16	0.083	1.94	0.49	7.66	0.81
DA 5.2	0.033	0.128	0.50	0.08	2.27	0.85
DA 6	0.10	0.104	0.85	0.10	4.83	0.90
DA 7	0.20	0.104	1.34	0.19	6.83	0.88

[1]Manning's n calculated using steep slope procedures in HEC-15, as prescribed in Section 7.6.9 of the ConnDOT Drainage Manual, as well as, the values listed in Table 7-4 of the ConnDOT Drainage Manual.

To determine the type of swale lining necessary to armor the swales and protect against erosive forces imparted by stormwater flows, shear stresses were calculated. Rock riprap lining was selected to armor the swales in order to withstand the calculated shear stresses. See Table 6 below for a summary of the results of the calculated shear stress and riprap sizing analysis.

Table 6 – Shear Stress and Riprap Sizing Analysis

Swale	Calculated Shear Stress (lb/ft^2)	Required ConnDOT Riprap[1]		
		Permissible Shear Stress[2] (lb/ft^2)	Classification	D_{50} Size (inches)
DA 1.1	2.25	2.68	Intermediate	8
DA 1. 2	0.15	1.68	Modified	5
DA 2	0.75	1.68	Modified	5
DA 3	2.11	2.68	Intermediate	8
DA 4	1.94	2.68	Intermediate	8
DA 5.1	1.90	2.68	Intermediate	8
DA 5.2	0.31	1.68	Modified	5
DA 6	0.62	1.68	Modified	5
DA 7	1.50	1.68	Modified	5

[1]Determined by selecting riprap with a higher permissible shear stress than the calculated shear stress
[2]Permissible shear stress for lining materials is taken from Table 7-4 of the ConnDOT Drainage Manual

Based on the analyses, each of these swales will be capable of safely conveying the 10-year peak storm flows calculated for their respective Drainage Area, provide the required 0.25 feet of freeboard, and withstand calculated shear stresses.

3.3 OUTLET PROTECTION

Basis of Design

In accordance with the design criteria and procedures set forth in Section 11.13.3 of the ConnDOT Drainage Manual, riprap outlet protection shall be designed to reduce the erosive potential at all discharge points.

Design Methodology

The type and dimensions of rip rap protection was determined by the guidelines established in Sections 11.13.2 and 11.13.5 of the ConnDOT Drainage Manual, and the following:

- Length (L_a) – Tables 11-12.1 and 11-13.1 of the ConnDOT Drainage Manual
- Width of apron at pipe outlet (W_1) and width of apron at terminus (W_2) – Equation 11.33 of the ConnDOT Drainage Manual, as well as, Section 11.13.5 of the ConnDOT Drainage Manual.
- Riprap Specification – Table 11.11 of the ConnDOT Drainage Manual

See Appendix J for outlet protection calculations.

Design Summary

Based on recommended design procedures in Section 11.13.2 of the ConnDOT Drainage Manual, a Type A riprap apron shall be used at all of the swale discharge points. The selected riprap apron shall have a length (L_a) of 10 feet, a width of apron at outlet (W_1) of 5 feet, and a width of apron at terminus (W_2) of 10 feet . Type A riprap aprons shall utilize modified riprap for erosion protection. A Type C riprap apron shall be used at both culvert discharge locations. The culvert at DP 1 and culverts at DP 5 shall have a L_a of 24 feet and 12 feet, respectively. The width of the Type C riprap aprons shall match the width of the downstream channel. Type C riprap aprons shall utilize intermediate riprap for erosion protection (See Figure 5 for drainage details).

Table 7 on the following page summarizes the minimum outlet protection requirements.

Table 7 – Outlet Protection Requirements

<table>
<tr><th rowspan="2">Design Point</th><th rowspan="2">Structure</th><th rowspan="2">Diameter or Span (ft)</th><th rowspan="2">Outlet Velocity (ft/sec)</th><th rowspan="2">10-year Peak Discharge (ft^3/sec)</th><th rowspan="2">Outlet Type</th><th colspan="4">Calculated Dimensions[6]</th></tr>
<tr><th>L_a[1] (ft)</th><th>W_1[2] (ft)</th><th>W_2[3] (ft)</th><th>Riprap Specification[4]</th></tr>
<tr><td>DA 1.1</td><td>Swale[5]</td><td>1.00</td><td>2.24</td><td>0.5</td><td rowspan="9">Type A Riprap Apron</td><td>10</td><td>3</td><td>10</td><td>Modified</td></tr>
<tr><td>DA 1.2</td><td>Swale[5]</td><td>1.00</td><td>0.52</td><td>0.2</td><td>10</td><td>3</td><td>10</td><td>Modified</td></tr>
<tr><td>DA 2</td><td>Swale[5]</td><td>1.00</td><td>1.14</td><td>0.2</td><td>10</td><td>3</td><td>10</td><td>Modified</td></tr>
<tr><td>DA 3</td><td>Swale[5]</td><td>1.00</td><td>2.15</td><td>0.6</td><td>10</td><td>3</td><td>10</td><td>Modified</td></tr>
<tr><td>DA 4</td><td>Swale[5]</td><td>1.00</td><td>2.05</td><td>0.6</td><td>10</td><td>3</td><td>10</td><td>Modified</td></tr>
<tr><td>DA 5.1</td><td>Swale[5]</td><td>1.00</td><td>1.94</td><td>0.5</td><td>10</td><td>3</td><td>10</td><td>Modified</td></tr>
<tr><td>DA 5.2</td><td>Swale[5]</td><td>1.00</td><td>0.50</td><td>0.1</td><td>10</td><td>3</td><td>10</td><td>Modified</td></tr>
<tr><td>DA 6</td><td>Swale[5]</td><td>1.00</td><td>0.85</td><td>0.1</td><td>10</td><td>3</td><td>10</td><td>Modified</td></tr>
<tr><td>DA 7</td><td>Swale[5]</td><td>1.00</td><td>1.34</td><td>0.2</td><td>10</td><td>3</td><td>10</td><td>Modified</td></tr>
<tr><td>DP 1</td><td>Culvert</td><td>6.00</td><td>9.92</td><td>40.2</td><td rowspan="2">Type C Riprap Apron</td><td>24</td><td colspan="2" rowspan="2">Match Downstream Channel</td><td>Intermediate</td></tr>
<tr><td>DP 5</td><td>Culverts</td><td>8.00</td><td>7.44</td><td>5.2</td><td>12</td><td>Intermediate</td></tr>
</table>

[1]L_a values determined using Table 11-12.1 and 11-13.1 of the ConnDOT Drainage Manual.
[2]W_1 = width of apron at pipe outlet
[3]W_2 = width of apron at terminus
[4]Riprap specification selected from Table 11.11 of the ConnDOT Drainage Manual
[5]Diameter used for swales is the bottom channel width
[6]Dimensions represent minimum acceptable parameters based on calculations. Actual dimensions selected for use may differ

Based on analysis of proposed outfall locations, discharge velocities meet the ConnDOT requirements for use of riprap aprons (outlet velocities are less than 14 fps). A Type A riprap aprong with dimensions of 10’ (L_a) x 5’ (W_1) x 10’ (W_2) is sufficient to reduce the erosive potential at swale discharge points. Type C riprap aprons with widths matching the downstream channel and an L_a value of 24 feet (DP 1) and 12 feet (DP 5) are sufficient to reduce the erosive potential at the culvert discharge points.

4.0 INSPECTION AND MAINTENANCE

Inspection and maintenance of the stormwater collection system (riprap lined swales, storm drain culverts, and riprap aprons) is critical to maintaining proper function. Normally, a visual inspection of all components should be completed annually and after major storm events. Due to steep gradients which produce high shear stresses in the proposed swales, an increased inspection and maintenance schedule is required. A visual inspection of the swale riprap lining should be completed semi-annually and after major storm events.

The following maintenance tasks should be completed during the inspection process:

- Removal of any organic matter, trash/debris, or obstructions found in swales or riprap aprons
- Removal of any accumulated sediment found in culvert, swales or riprap aprons
- Removal of any potential obstructions at culvert inlet/outlet points
- Replacement of any riprap material that may have washed away during large storm events

Careful inspection and proper maintenance on a regular basis will enable the system to safely convey stormwater flows and reduce the risk of system backup or overflow during major storm events.

5.0 CONCLUSION

All proposed drainage improvements (swales, culverts, outlet protection) have been designed in accordance with the engineering guidelines established in the ConnDOT Drainage Manual, the Connecticut Department of Environmental Protection Stream Crossing Guidelines and guidelines established by the Army Corps of Engineers. Based on the analysis, the following design parameters are recommended:

- The wetland crossing at DP 1 shall be constructed using a 3-foot high x 6-foot wide concrete box culvert, with an invert set 12 inches below the adjacent streambed elevation. The crossing shall be 42 feet in length and set at a slope to match the gradient immediately upstream and downstream of the culvert. The culvert will meet the Army Corps of Engineers requirements of safely conveying the 50-year design storm peak flows.

- The wetland crossing at DP 5 shall be constructed using three (3) 24-inch diameter RCP with inverts set 12-inches below the adjacent streambed elevation. The crossing shall be 35-feet in length and set at a slope to match the gradient immediately upstream and downstream of the culvert. The culvert will meet the Army Corps of Engineers requirements of safely conveying the 50-year design storm peak flows.

- Swales shall be at minimum 1-foot wide flat bottom, 1-foot deep, riprap lined trapezoidal swales with 2:1 side slopes. The designed swales will meet the ConnDOT requirements for conveying the 10-year design storm peak flows while withstanding the calculated shear stresses. They will also meet the DEEP requirement of providing 0.25 feet of freeboard.

- Outlet protection for swales shall be Type A riprap aprons with the following minimum parameters:
  - Length (L_a) – 10 feet
  - Width of apron at pipe outlet (W_1) – 5 feet
  - Width of apron at terminus (W_2) – 10 feet
  - Utilize modified riprap for armoring.

  This will meet the ConnDOT requirements for use of riprap aprons (discharge velocities < 14 fps) to provide erosion protection at outfall locations.

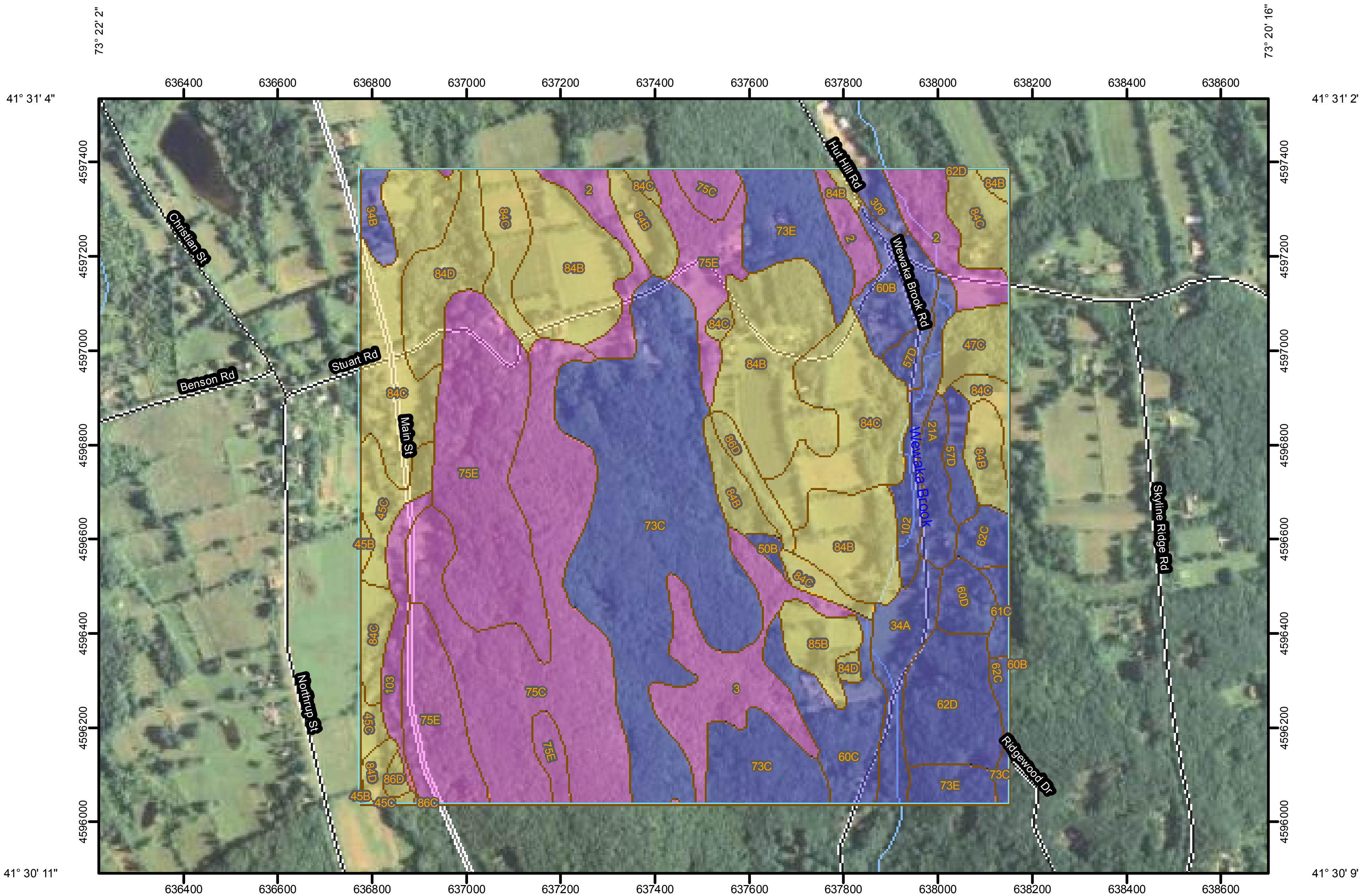
- Outlet protection for culverts shall be Type C riprap aprons with the following minimum parameters:
  - Length (L_a) – 24-feet at Culvert DP 1, 12-feet at Culvert DP 5
  - Width of apron at pipe outlet (W_1) – Match width at outlet
  - Width of apron at terminus (W_2) – Match downstream width
  - Utilize intermediate riprap for armoring.

  This will meet the ConnDOT requirements for use of riprap aprons (discharge velocities < 14fps) to provide erosion protection at outfall locations.

APPENDIX A

NRCS HYDROLOGIC SOIL GROUP MAP

Hydrologic Soil Group—State of Connecticut
(Appendix A)



73° 22' 3"
73° 20' 17"

Map Scale: 1:11,800 if printed on A size (8.5" x 11") sheet.

Meters
0 150 300 600 900

Feet
0 500 1,000 2,000 3,000

N

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Units

Soil Ratings

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Political Features

Cities

Water Features

Streams and Canals

Transportation

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

MAP INFORMATION

Map Scale: 1:11,800 if printed on A size (8.5" × 11") sheet.

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

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

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 18N NAD83

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 10, Mar 31, 2011

Date(s) aerial images were photographed: 8/5/2006

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

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — State of Connecticut (CT600)				
Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
2	Ridgebury fine sandy loam	D	16.8	3.7%
3	Ridgebury, Leicester, and Whitman soils, extremely stony	D	17.8	3.9%
21A	Ninigret and Tisbury soils, 0 to 5 percent slopes	B	5.0	1.1%
34A	Merrimac sandy loam, 0 to 3 percent slopes	B	9.1	2.0%
34B	Merrimac sandy loam, 3 to 8 percent slopes	B	2.7	0.6%
38C	Hinckley gravelly sandy loam, 3 to 15 percent slopes	A	0.1	0.0%
45B	Woodbridge fine sandy loam, 3 to 8 percent slopes	C	0.6	0.1%
45C	Woodbridge fine sandy loam, 8 to 15 percent slopes	C	7.0	1.5%
47C	Woodbridge fine sandy loam, 2 to 15 percent slopes, extremely stony	C	5.3	1.2%
50B	Sutton fine sandy loam, 3 to 8 percent slopes	B	0.9	0.2%
57D	Gloucester gravelly sandy loam, 15 to 25 percent slopes	B	5.4	1.2%
60B	Canton and Charlton soils, 3 to 8 percent slopes	B	8.1	1.8%
60C	Canton and Charlton soils, 8 to 15 percent slopes	B	11.6	2.5%
60D	Canton and Charlton soils, 15 to 25 percent slopes	B	4.0	0.9%
61C	Canton and Charlton soils, 8 to 15 percent slopes, very stony	B	2.0	0.4%
62C	Canton and Charlton soils, 3 to 15 percent slopes, extremely stony	B	4.3	0.9%
62D	Canton and Charlton soils, 15 to 35 percent slopes, extremely stony	B	12.9	2.8%
73C	Charlton-Chatfield complex, 3 to 15 percent slopes, very rocky	B	71.2	15.5%
73E	Charlton-Chatfield complex, 15 to 45 percent slopes, very rocky	B	14.6	3.2%
75C	Hollis-Chatfield-Rock outcrop complex, 3 to 15 percent slopes	D	50.5	11.0%
75E	Hollis-Chatfield-Rock outcrop complex, 15 to 45 percent slopes	D	55.2	12.0%
84B	Paxton and Montauk fine sandy loams, 3 to 8 percent slopes	C	59.2	12.9%

Hydrologic Soil Group— Summary by Map Unit — State of Connecticut (CT600)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
84C	Paxton and Montauk fine sandy loams, 8 to 15 percent slopes	C	57.5	12.5%
84D	Paxton and Montauk fine sandy loams, 15 to 25 percent slopes	C	12.9	2.8%
85B	Paxton and Montauk fine sandy loams, 3 to 8 percent slopes, very stony	C	5.3	1.2%
86C	Paxton and Montauk fine sandy loams, 3 to 15 percent slopes, extremely stony	C	0.1	0.0%
86D	Paxton and Montauk fine sandy loams, 15 to 35 percent slopes, extremely stony	C	3.8	0.8%
102	Pootatuck fine sandy loam	B	7.0	1.5%
103	Rippowam fine sandy loam	D	5.3	1.1%
306	Udorthents-Urban land complex	B	2.2	0.5%
Totals for Area of Interest			**458.3**	**100.0%**

Description

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

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

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

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

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

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

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

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

APPENDIX B

COMPOSITE RUNOFF COEFFICIENT CALCULATIONS

Drainage Area	Area (Acres)														Average C
	HSG A			HSG B			HSG C			HSG D			Gravel	Total	
	F	A	S	F	A	S	F	A	S	F	A	S			
DA 1	0.00	0.00	0.00	0.00	5.36	26.05	0.00	6.13	19.19	0.00	3.79	6.85	0.20	67.56	0.27
DA 1.1	0.00	0.00	0.00	0.00	0.19	0.03	0.00	0.00	0.00	0.00	0.07	0.01	0.05	0.36	0.30
DA 1.2	0.00	0.00	0.00	0.01	0.04	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.17	0.29
DP 1[1]	0.00	0.00	0.00	0.01	5.60	26.17	0.00	6.13	19.19	0.00	3.85	6.86	0.27	68.09	0.27
DA 2	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.05	0.12	0.00	0.00	0.00	0.00	0.22	0.27
DA 3	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.05	0.25	0.00	0.00	0.00	0.03	0.38	0.33
DA 4	0.00	0.00	0.00	0.01	0.04	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.40	0.33
DA 5	0.00	0.00	0.00	0.38	1.14	3.77	0.00	0.00	0.00	0.00	0.33	0.37	0.09	6.09	0.24
DA 5.1	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.06	0.05	0.25	0.40
DA 5.2	0.00	0.00	0.00	0.00	0.01	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.23
DP 5[2]	0.00	0.00	0.00	0.38	1.15	3.97	0.00	0.00	0.00	0.00	0.33	0.44	0.15	6.41	0.24
DA 6	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.05	0.45
DA 7	0.00	0.00	0.00	0.00	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.09	0.42

[1]DP 1 consists of DA 1, DA 1.1 and DA 1.2

[2]DP5 consists of DA 5, DA 5.1 and DA 5.2

Surface Type	Runoff Coefficient (C)[3]		
	Flat (F) 0 - 1%	Average (A) 2 - 6%	Steep (S) > 6%
HSG A	0.09	0.14	0.18
HSG B	0.12	0.17	0.24
HSG C	0.16	0.21	0.31
HSG D	0.2	0.25	0.38
Gravel	0.85		

[3]C-values obtained from Tables 6-3 and 6-5 of the ConnDOT Drainage Manual

APPENDIX C

TIME OF CONCENTRATION CALCULATIONS

CHA, Inc.

Worksheet 3: Time of Concentration (Tc)

Project:	SBA Bridgewater	Job No.	15363-1054	By	JDM	Date	2/23/2012
Location:	Woodbridge, CT			Checked	KDT	Date	

Proposed

Subarea: DA 1

		High	Low	Run	Slope
Sheet	AB	650	635	100	0.150
Shallow	BC	635	482.2	2911	0.052
Channel	CD	0	0	1	0.000

1. Sheet Flow

	Units	Segment ID A-B			
1. Surface Description (Chap. 6, Table C-1)		WOODS			
2. Manning's roughness coeff., 'n' (Chap. 6, Table C-1)		0.400			
3. Flow length, L (total L ≤ 150 ft	ft	100			
4. Two-year 24-hour rainfall, P_2 (Chap. 6, Table B-1)	in	3.2			
5. Land Slope, s	ft/ft	0.150			
6. $T_t = \frac{0.007\,(nL)^{0.8}}{P_2^{0.5}\,s^{0.4}}$	hr	0.160	0.000	0.000	0.160

2. Shallow Concentrated Flow

	Units	Segment ID B-C			
7. Surface description (Paved or Unpaved)		U			
8. Flow length, L	ft	2911			
9. Watercourse slope, s	ft/ft	0.052			
10. Average velocity, V	ft/s	1.235			
11. $T_t = \frac{L}{3600\,V}$	hr	0.655	0.000	0.000	0.655

3. Channel Flow

	Units	Segment ID C-D			
12. Cross sectional flow area, a	ft^2	8.25			
13. Wetted perimeter, p_w	ft	10.5			
14. Hydraulic radius, $r = a/p_w$	ft	0.79			
15. Channel slope, s	ft/ft	0.000			
16. Manning's roughness coefficient, n		0.035			
17. $V = \frac{1.49\,r^{2/3}\,s^{1/2}}{n}$	ft/s	0.000			
18. Flow Length, L	ft	1			
19. $T_t = \frac{L}{3600\,V}$	hr	0.000	0.000	0.000	0.000

20. Total Tc For Watershed or Subarea (Add Steps 6, 11, and 19)

hr = 0.81

min = 48.88

CHA, Inc.

Worksheet 3: Time of Concentration (Tc)

Project:	SBA Bridgewater	Job No.	15363-1054	By	JDM	Date	2/23/2012
Location:	Woodbridge, CT			Checked	KDT	Date	

Proposed

Subarea: DA 1.1

		High	Low	Run	Slope
Sheet	AB	521	518	17	0.176
Shallow	BC	0	0	1	0.000
Channel	CD	518	499.5	347.7	0.053

1. Sheet Flow

	Segment ID	**A-B**			
1. Surface Description (Chap. 6, Table C-1)		WOODS			
2. Manning's roughness coeff., 'n' (Chap. 6, Table C-1)		0.400			
3. Flow length, L (total L $\leq$ 150 ft	ft	17			
4. Two-year 24-hour rainfall, P_2 (Chap. 6, Table B-1)	in	3.2			
5. Land Slope, s	ft/ft	0.176			
6. $T_t = \frac{0.007\,(nL)^{0.8}}{P_2^{0.5}\,s^{0.4}}$	hr	0.036	0.000	0.000	0.036

2. Shallow Concentrated Flow

	Segment ID	**B-C**			
7. Surface description (Paved or Unpaved)		U			
8. Flow length, L	ft	1			
9. Watercourse slope, s	ft/ft	0.000			
10. Average velocity, V	ft/s	0.000			
11. $T_t = \frac{L}{3600\,V}$	hr	0.000	0.000	0.000	0.000

3. Channel Flow

	Segment ID	**C-D**			
12. Cross sectional flow area, a	ft^2	3.00			
13. Wetted perimeter, p_w	ft	5.5			
14. Hydraulic radius, $r = a/p_w$	ft	0.55			
15. Channel slope, s	ft/ft	0.053			
16. Manning's roughness coefficient, n		0.078			
17. $V = \frac{1.49\,r^{2/3}\,s^{1/2}}{n}$	ft/s	2.952			
18. Flow Length, L	ft	348			
19. $T_t = \frac{L}{3600\,V}$	hr	0.033	0.000	0.000	0.033

20. Total Tc For Watershed or Subarea (Add Steps 6, 11, and 19)

hr = 0.07

min = 4.14

CHA, Inc.

Worksheet 3: Time of Concentration (Tc)

Project:	SBA Bridgewater	Job No.	15363-1054	By	JDM	Date	2/23/2012
Location:	Woodbridge, CT			Checked	KDT	Date	
	Proposed			Subarea:	DA 1.2		

		High	Low	Run	Slope
Sheet	AB	540	530.25	100	0.098
Shallow	BC	530.25	527.9	15	0.157
Channel	CD	527.9	526.2	140	0.012

1. Sheet Flow

	Units	Segment ID A-B			
1. Surface Description (Chap. 6, Table C-1)		WOODS			
2. Manning's roughness coeff., 'n' (Chap. 6, Table C-1)		0.400			
3. Flow length, L (total L ≤ 150 ft	ft	100			
4. Two-year 24-hour rainfall, P_2 (Chap. 6, Table B-1)	in	3.2			
5. Land Slope, s	ft/ft	0.098			
6. $T_t = \dfrac{0.007\,(nL)^{0.8}}{P_2^{0.5}\,s^{0.4}}$	hr	0.190	0.000	0.000	0.190

2. Shallow Concentrated Flow

	Units	Segment ID B-C			
7. Surface description (Paved or Unpaved)		U			
8. Flow length, L	ft	15			
9. Watercourse slope, s	ft/ft	0.157			
10. Average velocity, V	ft/s	2.133			
11. $T_t = \dfrac{L}{3600\,V}$	hr	0.002	0.000	0.000	0.002

3. Channel Flow

	Units	Segment ID C-D			
12. Cross sectional flow area, a	ft^2	3.00			
13. Wetted perimeter, p_w	ft	5.5			
14. Hydraulic radius, $r = a/p_w$	ft	0.55			
15. Channel slope, s	ft/ft	0.012			
16. Manning's roughness coefficient, n		0.088			
17. $V = \dfrac{1.49\,r^{2/3}\,s^{1/2}}{n}$	ft/s	1.250			
18. Flow Length, L	ft	140			
19. $T_t = \dfrac{L}{3600\,V}$	hr	0.031	0.000	0.000	0.031

20. Total Tc For Watershed or Subarea (Add Steps 6, 11, and 19)

hr = 0.22

min = 13.38

CHA, Inc.

Worksheet 3: Time of Concentration (Tc)

Project:	SBA Bridgewater	Job No.	15363-1054	By	JDM	Date	2/23/2012
Location:	Woodbridge, CT			Checked	KDT	Date	
	Proposed			Subarea:	DA 2		

		High	Low	Run	Slope
Sheet	AB	502	498.3	100	0.037
Shallow	BC	498.3	489.5	80	0.110
Channel	CD	489.5	484.5	65	0.077

1. Sheet Flow

	Units	Segment ID A-B			
1. Surface Description (Chap. 6, Table C-1)		WOODS			
2. Manning's roughness coeff., 'n' (Chap. 6, Table C-1)		0.400			
3. Flow length, L (total L $\leq$ 150 ft	ft	100			
4. Two-year 24-hour rainfall, P_2 (Chap. 6, Table B-1)	in	3.2			
5. Land Slope, s	ft/ft	0.037			
6. $T_t = \frac{0.007\,(nL)^{0.8}}{P_2^{0.5}\,s^{0.4}}$	hr	0.280	0.000	0.000	0.280

2. Shallow Concentrated Flow

	Units	Segment ID B-C			
7. Surface description (Paved or Unpaved)		U			
8. Flow length, L	ft	80			
9. Watercourse slope, s	ft/ft	0.110			
10. Average velocity, V	ft/s	1.788			
11. $T_t = \frac{L}{3600\,V}$	hr	0.012	0.000	0.000	0.012

3. Channel Flow

	Units	Segment ID C-D			
12. Cross sectional flow area, a	ft^2	3.00			
13. Wetted perimeter, p_w	ft	5.5			
14. Hydraulic radius, $r = a/p_w$	ft	0.55			
15. Channel slope, s	ft/ft	0.077			
16. Manning's roughness coefficient, n		0.088			
17. $V = \frac{1.49\,r^{2/3}\,s^{1/2}}{n}$	ft/s	3.146			
18. Flow Length, L	ft	65			
19. $T_t = \frac{L}{3600\,V}$	hr	0.006	0.000	0.000	0.006

20. Total Tc For Watershed or Subarea (Add Steps 6, 11, and 19)

hr = 0.30

min = 17.88

CHA, Inc.

Worksheet 3: Time of Concentration (Tc)

Project:	SBA Bridgewater	Job No.	15363-1054	By	JDM	Date	2/23/2012
Location:	Woodbridge, CT			Checked	KDT	Date	

Proposed

Subarea: DA 3

		High	Low	Run	Slope
Sheet	AB	510	497.8	88.5	0.138
Shallow	BC	0	0	1	0.000
Channel	CD	497.8	495.5	187.8	0.012

1. Sheet Flow

Segment ID		**A-B**			
1. Surface Description (Chap. 6, Table C-1)		WOODS			
2. Manning's roughness coeff., 'n' (Chap. 6, Table C-1)		0.400			
3. Flow length, L (total L ≤ 150 ft	ft	89			
4. Two-year 24-hour rainfall, P_2 (Chap. 6, Table B-1)	in	3.2			
5. Land Slope, s	ft/ft	0.138			
6. $T_t = \frac{0.007\,(nL)^{0.8}}{P_2^{0.5}\, s^{0.4}}$	hr	0.150	0.000	0.000	0.150

2. Shallow Concentrated Flow

Segment ID		**B-C**			
7. Surface description (Paved or Unpaved)		U			
8. Flow length, L	ft	1			
9. Watercourse slope, s	ft/ft	0.000			
10. Average velocity, V	ft/s	0.000			
11. $T_t = \frac{L}{3600\,V}$	hr	0.000	0.000	0.000	0.000

3. Channel Flow

Segment ID		**C-D**			
12. Cross sectional flow area, a	ft^2	3.00			
13. Wetted perimeter, p_w	ft	5.5			
14. Hydraulic radius, $r = a/p_w$	ft	0.55			
15. Channel slope, s	ft/ft	0.012			
16. Manning's roughness coefficient, n		0.079			
17. $V = \frac{1.49\, r^{2/3}\, s^{1/2}}{n}$	ft/s	1.399			
18. Flow Length, L	ft	188			
19. $T_t = \frac{L}{3600\,V}$	hr	0.037	0.000	0.000	0.037

20. Total Tc For Watershed or Subarea (Add Steps 6, 11, and 19)

hr = 0.19

min = 11.24

CHA, Inc.

Worksheet 3: Time of Concentration (Tc)

Project:	SBA Bridgewater	Job No.	15363-1054	By	JDM	Date	2/23/2012
Location:	Woodbridge, CT			Checked	KDT	Date	

Proposed

Subarea: DA 4

		High	Low	Run	Slope
Sheet	AB	1	0.9	0	0.000
Shallow	BC	0	0	1	0.000
Channel	CD	528	499.5	247	0.115

1. Sheet Flow

	Segment ID	**A-B**			
1. Surface Description (Chap. 6, Table C-1)		WOODS			
2. Manning's roughness coeff., 'n' (Chap. 6, Table C-1)		0.400			
3. Flow length, L (total L ≤ 150 ft	ft	0			
4. Two-year 24-hour rainfall, P_2 (Chap. 6, Table B-1)	in	3.2			
5. Land Slope, s	ft/ft	0.000			
6. $T_t = \frac{0.007\ (nL)^{0.8}}{P_2^{0.5}\ s^{0.4}}$	hr	0.000	0.000	0.000	0.000

2. Shallow Concentrated Flow

	Segment ID	**B-C**			
7. Surface description (Paved or Unpaved)		U			
8. Flow length, L	ft	1			
9. Watercourse slope, s	ft/ft	0.000			
10. Average velocity, V	ft/s	0.000			
11. $T_t = \frac{L}{3600\ V}$	hr	0.000	0.000	0.000	0.000

3. Channel Flow

	Segment ID	**C-D**			
12. Cross sectional flow area, a	ft^2	3.00			
13. Wetted perimeter, p_w	ft	5.5			
14. Hydraulic radius, $r = a/p_w$	ft	0.55			
15. Channel slope, s	ft/ft	0.115			
16. Manning's roughness coefficient, n		0.080			
17. $V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n}$	ft/s	4.239			
18. Flow Length, L	ft	247			
19. $T_t = \frac{L}{3600\ V}$	hr	0.016	0.000	0.000	0.016

20. Total Tc For Watershed or Subarea (Add Steps 6, 11, and 19)

hr =	**0.02**
min =	**0.97**

CHA, Inc.

Worksheet 3: Time of Concentration (Tc)

Project:	SBA Bridgewater	Job No.	15363-1054	By	JDM	Date	2/23/2012
Location:	Woodbridge, CT			Checked	KDT	Date	

Proposed

Subarea: DA 5

		High	Low	Run	Slope
Sheet	AB	641	631	100	0.100
Shallow	BC	631	527	1218	0.085
Channel	CD	0	0	1	0.000

1. Sheet Flow

	Segment ID	**A-B**			
1. Surface Description (Chap. 6, Table C-1)		WOODS			
2. Manning's roughness coeff., 'n' (Chap. 6, Table C-1)		0.400			
3. Flow length, L (total L $\leq$ 150 ft	ft	100			
4. Two-year 24-hour rainfall, P_2 (Chap. 6, Table B-1)	in	3.2			
5. Land Slope, s	ft/ft	0.100			
6. $T_t = \frac{0.007\ (nL)^{0.8}}{P_2^{0.5}\ s^{0.4}}$	hr	0.188	0.000	0.000	0.188

2. Shallow Concentrated Flow

	Segment ID	**B-C**			
7. Surface description (Paved or Unpaved)		U			
8. Flow length, L	ft	1218			
9. Watercourse slope, s	ft/ft	0.085			
10. Average velocity, V	ft/s	1.575			
11. $T_t = \frac{L}{3600\ V}$	hr	0.215	0.000	0.000	0.215

3. Channel Flow

	Segment ID	**C-D**			
12. Cross sectional flow area, a	ft^2	3.00			
13. Wetted perimeter, p_w	ft	5.5			
14. Hydraulic radius, $r = a/p_w$	ft	0.55			
15. Channel slope, s	ft/ft	0.000			
16. Manning's roughness coefficient, n		0.035			
17. $V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n}$	ft/s	0.000			
18. Flow Length, L	ft	1			
19. $T_t = \frac{L}{3600\ V}$	hr	0.000	0.000	0.000	0.000

20. Total Tc For Watershed or Subarea (Add Steps 6, 11, and 19)

hr = 0.40

min = 24.17

CHA, Inc.

Worksheet 3: Time of Concentration (Tc)

Project:	SBA Bridgewater	Job No.	15363-1054	By	JDM	Date	2/23/2012
Location:	Woodbridge, CT			Checked	KDT	Date	
	Proposed			Subarea:	DA 5.1		

		High	Low	Run	Slope
Sheet	AB	582.1	566.67	100	0.154
Shallow	BC	566.67	562	21.5	0.217
Channel	CD	562	531	257	0.121

1. Sheet Flow

	Units				
Segment ID		**A-B**			
1. Surface Description (Chap. 6, Table C-1)		WOODS			
2. Manning's roughness coeff., 'n' (Chap. 6, Table C-1)		0.400			
3. Flow length, L (total L $\leq$ 150 ft	ft	100			
4. Two-year 24-hour rainfall, P_2 (Chap. 6, Table B-1)	in	3.2			
5. Land Slope, s	ft/ft	0.154			
6. $T_t = \dfrac{0.007\,(nL)^{0.8}}{P_2^{0.5}\,s^{0.4}}$	hr	0.158	0.000	0.000	0.158

2. Shallow Concentrated Flow

	Units				
Segment ID		**B-C**			
7. Surface description (Paved or Unpaved)		U			
8. Flow length, L	ft	22			
9. Watercourse slope, s	ft/ft	0.217			
10. Average velocity, V	ft/s	2.512			
11. $T_t = \dfrac{L}{3600\,V}$	hr	0.002	0.000	0.000	0.002

3. Channel Flow

	Units				
Segment ID		**C-D**			
12. Cross sectional flow area, a	ft^2	3.00			
13. Wetted perimeter, p_w	ft	5.5			
14. Hydraulic radius, $r = a/p_w$	ft	0.55			
15. Channel slope, s	ft/ft	0.121			
16. Manning's roughness coefficient, n		0.083			
17. $V = \dfrac{1.49\,r^{2/3}\,s^{1/2}}{n}$	ft/s	4.177			
18. Flow Length, L	ft	257			
19. $T_t = \dfrac{L}{3600\,V}$	hr	0.017	0.000	0.000	0.017

20. Total Tc For Watershed or Subarea (Add Steps 6, 11, and 19)

hr = 0.18

min = 10.65

CHA, Inc.

Worksheet 3: Time of Concentration (Tc)

Project:	SBA Bridgewater	Job No.	15363-1054	By	JDM	Date	2/23/2012
Location:	Woodbridge, CT			Checked	KDT	Date	

Proposed

Subarea: DA 5.2

		High	Low	Run	Slope
Sheet	AB	612	590.2	100	0.218
Shallow	BC	590.2	582.67	30.5	0.247
Channel	CD	582.67	581.5	36	0.032

1. Sheet Flow

	Units				
Segment ID		**A-B**			
1. Surface Description (Chap. 6, Table C-1)		WOODS			
2. Manning's roughness coeff., 'n' (Chap. 6, Table C-1)		0.400			
3. Flow length, L (total L ≤ 150 ft	ft	100			
4. Two-year 24-hour rainfall, P_2 (Chap. 6, Table B-1)	in	3.2			
5. Land Slope, s	ft/ft	0.218			
6. $T_t = \frac{0.007\,(nL)^{0.8}}{P_2^{0.5}\,s^{0.4}}$	hr	0.138	0.000	0.000	0.138

2. Shallow Concentrated Flow

	Units				
Segment ID		**B-C**			
7. Surface description (<u>P</u>aved or <u>U</u>npaved)		U			
8. Flow length, L	ft	31			
9. Watercourse slope, s	ft/ft	0.247			
10. Average velocity, V	ft/s	2.678			
11. $T_t = \frac{L}{3600\,V}$	hr	0.003	0.000	0.000	0.003

3. Channel Flow

	Units				
Segment ID		**C-D**			
12. Cross sectional flow area, a	ft^2	3.00			
13. Wetted perimeter, p_w	ft	5.5			
14. Hydraulic radius, $r = a/p_w$	ft	0.55			
15. Channel slope, s	ft/ft	0.032			
16. Manning's roughness coefficient, n		0.128			
17. $V = \frac{1.49\,r^{2/3}\,s^{1/2}}{n}$	ft/s	1.406			
18. Flow Length, L	ft	36			
19. $T_t = \frac{L}{3600\,V}$	hr	0.007	0.000	0.000	0.007

20. Total Tc For Watershed or Subarea (Add Steps 6, 11, and 19)

hr = 0.15

min = 8.88

CHA, Inc.

Worksheet 3: Time of Concentration (Tc)

Project:	SBA Bridgewater	Job No.	15363-1054	By	JDM	Date	2/23/2012
Location:	Woodbridge, CT			Checked	KDT	Date	
	Proposed			Subarea:	DA 6		

		High	Low	Run	Slope
Sheet	AB	556	547	43.5	0.207
Shallow	BC	0	0	1	0.000
Channel	CD	547	545	20	0.100

1. Sheet Flow

	Segment ID	**A-B**			
1. Surface Description (Chap. 6, Table C-1)		WOODS			
2. Manning's roughness coeff., 'n' (Chap. 6, Table C-1)		0.400			
3. Flow length, L (total L $\leq$ 150 ft	ft	44			
4. Two-year 24-hour rainfall, P_2 (Chap. 6, Table B-1)	in	3.2			
5. Land Slope, s	ft/ft	0.207			
6. $T_t = \dfrac{0.007\ (nL)^{0.8}}{P_2^{0.5}\ s^{0.4}}$	hr	0.072	0.000	0.000	0.072

2. Shallow Concentrated Flow

	Segment ID	**B-C**			
7. Surface description (Paved or Unpaved)		U			
8. Flow length, L	ft	1			
9. Watercourse slope, s	ft/ft	0.000			
10. Average velocity, V	ft/s	0.000			
11. $T_t = \dfrac{L}{3600\ V}$	hr	0.000	0.000	0.000	0.000

3. Channel Flow

	Segment ID	**C-D**			
12. Cross sectional flow area, a	ft^2	3.00			
13. Wetted perimeter, p_w	ft	5.5			
14. Hydraulic radius, $r = a/p_w$	ft	0.55			
15. Channel slope, s	ft/ft	0.100			
16. Manning's roughness coefficient, n		0.104			
17. $V = \dfrac{1.49\ r^{2/3}\ s^{1/2}}{n}$	ft/s	3.036			
18. Flow Length, L	ft	20			
19. $T_t = \dfrac{L}{3600\ V}$	hr	0.002	0.000	0.000	0.002

20. Total Tc For Watershed or Subarea (Add Steps 6, 11, and 19)

hr =	**0.07**
min =	**4.44**

CHA, Inc.

Worksheet 3: Time of Concentration (Tc)

Project:	SBA Bridgewater	Job No.	15363-1054	By	JDM	Date	2/23/2012
Location:	Woodbridge, CT			Checked	KDT	Date	

Proposed

Subarea: DA 7

		High	Low	Run	Slope
Sheet	AB	583	579	67.4	0.059
Shallow	BC	0	0	1	0.000
Channel	CD	579	556	116.905	0.197

1. Sheet Flow

	Unit				
Segment ID		**A-B**			
1. Surface Description (Chap. 6, Table C-1)		WOODS			
2. Manning's roughness coeff., 'n' (Chap. 6, Table C-1)		0.400			
3. Flow length, L (total L ≤ 150 ft	ft	67			
4. Two-year 24-hour rainfall, P_2 (Chap. 6, Table B-1)	in	3.2			
5. Land Slope, s	ft/ft	0.059			
6. $T_t = \frac{0.007\,(nL)^{0.8}}{P_2^{0.5}\,s^{0.4}}$	hr	0.169	0.000	0.000	0.169

2. Shallow Concentrated Flow

	Unit				
Segment ID		**B-C**			
7. Surface description (Paved or Unpaved)		U			
8. Flow length, L	ft	1			
9. Watercourse slope, s	ft/ft	0.000			
10. Average velocity, V	ft/s	0.000			
11. $T_t = \frac{L}{3600\,V}$	hr	0.000	0.000	0.000	0.000

3. Channel Flow

	Unit				
Segment ID		**C-D**			
12. Cross sectional flow area, a	ft^2	3.00			
13. Wetted perimeter, p_w	ft	5.5			
14. Hydraulic radius, $r = a/p_w$	ft	0.55			
15. Channel slope, s	ft/ft	0.197			
16. Manning's roughness coefficient, n		0.104			
17. $V = \frac{1.49\,r^{2/3}\,s^{1/2}}{n}$	ft/s	4.258			
18. Flow Length, L	ft	117			
19. $T_t = \frac{L}{3600\,V}$	hr	0.008	0.000	0.000	0.008

20. Total Tc For Watershed or Subarea (Add Steps 6, 11, and 19)

hr = 0.18

min = 10.59

APPENDIX D

CULVERTMASTER OUTPUT DATA

Culvert Calculator Report
DP-1 (10 yr Design Storm)

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	485.50	ft	Headwater Depth/Height	1.05	
Computed Headwater Eleva	484.09	ft	Discharge	41.00	cfs
Inlet Control HW Elev.	483.91	ft	Tailwater Elevation	0.00	ft
Outlet Control HW Elev.	484.09	ft	Control Type	Entrance Control	

Grades					
Upstream Invert	482.00	ft	Downstream Invert	481.00	ft
Length	42.00	ft	Constructed Slope	0.023810	ft/ft

Hydraulic Profile					
Profile	S2		Depth, Downstream	0.69	ft
Slope Type	Steep		Normal Depth	0.61	ft
Flow Regime	Supercritical		Critical Depth	1.13	ft
Velocity Downstream	9.92	ft/s	Critical Slope	0.003621	ft/ft

Section					
Section Shape	Box		Mannings Coefficient	0.013	
Section Material	Concrete		Span	6.00	ft
Section Size	6 x 2 ft		Rise	2.00	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	484.09	ft	Upstream Velocity Head	0.57	ft
Ke	0.70		Entrance Loss	0.40	ft

Inlet Control Properties					
Inlet Control HW Elev.	483.91	ft	Flow Control	N/A	
Inlet Type	0° wingwall flares		Area Full	12.0	ft²
K	0.06100		HDS 5 Chart	8	
M	0.75000		HDS 5 Scale	3	
C	0.04230		Equation Form	1	
Y	0.82000				

Culvert Calculator Report
DP-1 (50 yr Design Storm)

Solve For: Headwater Elevation

Culvert Summary

Allowable HW Elevation	485.50	ft	Headwater Depth/Height	1.41	
Computed Headwater Eleva	484.82	ft	Discharge	64.00	cfs
Inlet Control HW Elev.	484.74	ft	Tailwater Elevation	0.00	ft
Outlet Control HW Elev.	484.82	ft	Control Type	Entrance Control	

Grades

Upstream Invert	482.00	ft	Downstream Invert	481.00	ft
Length	42.00	ft	Constructed Slope	0.023810	ft/ft

Hydraulic Profile

Profile	S2		Depth, Downstream	0.97	ft
Slope Type	Steep		Normal Depth	0.81	ft
Flow Regime	Supercritical		Critical Depth	1.52	ft
Velocity Downstream	11.05	ft/s	Critical Slope	0.003700	ft/ft

Section

Section Shape	Box		Mannings Coefficient	0.013	
Section Material	Concrete		Span	6.00	ft
Section Size	6 x 2 ft		Rise	2.00	ft
Number Sections	1				

Outlet Control Properties

Outlet Control HW Elev.	484.82	ft	Upstream Velocity Head	0.76	ft
Ke	0.70		Entrance Loss	0.53	ft

Inlet Control Properties

Inlet Control HW Elev.	484.74	ft	Flow Control	N/A	
Inlet Type	0° wingwall flares		Area Full	12.0	ft²
K	0.06100		HDS 5 Chart	8	
M	0.75000		HDS 5 Scale	3	
C	0.04230		Equation Form	1	
Y	0.82000				

Culvert Calculator Report
DP-5 (10 yr Design Storm)

Solve For: Headwater Elevation

Culvert Summary

Allowable HW Elevation	529.00	ft	Headwater Depth/Height	0.46	
Computed Headwater Eleva	527.46	ft	Discharge	5.17	cfs
Inlet Control HW Elev.	527.40	ft	Tailwater Elevation	0.00	ft
Outlet Control HW Elev.	527.46	ft	Control Type	Entrance Control	

Grades

Upstream Invert	527.00	ft	Downstream Invert	524.00	ft
Length	35.00	ft	Constructed Slope	0.085714	ft/ft

Hydraulic Profile

Profile	S2		Depth, Downstream	0.12	ft
Slope Type	Steep		Normal Depth	0.12	ft
Flow Regime	Supercritical		Critical Depth	0.29	ft
Velocity Downstream	7.44	ft/s	Critical Slope	0.005433	ft/ft

Section

Section Shape	Arch		Mannings Coefficient	0.013	
Section Material	Concrete		Span	2.00	ft
Section Size	24 x 12 inch		Rise	1.00	ft
Number Sections	3				

Outlet Control Properties

Outlet Control HW Elev.	527.46	ft	Upstream Velocity Head	0.15	ft
Ke	0.20		Entrance Loss	0.03	ft

Inlet Control Properties

Inlet Control HW Elev.	527.40	ft	Flow Control	Unsubmerged	
Inlet Type	Groove end projecting (arch)		Area Full	4.7	ft²
K	0.00450		HDS 5 Chart	0	
M	2.00000		HDS 5 Scale	0	
C	0.03170		Equation Form	1	
Y	0.69000				

Culvert Calculator Report
DP-5 (50 yr Design Storm)

Solve For: Headwater Elevation

Culvert Summary

Allowable HW Elevation	529.00	ft	Headwater Depth/Height	0.62	
Computed Headwater Eleva	527.62	ft	Discharge	7.90	cfs
Inlet Control HW Elev.	527.55	ft	Tailwater Elevation	0.00	ft
Outlet Control HW Elev.	527.62	ft	Control Type	Entrance Control	

Grades

Upstream Invert	527.00	ft	Downstream Invert	524.00	ft
Length	35.00	ft	Constructed Slope	0.085714	ft/ft

Hydraulic Profile

Profile	S2		Depth, Downstream	0.15	ft
Slope Type	Steep		Normal Depth	0.15	ft
Flow Regime	Supercritical		Critical Depth	0.38	ft
Velocity Downstream	8.71	ft/s	Critical Slope	0.005670	ft/ft

Section

Section Shape	Arch		Mannings Coefficient	0.013	
Section Material	Concrete		Span	2.00	ft
Section Size	24 x 12 inch		Rise	1.00	ft
Number Sections	3				

Outlet Control Properties

Outlet Control HW Elev.	527.62	ft	Upstream Velocity Head	0.20	ft
Ke	0.20		Entrance Loss	0.04	ft

Inlet Control Properties

Inlet Control HW Elev.	527.55	ft	Flow Control	N/A	
Inlet Type	Groove end projecting (arch)		Area Full	4.7	ft²
K	0.00450		HDS 5 Chart	0	
M	2.00000		HDS 5 Scale	0	
C	0.03170		Equation Form	1	
Y	0.69000				

APPENDIX E

CULVERT CAPACITY CALCULATIONS

CULVERT CAPACITY
By CHA Inc.

JOB DATA

Project:	SBA Bridgewater
Calc. by:	JDM
Date:	2/20/12
Pipe at:	DP 1

EQUATIONS:

Manning's Equation, $V = (1.49/n)R^{2/3}S^{1/2}$
$Q = VA$
Froude Number = $V/(gd)^{1/2}$

INPUT:

Width (L) =	6.00	ft	3' x 6' Concrete Box Culvert
Depth of flow (d) =	2.00	ft	
Manning's n =	0.013		from CulvertMaster Software
Slope of pipe (s) =	0.0240	ft/ft	

OUTPUT:

Angle (a) =	2.46	radians						
Wet Perimeter (P) =	10.00	ft						
Area of Flow (A) =	12.00	sq. ft.						
Hydr. Radius (R) =	1.20	ft						
Velocity of Flow (V) =	20.06	fps						
Flow Capacity (Q) =	240.76	cfs	=	155,595,330	gpd	=	**108052.3**	gpm
Froude Number (F) =	2.50	>1, supercritical flow						

<u>CULVERT CAPACITY</u>
By CHA Inc.

JOB DATA

Project:	SBA Bridgewater
Calc. by:	JDM
Date:	2/20/12
Pipe at:	DP 5

EQUATIONS:

Manning's Equation, $V = (1.49/n)R^{2/3}S^{1/2}$
$Q = VA$
Froude Number $= V/(gd)^{1/2}$

INPUT:

Diameter (D) =	2.00	ft	(3) 24" culverts
Depth of flow (d) =	1.00	ft	
Manning's n =	0.013		from CulvertMaster Software
Slope of pipe (s) =	0.0850	ft/ft	

OUTPUT:

Angle (a) =	3.14	radians						
Wet Perimeter (P) =	3.14	ft						
Area of Flow (A) =	1.57	sq. ft.						
Hydr. Radius (R) =	0.50	ft						
Velocity of Flow (V) =	21.00	fps						
Flow Capacity (Q)* =	98.97	cfs	=	63,961,517	gpd	=	**44417.7**	gpm
Froude Number (F) =	3.70	>1, supercritical flow						

*Flow capacity multiplied by 3 to account for multiple culvert barrels.

APPENDIX F

MANNINGS N CALCULATIONS

DA 1.1		
Inputs		
Flow Depth (d_a)	0.18	ft
Rip Rap D_{50}	0.666667	ft
Swale Bottom Width (B)	1	
Swale Side Slope (Z)	2	
Froude Number (FR)	0.930484	
Outputs		
Swale Top Width (T)	1.72	ft
b	0.256	
f(CG)	0.562	
f(REG)	4.484	
f(FR)	1.009	
d_a/D_{50}	0.27	>0.3
Manning's n	**0.078**	

DA 1.2		
Inputs		
Flow Depth (d_a)	0.28	ft
Rip Rap D_{50}	0.416667	ft
Swale Bottom Width (B)	1	
Swale Side Slope (Z)	2	
Froude Number (FR)	0.16	
Outputs		
Swale Top Width (T)	2.12	ft
b	0.395	
f(CG)	0.450	
f(REG)	9.429	
f(FR)	0.546	
d_a/D_{50}	0.671999	>0.3
Manning's n	**0.092**	

DA 2		
Inputs		
Flow Depth (d_a)	0.16	ft
Rip Rap D_{50}	0.416667	ft
Swale Bottom Width (B)	1	
Swale Side Slope (Z)	2	
Froude Number (FR)	0.50	
Outputs		
Swale Top Width (T)	1.64	ft
b	0.281	
f(CG)	0.520	
f(REG)	5.716	
f(FR)	0.743	
d_a/D_{50}	0.384	>0.3
Manning's n	**0.088**	

DA 3		
Inputs		
Flow Depth (d_a)	0.2	ft
Rip Rap D_{50}	0.6667	ft
Swale Bottom Width (B)	1	
Swale Side Slope (Z)	2	
Froude Number (FR)	0.85	
Outputs		
Swale Top Width (T)	1.8	ft
b	0.273	
f(CG)	0.549	
f(REG)	4.901	
f(FR)	0.941	
d_a/D_{50}	0.299985	>0.3
Manning's n	**0.079**	

DA 4		
Inputs		
Flow Depth (d_a)	0.23	ft
Rip Rap D_{50}	0.6667	ft
Swale Bottom Width (B)	1	
Swale Side Slope (Z)	2	
Froude Number (FR)	0.75	
Outputs		
Swale Top Width (T)	1.92	ft
b	0.297	
f(CG)	0.533	
f(REG)	5.517	
f(FR)	0.870	
d_a/D_{50}	0.344983	>0.3
Manning's n	**0.080**	

DA 5.1		
Inputs		
Flow Depth (d_a)	0.19	ft
Rip Rap D_{50}	0.6667	ft
Swale Bottom Width (B)	1	
Swale Side Slope (Z)	2	
Froude Number (FR)	0.78	
Outputs		
Swale Top Width (T)	1.76	ft
b	0.264	
f(CG)	0.555	
f(REG)	4.693	
f(FR)	0.919	
d_a/D_{50}	0.284986	>0.3
Manning's n	**0.083**	

DA 5.2		
Inputs		
Flow Depth (d_a)	0.15	ft
Rip Rap D_{50}	0.41667	ft
Swale Bottom Width (B)	1	
Swale Side Slope (Z)	2	
Froude Number (FR)	0.23	
Outputs		
Swale Top Width (T)	1.6	ft
b	0.270	
f(CG)	0.528	
f(REG)	5.397	
f(FR)	0.526	
d_a/D_{50}	0.359997	>0.3
Manning's n	**0.128**	

DA 6		
Inputs		
Flow Depth (d_a)	0.1	ft
Rip Rap D_{50}	0.416667	ft
Swale Bottom Width (B)	1	
Swale Side Slope (Z)	2	
Froude Number (FR)	0.48	
Outputs		
Swale Top Width (T)	1.4	ft
b	0.206	
f(CG)	0.581	
f(REG)	3.766	
f(FR)	0.782	
d_a/D_{50}	0.24	>0.3
Manning's n	**0.105**	

*d_a/D_{50} < 0.3. Refer to Table 7-2 of the ConnDOT Drainage Manual for n-value.

DA 7		
Inputs		
Flow Depth (d_a)	0.12	ft
Rip Rap D_{50}	0.416667	ft
Swale Bottom Width (B)	1	
Swale Side Slope (Z)	2	
Froude Number (FR)	0.68	
Outputs		
Swale Top Width (T)	1.48	ft
b	0.233	
f(CG)	0.557	
f(REG)	4.427	
f(FR)	0.903	
d_a/D_{50}	0.288	>0.3
Manning's n	**0.083**	*

*d_a/D_{50} < 0.3. Refer to Table 7-2 of the ConnDOT Drainage Manual for n-value.

APPENDIX G

SWALE SIZING CALCULATIONS

TRAPAZOIDAL RIPRAP SWALE CAPACITY
CHA, Inc.

PROJECT DATA:

Project:	18301-1015
Calc. by:	JDM
Date:	February 2012
Swale ID:	DA 1.1

EQUATIONS:

Manning's Equation, $V = (1.49/n)R^{2/3}S^{1/2}$
Froude number, $F = V/(gd)^{1/2}$
$Q = VA$
$d75 = 12(118QS_b^{13/6}R/P)^{2/5}$

INPUT:

Base width (b) =	1.0	ft	
Sideslope (z) =	2	on 1	
Depth of flow (d) =	0.75	ft	
Swale Depth=	1.00	ft	
Manning's n =	0.078		Rip-Rap
Slope of ditch (s) =	0.2000	ft/ft	

OUTPUT:

Wet Perimeter (P) =	4.35	ft
Area of Flow (A) =	1.88	sq. ft.
Hydr. Radius (R) =	0.43	ft
Freeboard =	0.25	ft
Velocity of Flow (V) =	4.86	fps
Flow Capacity (Q) =	9.11	cfs
Froude number, F =	0.99	<1, subcritical flow

NOTE: Verify Mannings n - See Appendix F for Calculation

TRAPAZOIDAL RIPRAP SWALE CAPACITY
CHA, Inc.

PROJECT DATA:

Project:	18301-1015
Calc. by:	JDM
Date:	February 2012
Swale ID:	DA 1.2

EQUATIONS:

Manning's Equation, $V = (1.49/n)R^{2/3}S^{1/2}$

Froude number, $F = V/(gd)^{1/2}$

$Q = VA$

$d75 = 12(118QS_b^{13/6}R/P)^{2/5}$

INPUT:

Base width (b) =	1.0	ft	
Sideslope (z) =	2	on 1	
Depth of flow (d) =	0.75	ft	
Swale Depth=	1.00	ft	
Manning's n =	0.088		Rip-Rap
Slope of ditch (s) =	0.0083	ft/ft	

OUTPUT:

Wet Perimeter (P) =	4.35	ft
Area of Flow (A) =	1.88	sq. ft.
Hydr. Radius (R) =	0.43	ft
Freeboard =	0.25	ft
Velocity of Flow (V) =	0.88	fps
Flow Capacity (Q) =	1.65	cfs
Froude number, F =	0.18	<1, subcritical flow

NOTE: Verify Mannings n - See Appendix F for Calculation

TRAPAZOIDAL RIPRAP SWALE CAPACITY
CHA, Inc.

PROJECT DATA:

Project:	18301-1015
Calc. by:	JDM
Date:	February 2012
Swale ID:	DA 2

EQUATIONS:

Manning's Equation, $V = (1.49/n)R^{2/3}S^{1/2}$

Froude number, $F = V/(gd)^{1/2}$

$Q = VA$

$d75 = 12(118QS_b^{13/6}R/P)^{2/5}$

INPUT:

Base width (b) =	1.0	ft	
Sideslope (z) =	2	on 1	
Depth of flow (d) =	0.75	ft	
Swale Depth=	1.00	ft	
Manning's n =	0.088		Rip-Rap
Slope of ditch (s) =	0.0750	ft/ft	

OUTPUT:

Wet Perimeter (P) =	4.35	ft
Area of Flow (A) =	1.88	sq. ft.
Hydr. Radius (R) =	0.43	ft
Freeboard =	0.25	ft
Velocity of Flow (V) =	2.64	fps
Flow Capacity (Q) =	4.94	cfs
Froude number, F =	0.54	<1, subcritical flow

NOTE: Verify Mannings n - See Appendix F for Calculation

TRAPAZOIDAL RIPRAP SWALE CAPACITY
CHA, Inc.

PROJECT DATA:

Project:	18301-1015
Calc. by:	JDM
Date:	February 2012
Swale ID:	DA 3

EQUATIONS:

Manning's Equation, $V = (1.49/n)R^{2/3}S^{1/2}$

Froude number, $F = V/(gd)^{1/2}$

$Q = VA$

$d75 = 12(118QS_b^{13/6}R/P)^{2/5}$

INPUT:

Base width (b) =	1.0	ft	
Sideslope (z) =	2	on 1	
Depth of flow (d) =	0.75	ft	
Swale Depth=	1.00	ft	
Manning's n =	0.079		Rip-Rap
Slope of ditch (s) =	0.1690	ft/ft	

OUTPUT:

Wet Perimeter (P) =	4.35	ft
Area of Flow (A) =	1.88	sq. ft.
Hydr. Radius (R) =	0.43	ft
Freeboard =	0.25	ft
Velocity of Flow (V) =	4.41	fps
Flow Capacity (Q) =	8.27	cfs
Froude number, F =	0.90	<1, subcritical flow

NOTE: Verify Mannings n - See Appendix F for Calculation

TRAPAZOIDAL RIPRAP SWALE CAPACITY
CHA, Inc.

PROJECT DATA:

Project:	18301-1015
Calc. by:	JDM
Date:	February 2012
Swale ID:	DA 4

EQUATIONS:

Manning's Equation, $V = (1.49/n)R^{2/3}S^{1/2}$
Froude number, $F = V/(gd)^{1/2}$
$Q = VA$
$d75 = 12(118QS_b^{13/6}R/P)^{2/5}$

INPUT:

Base width (b) =	1.0	ft	
Sideslope (z) =	2	on 1	
Depth of flow (d) =	0.75	ft	
Swale Depth=	1.00	ft	
Manning's n =	0.080		Rip-Rap
Slope of ditch (s) =	0.1350	ft/ft	

OUTPUT:

Wet Perimeter (P) =	4.35	ft
Area of Flow (A) =	1.88	sq. ft.
Hydr. Radius (R) =	0.43	ft
Freeboard =	0.25	ft
Velocity of Flow (V) =	3.89	fps
Flow Capacity (Q) =	7.30	cfs
Froude number, F =	0.79	<1, subcritical flow

NOTE: Verify Mannings n - See Appendix F for Calculation

TRAPAZOIDAL RIPRAP SWALE CAPACITY
CHA, Inc.

PROJECT DATA:

Project:	18301-1015
Calc. by:	JDM
Date:	February 2012
Swale ID:	DA 5.1

EQUATIONS:

Manning's Equation, $V = (1.49/n)R^{2/3}S^{1/2}$
Froude number, $F = V/(gd)^{1/2}$
$Q = VA$
$d75 = 12(118QS_b^{13/6}R/P)^{2/5}$

INPUT:

Base width (b) =	1.0	ft	
Sideslope (z) =	2	on 1	
Depth of flow (d) =	0.75	ft	
Swale Depth=	1.00	ft	
Manning's n =	0.083		Rip-Rap
Slope of ditch (s) =	0.1600	ft/ft	

OUTPUT:

Wet Perimeter (P) =	4.35	ft
Area of Flow (A) =	1.88	sq. ft.
Hydr. Radius (R) =	0.43	ft
Freeboard =	0.25	ft
Velocity of Flow (V) =	4.08	fps
Flow Capacity (Q) =	7.66	cfs
Froude number, F =	0.83	<1, subcritical flow

NOTE: Verify Mannings n - See Appendix F for Calculation

TRAPAZOIDAL RIPRAP SWALE CAPACITY
CHA, Inc.

PROJECT DATA:

Project:	18301-1015
Calc. by:	JDM
Date:	February 2012
Swale ID:	DA 5.2

EQUATIONS:

Manning's Equation, $V = (1.49/n)R^{2/3}S^{1/2}$
Froude number, $F = V/(gd)^{1/2}$
$Q = VA$
$d75 = 12(118QS_b^{13/6}R/P)^{2/5}$

INPUT:

Base width (b) =	1.0	ft	
Sideslope (z) =	2	on 1	
Depth of flow (d) =	0.75	ft	
Swale Depth=	1.00	ft	
Manning's n =	0.128		Rip-Rap
Slope of ditch (s) =	0.0333	ft/ft	

OUTPUT:

Wet Perimeter (P) =	4.35	ft
Area of Flow (A) =	1.88	sq. ft.
Hydr. Radius (R) =	0.43	ft
Freeboard =	0.25	ft
Velocity of Flow (V) =	1.21	fps
Flow Capacity (Q) =	2.27	cfs
Froude number, F =	0.25	<1, subcritical flow

NOTE: Verify Mannings n - See Appendix F for Calculation

TRAPAZOIDAL RIPRAP SWALE CAPACITY
CHA, Inc.

PROJECT DATA:

Project:	18301-1015
Calc. by:	JDM
Date:	February 2012
Swale ID:	DA 6

EQUATIONS:

Manning's Equation, $V = (1.49/n)R^{2/3}S^{1/2}$

Froude number, $F = V/(gd)^{1/2}$

$Q = VA$

$d75 = 12(118QS_b^{13/6}R/P)^{2/5}$

INPUT:

Base width (b) =	1.0	ft	
Sideslope (z) =	2	on 1	
Depth of flow (d) =	0.75	ft	
Swale Depth=	1.00	ft	
Manning's n =	0.104		Rip-Rap
Slope of ditch (s) =	0.1000	ft/ft	

OUTPUT:

Wet Perimeter (P) =	4.35	ft
Area of Flow (A) =	1.88	sq. ft.
Hydr. Radius (R) =	0.43	ft
Freeboard =	0.25	ft
Velocity of Flow (V) =	2.58	fps
Flow Capacity (Q) =	4.83	cfs
Froude number, F =	0.52	<1, subcritical flow

NOTE: Verify Mannings n - See Appendix F for Calculation

TRAPAZOIDAL RIPRAP SWALE CAPACITY
CHA, Inc.

PROJECT DATA:

Project:	18301-1015
Calc. by:	JDM
Date:	February 2012
Swale ID:	DA 7

EQUATIONS:

Manning's Equation, $V = (1.49/n)R^{2/3}S^{1/2}$

Froude number, $F = V/(gd)^{1/2}$

$Q = VA$

$d75 = 12(118QS_b^{13/6}R/P)^{2/5}$

INPUT:

Base width (b) =	1.0	ft	
Sideslope (z) =	2	on 1	
Depth of flow (d) =	0.75	ft	
Swale Depth=	1.00	ft	
Manning's n =	0.104		Rip-Rap
Slope of ditch (s) =	0.2000	ft/ft	

OUTPUT:

Wet Perimeter (P) =	4.35	ft
Area of Flow (A) =	1.88	sq. ft.
Hydr. Radius (R) =	0.43	ft
Freeboard =	0.25	ft
Velocity of Flow (V) =	3.64	fps
Flow Capacity (Q) =	6.83	cfs
Froude number, F =	0.74	<1, subcritical flow

NOTE: Verify Mannings n - See Appendix F for Calculation

TRAPAZOIDAL RIPRAP SWALE SIZING
CHA, Inc.

PROJECT DATA:

Project:	18301-1015
Calc. by:	JDM
Date:	February 2012
Swale ID:	DA 1.1

EQUATIONS:

Manning's Equation, $V = (1.49/n)R^{2/3}S^{1/2}$
Froude number, $F = V/(gd)^{1/2}$
$Q = VA$
$d75 = 12(118QS_b^{13/6}R/P)^{2/5}$

INPUT:

Base width (b) =	1.0	ft	
Sideslope (z) =	2	on 1	
Depth of flow (d) =	0.18	ft	
Swale Depth=	1.00	ft	
Manning's n =	0.078		Rip-Rap
Slope of ditch (s) =	0.2000	ft/ft	

OUTPUT:

Wet Perimeter (P) =	1.80	ft
Area of Flow (A) =	0.24	sq. ft.
Hydr. Radius (R) =	0.14	ft
Freeboard =	0.82	ft
Velocity of Flow (V) =	2.24	fps
Flow Capacity (Q) =	0.55	cfs
Froude number, F =	0.93	<1, subcritical flow

NOTE: Verify Mannings n - See Appendix E for Calculation

<u>TRAPAZOIDAL RIPRAP SWALE SIZING</u>
CHA, Inc.

PROJECT DATA:

Project:	18301-1015
Calc. by:	JDM
Date:	February 2012
Swale ID:	DA 1.2

EQUATIONS:

Manning's Equation, $V = (1.49/n)R^{2/3}S^{1/2}$

Froude number, $F = V/(gd)^{1/2}$

$Q = VA$

$d75 = 12(118QS_b^{13/6}R/P)^{2/5}$

INPUT:

Base width (b) =	1.0	ft	
Sideslope (z) =	2	on 1	
Depth of flow (d) =	0.28	ft	
Swale Depth=	1.00	ft	
Manning's n =	0.092		Rip-Rap
Slope of ditch (s) =	0.0083	ft/ft	

OUTPUT:

Wet Perimeter (P) =	2.25	ft
Area of Flow (A) =	0.44	sq. ft.
Hydr. Radius (R) =	0.19	ft
Freeboard =	0.72	ft
Velocity of Flow (V) =	0.49	fps
Flow Capacity (Q) =	0.22	cfs
Froude number, F =	0.16	<1, subcritical flow

NOTE: Verify Mannings n - See Appendix E for Calculation

TRAPAZOIDAL RIPRAP SWALE SIZING
CHA, Inc.

PROJECT DATA:

Project:	18301-1015
Calc. by:	JDM
Date:	February 2012
Swale ID:	DA 2

EQUATIONS:

Manning's Equation, $V = (1.49/n)R^{2/3}S^{1/2}$
Froude number, $F = V/(gd)^{1/2}$
$Q = VA$
$d75 = 12(118QS_b^{13/6}R/P)^{2/5}$

INPUT:

Base width (b) =	1.0	ft	
Sideslope (z) =	2	on 1	
Depth of flow (d) =	0.16	ft	
Swale Depth=	1.00	ft	
Manning's n =	0.088		Rip-Rap
Slope of ditch (s) =	0.0750	ft/ft	

OUTPUT:

Wet Perimeter (P) =	1.72	ft
Area of Flow (A) =	0.21	sq. ft.
Hydr. Radius (R) =	0.12	ft
Freeboard =	0.84	ft
Velocity of Flow (V) =	1.14	fps
Flow Capacity (Q) =	0.24	cfs
Froude number, F =	0.50	<1, subcritical flow

NOTE: Verify Mannings n - See Appendix E for Calculation

TRAPAZOIDAL RIPRAP SWALE SIZING
CHA, Inc.

PROJECT DATA:

Project:	18301-1015
Calc. by:	JDM
Date:	February 2012
Swale ID:	DA 3

EQUATIONS:

Manning's Equation, $V = (1.49/n)R^{2/3}S^{1/2}$
Froude number, $F = V/(gd)^{1/2}$
$Q = VA$
$d75 = 12(118QS_b{}^{13/6}R/P)^{2/5}$

INPUT:

Base width (b) =	1.0	ft	
Sideslope (z) =	2	on 1	
Depth of flow (d) =	0.20	ft	
Swale Depth=	1.00	ft	
Manning's n =	0.079		Rip-Rap
Slope of ditch (s) =	0.1690	ft/ft	

OUTPUT:

Wet Perimeter (P) =	1.89	ft
Area of Flow (A) =	0.28	sq. ft.
Hydr. Radius (R) =	0.15	ft
Freeboard =	0.80	ft
Velocity of Flow (V) =	2.15	fps
Flow Capacity (Q) =	0.60	cfs
Froude number, F =	0.85	<1, subcritical flow

NOTE: Verify Mannings n - See Appendix E for Calculation

TRAPAZOIDAL RIPRAP SWALE SIZING
CHA, Inc.

PROJECT DATA:

Project:	18301-1015
Calc. by:	JDM
Date:	February 2012
Swale ID:	DA 4

EQUATIONS:

Manning's Equation, $V = (1.49/n)R^{2/3}S^{1/2}$
Froude number, $F = V/(gd)^{1/2}$
$Q = VA$
$d75 = 12(118QS_b^{13/6}R/P)^{2/5}$

INPUT:

Base width (b) =	1.0	ft	
Sideslope (z) =	2	on 1	
Depth of flow (d) =	0.23	ft	
Swale Depth=	1.00	ft	
Manning's n =	0.080		Rip-Rap
Slope of ditch (s) =	0.1350	ft/ft	

OUTPUT:

Wet Perimeter (P) =	2.03	ft	
Area of Flow (A) =	0.34	sq. ft.	
Hydr. Radius (R) =	0.17	ft	
Freeboard =	0.77	ft	
Velocity of Flow (V) =	2.05	fps	
Flow Capacity (Q) =	0.69	cfs	0.64
Froude number, F =	0.75	<1, subcritical flow	

NOTE: Verify Mannings n - See Appendix E for Calculation

<u>TRAPAZOIDAL RIPRAP SWALE SIZING</u>
CHA, Inc.

PROJECT DATA:

Project:	18301-1015
Calc. by:	JDM
Date:	February 2012
Swale ID:	DA 5.1

EQUATIONS:

Manning's Equation, $V = (1.49/n)R^{2/3}S^{1/2}$
Froude number, $F = V/(gd)^{1/2}$
$Q = VA$
$d75 = 12(118QS_b^{13/6}R/P)^{2/5}$

INPUT:

Base width (b) =	1.0	ft	
Sideslope (z) =	2	on 1	
Depth of flow (d) =	0.19	ft	
Swale Depth=	1.00	ft	
Manning's n =	0.083		Rip-Rap
Slope of ditch (s) =	0.1600	ft/ft	

OUTPUT:

Wet Perimeter (P) =	1.85	ft	
Area of Flow (A) =	0.26	sq. ft.	
Hydr. Radius (R) =	0.14	ft	
Freeboard =	0.81	ft	
Velocity of Flow (V) =	1.94	fps	
Flow Capacity (Q) =	0.51	cfs	0.49
Froude number, F =	0.78	<1, subcritical flow	

NOTE: Verify Mannings n - See Appendix E for Calculation

TRAPAZOIDAL RIPRAP SWALE SIZING
CHA, Inc.

PROJECT DATA:

Project:	18301-1015
Calc. by:	JDM
Date:	February 2012
Swale ID:	DA 5.2

EQUATIONS:

Manning's Equation, $V = (1.49/n)R^{2/3}S^{1/2}$
Froude number, $F = V/(gd)^{1/2}$
$Q = VA$
$d75 = 12(118QS_b^{13/6}R/P)^{2/5}$

INPUT:

Base width (b) =	1.0	ft	
Sideslope (z) =	2	on 1	
Depth of flow (d) =	0.15	ft	
Swale Depth=	1.00	ft	
Manning's n =	0.128		Rip-Rap
Slope of ditch (s) =	0.0333	ft/ft	

OUTPUT:

Wet Perimeter (P) =	1.67	ft
Area of Flow (A) =	0.20	sq. ft.
Hydr. Radius (R) =	0.12	ft
Freeboard =	0.85	ft
Velocity of Flow (V) =	0.50	fps
Flow Capacity (Q) =	0.10	cfs
Froude number, F =	0.23	<1, subcritical flow

NOTE: Verify Mannings n - See Appendix E for Calculation

TRAPAZOIDAL RIPRAP SWALE SIZING
CHA, Inc.

PROJECT DATA:

Project:	18301-1015
Calc. by:	JDM
Date:	February 2012
Swale ID:	DA 6

EQUATIONS:

Manning's Equation, $V = (1.49/n)R^{2/3}S^{1/2}$
Froude number, $F = V/(gd)^{1/2}$
$Q = VA$
$d75 = 12(118QS_b^{13/6}R/P)^{2/5}$

INPUT:

Base width (b) =	1.0	ft	
Sideslope (z) =	2	on 1	
Depth of flow (d) =	0.10	ft	
Swale Depth=	1.00	ft	
Manning's n =	0.104		Rip-Rap
Slope of ditch (s) =	0.1000	ft/ft	

OUTPUT:

Wet Perimeter (P) =	1.45	ft
Area of Flow (A) =	0.12	sq. ft.
Hydr. Radius (R) =	0.08	ft
Freeboard =	0.90	ft
Velocity of Flow (V) =	0.85	fps
Flow Capacity (Q) =	0.10	cfs
Froude number, F =	0.48	<1, subcritical flow

NOTE: Verify Mannings n - See Appendix E for Calculation

<u>TRAPAZOIDAL RIPRAP SWALE SIZING</u>
CHA, Inc.

PROJECT DATA:

Project:	18301-1015
Calc. by:	JDM
Date:	February 2012
Swale ID:	DA 7

EQUATIONS:

Manning's Equation, $V = (1.49/n)R^{2/3}S^{1/2}$
Froude number, $F = V/(gd)^{1/2}$
$Q = VA$
$d75 = 12(118QS_b^{13/6}R/P)^{2/5}$

INPUT:

Base width (b) =	1.0	ft	
Sideslope (z) =	2	on 1	
Depth of flow (d) =	0.12	ft	
Swale Depth=	1.00	ft	
Manning's n =	0.104		Rip-Rap
Slope of ditch (s) =	0.2000	ft/ft	

OUTPUT:

Wet Perimeter (P) =	1.54	ft
Area of Flow (A) =	0.15	sq. ft.
Hydr. Radius (R) =	0.10	ft
Freeboard =	0.88	ft
Velocity of Flow (V) =	1.34	fps
Flow Capacity (Q) =	0.20	cfs
Froude number, F =	0.68	<1, subcritical flow

NOTE: Verify Mannings n - See Appendix E for Calculation

APPENDIX H

SHEAR STRESS CALCULATIONS

Swale	Slope (ft/ft)	Hydraulic Radius (ft)	Max Flow Depth[1] (ft)	Average Shear Stress (lb/ft^2)	Max. Shear Stress (lb/ft^2)	Design Shear Stress[2] (lb/ft^2)	Selected ConnDOT Riprap		
							Permissible Shear Stress (lb/ft^2)	Classification	D_{50} Size (inches)
DA 1.1	0.20	0.14	0.18	1.69	2.25	2.25	2.68	Intermediate	8
DA 1.2	0.01	0.19	0.28	0.10	0.15	0.15	1.68	Modified	5
DA 2	0.08	0.12	0.16	0.58	0.75	0.75	1.68	Modified	5
DA 3	0.17	0.15	0.20	1.56	2.11	2.11	2.68	Intermediate	8
DA 4	0.14	0.17	0.23	1.39	1.94	1.94	2.68	Intermediate	8
DA 5.1	0.16	0.14	0.19	1.42	1.90	1.90	2.68	Intermediate	8
DA 5.2	0.03	0.12	0.15	0.24	0.31	0.31	1.68	Modified	5
DA 6	0.10	0.08	0.10	0.52	0.62	0.62	1.68	Modified	5
DA 7	0.20	0.10	0.12	1.21	1.50	1.50	1.68	Modified	5

[1]Max flow depth based on 10-year design storm

[2]Shear stress used to design swale armoring. Largest value among the average and maximum shear stresses.

Unit Weight of Water=	62.4	lb/ft^3

APPENDIX I

OUTLET PROTECTION CALCULATIONS

Design Point	Discharging Structure	Diameter or Span (ft)	Outlet Velocity (ft/sec)	10-year Peak Discharge (ft^3/sec)	Outlet Structure Type	Calculated Dimensions[6]			
						L_a[1] (ft)	W_1[2] (ft)	W_2[3] (ft)	Riprap Specification[4]
DA 1.1	Swale[5]	1	2.24	0.51	Type A Riprap Apron	10	3	10	Modified
DA 1.2	Swale[5]	1	0.49	0.21		10	3	10	Modified
DA 2	Swale[5]	1	1.14	0.23		10	3	10	Modified
DA 3	Swale[5]	1	2.15	0.59		10	3	10	Modified
DA 4	Swale[5]	1	2.05	0.64		10	3	10	Modified
DA 5.1	Swale[5]	1	1.94	0.49		10	3	10	Modified
DA 5.2	Swale[5]	1	0.50	0.08		10	3	10	Modified
DA 6	Swale[5]	1	0.85	0.10		10	3	10	Modified
DA 7	Swale[5]	1	1.34	0.19		10	3	10	Modified
DP 1	Culvert	6	9.92	40.20	Type C Riprap Apron	24	Match Downstream Channel		Intermediate
DP 5	Culverts	8	7.44	5.17		12			Intermediate

[1]L_a values determined using Table 11-12.1 and 11-13.1 of the ConnDOT Drainage Manual.

[2]W_1 = width of apron at pipe outlet

[3]W_2 = width of apron at terminus

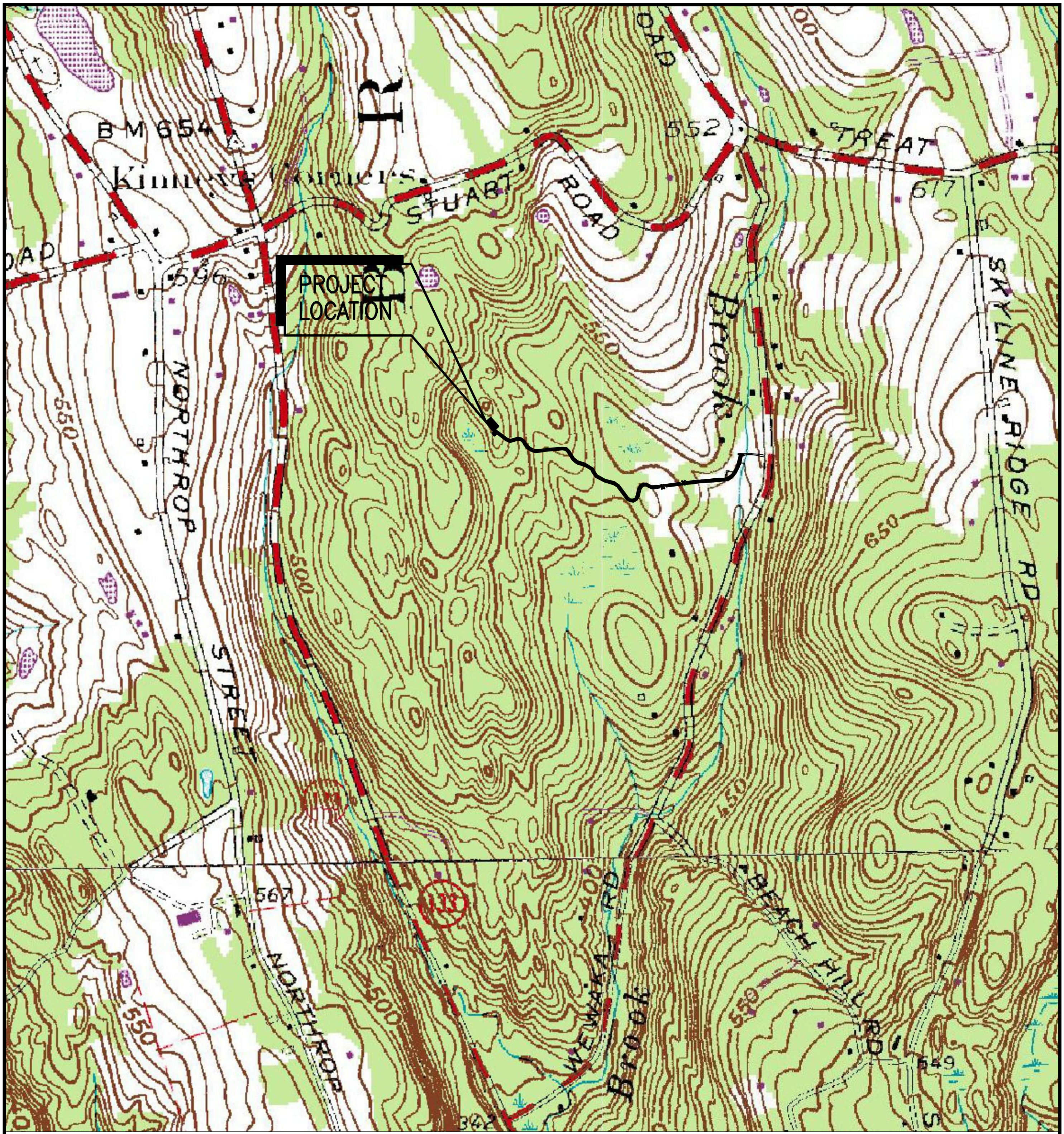
[4]Riprap specification selected from Table 11.11 of the ConnDOT Drainage Manual

[5]Diameter used for swales is the bottom channel width

[6]Dimensions represent minimum acceptable parameters based on calculations. Actual dimensions selected for use may differ.

FIGURE 1

USGS MAP



1 1992 USGS TOPO MAP: ROXBURY 41073-E3
SCALE: 1" = 1,000'
0 500 1000
SCALE IN FEET

TRUE NORTH

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CT 11934
BRIDGEWATER
WEWAKA BROOK ROAD
BRIDGEWATER, CT 06752
LITCHFIELD COUNTY
CHA PROJ. NO. - 15363-1054-30000

SHEET TITLE:
FIGURE 1

DATE:
02/03/12

REVISION: 0

DATE: 1/31/2012 1:28 PM FILE: I:\15363\SITES\1054 BRIDGEWATER 4 BENNETT\DRAINAGE\FIGURES\FIGURE 1_USGS_MAP.DWG

FIGURE 2

AERIAL MAP

1 **2004 AERIAL PHOTO**
SCALE: 1" = 1000'

0 500 1000
SCALE IN FEET

TRUE NORTH

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BRIDGEWATER
WEWAKA BROOK ROAD
BRIDGEWATER, CT 06752
LITCHFIELD COUNTY
CHA PROJ. NO. – 15363-1054-43000

SHEET TITLE:
FIGURE 2

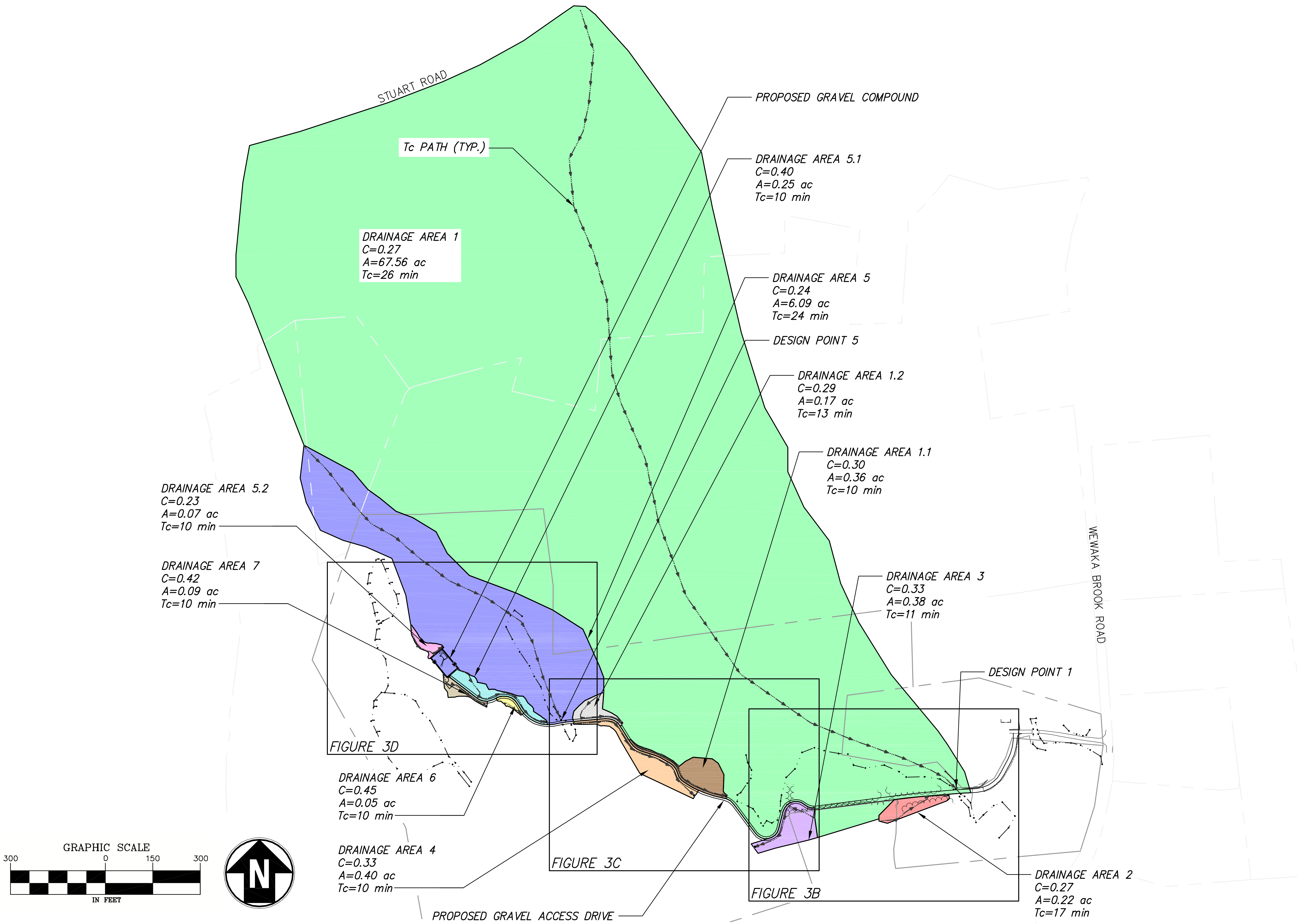
DATE:
02/03/12

REVISION: 0

DATE: 1/27/2012 1:03 PM FILE: I:\15363\SITES\1054 BRIDGEWATER 4 BENNETT\DRAINAGE\FIGURES\FIGURE 2_AERIAL_MAPS.DWG

FIGURES 3A-3D

DRAINAGE AREAS



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A&E PROJECT #:	15363-1054-43000
DRAWN BY:	JDM
CHECKED BY:	KDT

REVISIONS

NO.	DATE	DESCRIPTION
1	02/28/12	DRAINAGE REPORT FIGURE

PROJECT No.
15363–1054–43000

SITE NAME:
BRIDGEWATER

SITE NUMBER:
CT 11934

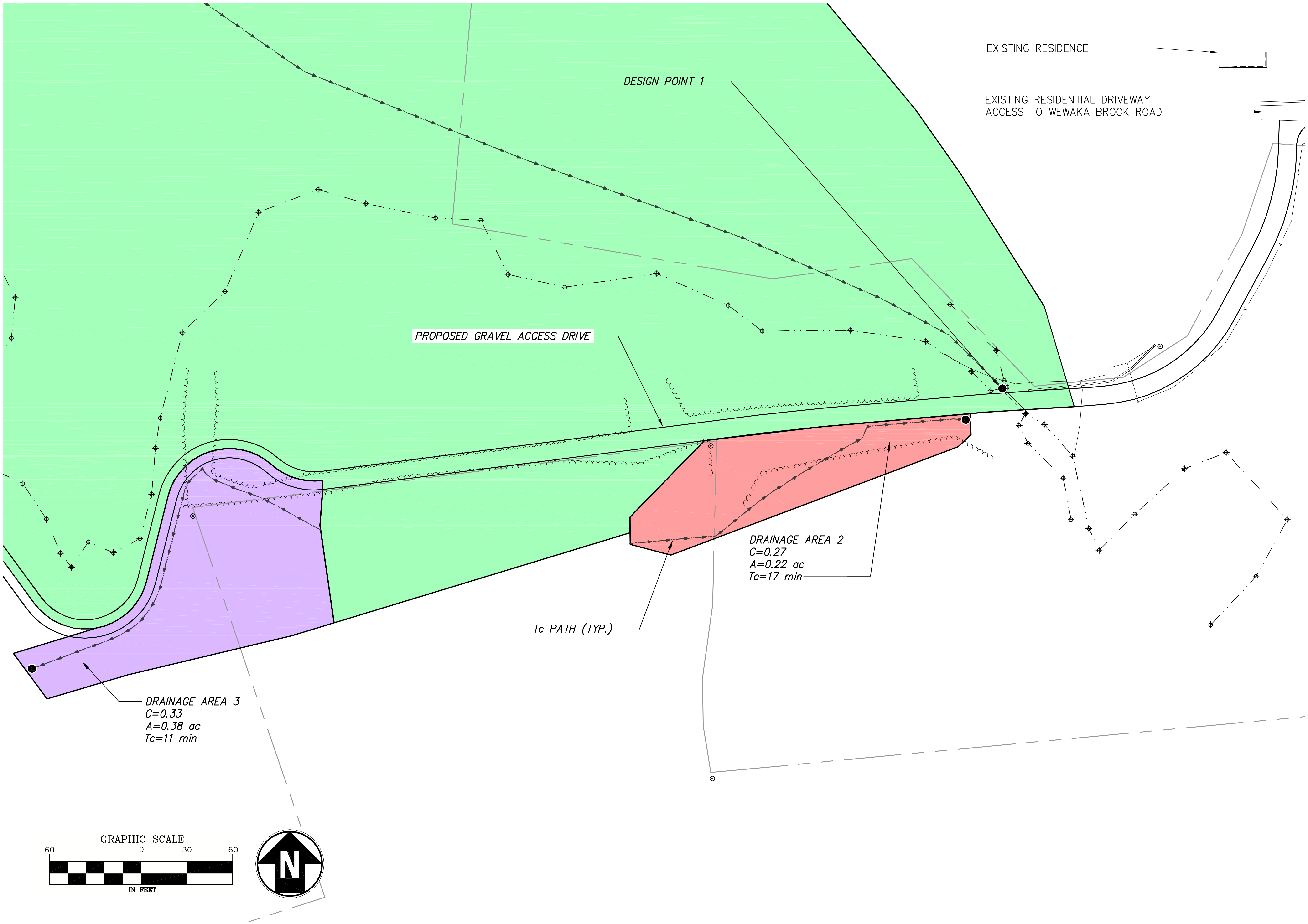
SITE ADDRESS:
WEWAKA BROOK ROAD
BRIDGEWATER, CT 06752

DESIGN TYPE:
RAW LAND

SHEET TITLE:
OVERALL DRAINAGE AREAS

DRAWING NO.
FIGURE 3A

REVISION:
0



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A&E PROJECT #:	15363-1054-43000
DRAWN BY:	JDM
CHECKED BY:	KDT

REVISIONS

NO.	DATE	DESCRIPTION
1	02/28/12	DRAINAGE REPORT FIGURE

PROJECT No.
15363-1054-43000

SITE NAME:
BRIDGEWATER

SITE NUMBER:
CT 11934

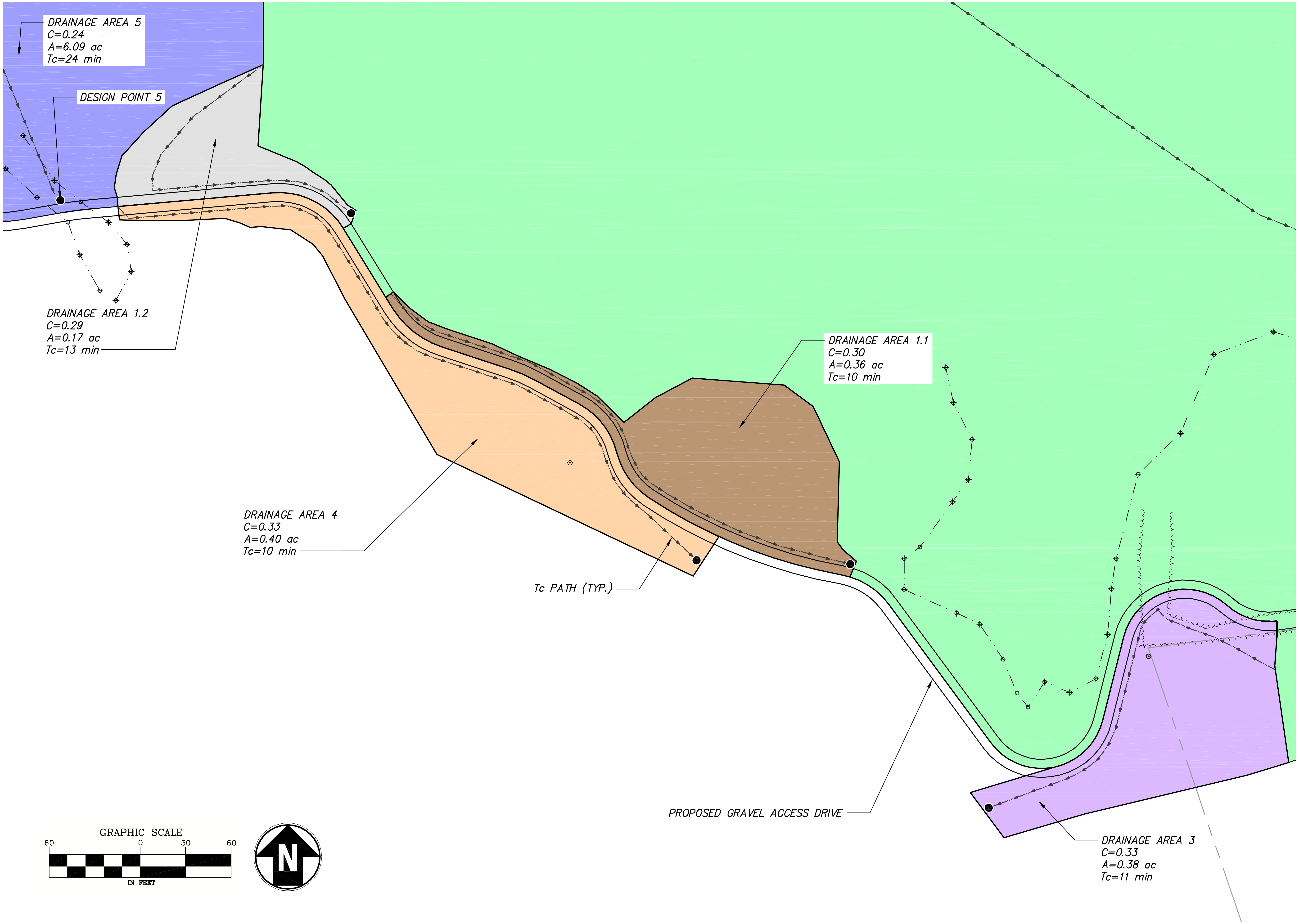
SITE ADDRESS:
WEWAKA BROOK ROAD
BRIDGEWATER, CT 06752

DESIGN TYPE:
RAW LAND

SHEET TITLE:
DRAINAGE AREAS

DRAWING NO.
FIGURE 3B

REVISION:
0



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2139 Silas Deane Highway, Suite 212 · Rocky Hill, CT 06067-2336
Main: (860) 257-4557 · www.chacompanies.com

A&E PROJECT #:	15363-1054-43000
DRAWN BY:	JDM
CHECKED BY:	KDT

REVISIONS

NO.	DATE	DESCRIPTION
1	02/28/12	DRAINAGE REPORT FIGURE

PROJECT No.
15363-1054-43000

SITE NAME:
BRIDGEWATER

SITE NUMBER:
CT 11934

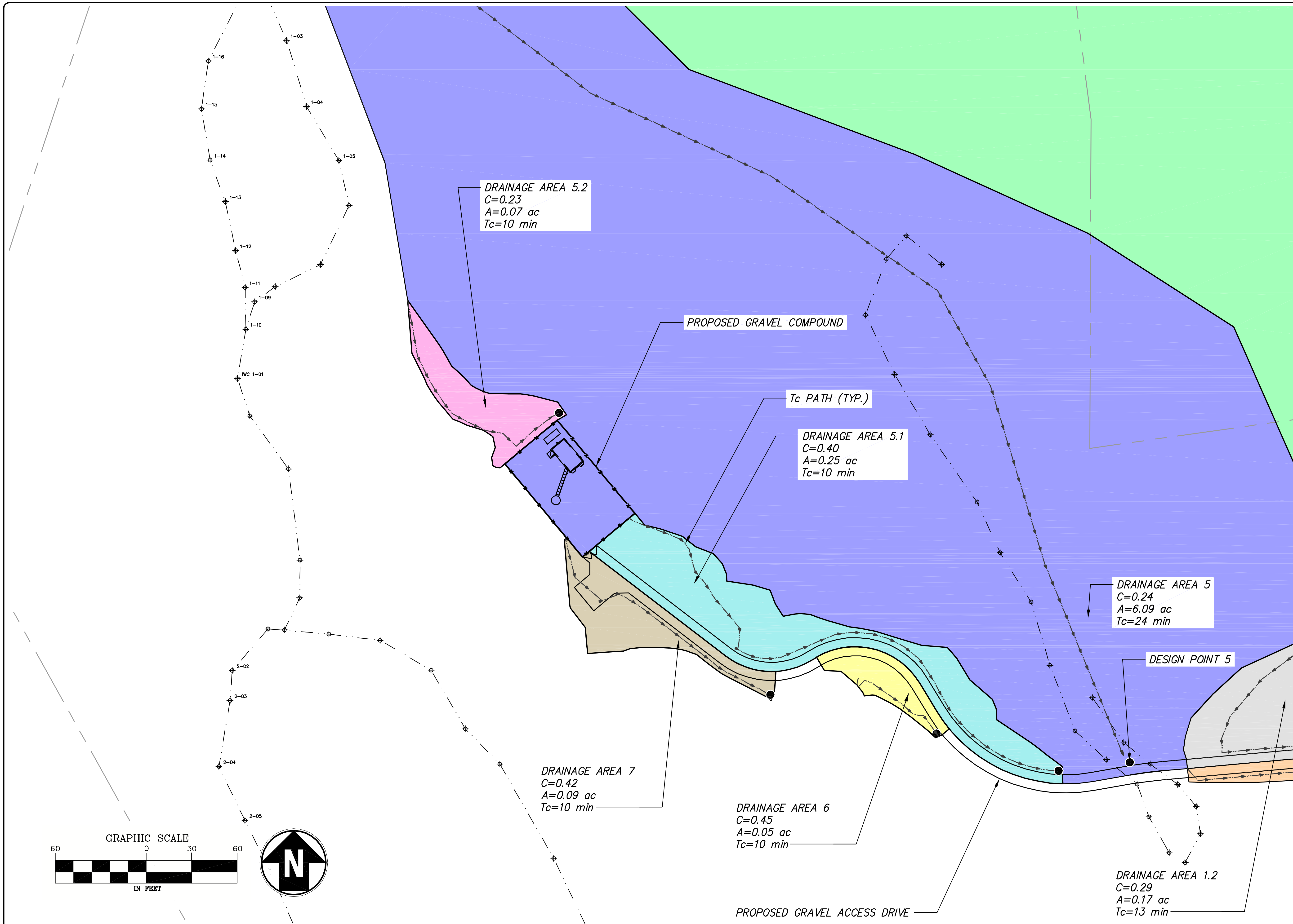
SITE ADDRESS:
WEWAKA BROOK ROAD
BRIDGEWATER, CT 06752

DESIGN TYPE:
RAW LAND

SHEET TITLE:
DRAINAGE AREAS

DRAWING NO.
FIGURE 3C

REVISION:
0



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SBA TOWERS III LLC
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BRIDGEWATER, CT 06752

DESIGN TYPE:
RAW LAND

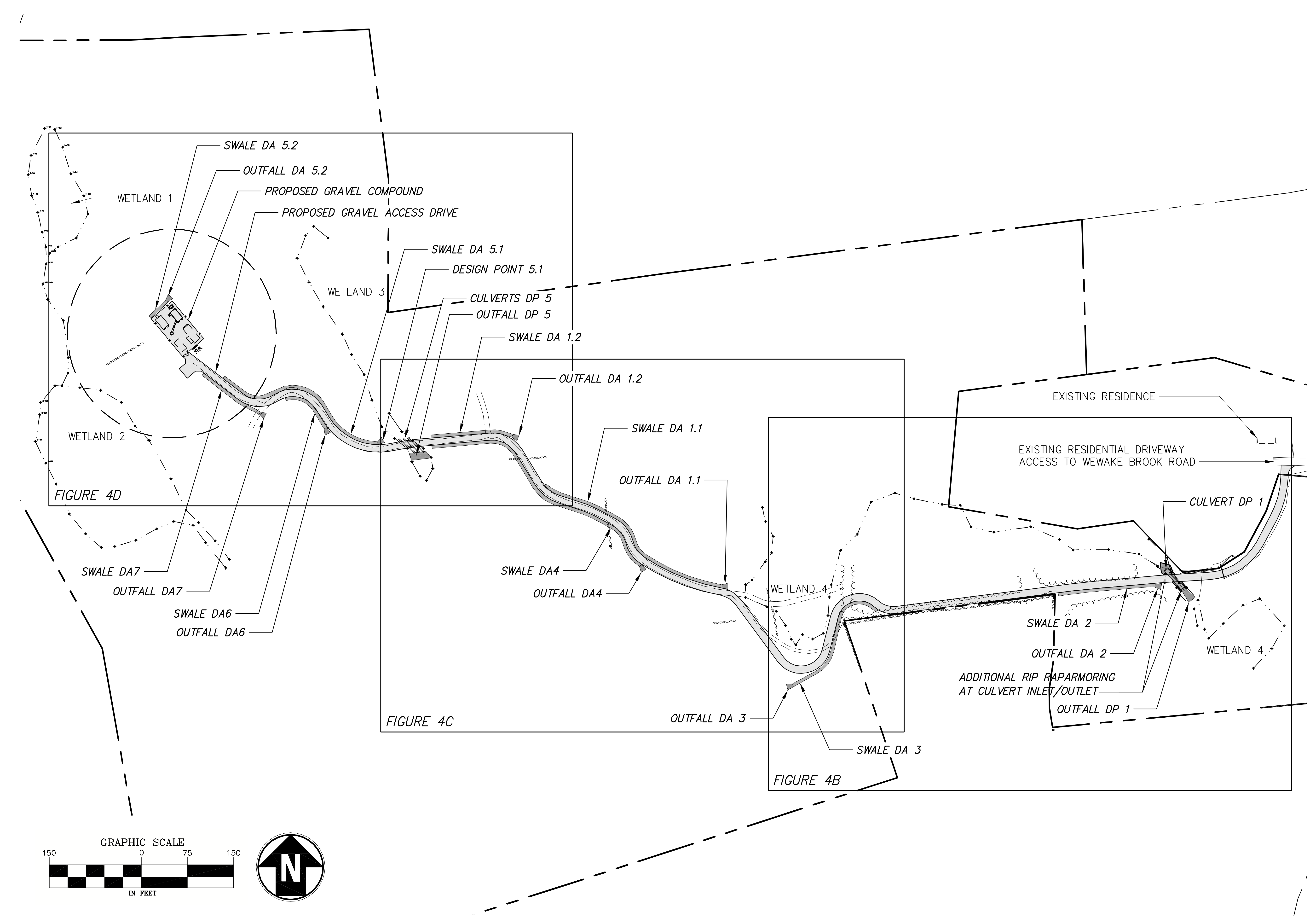
SHEET TITLE:
DRAINAGE AREAS

DRAWING NO.
FIGURE 3D

REVISION:
0

FIGURES 4A-4D

DRAINAGE DESIGN



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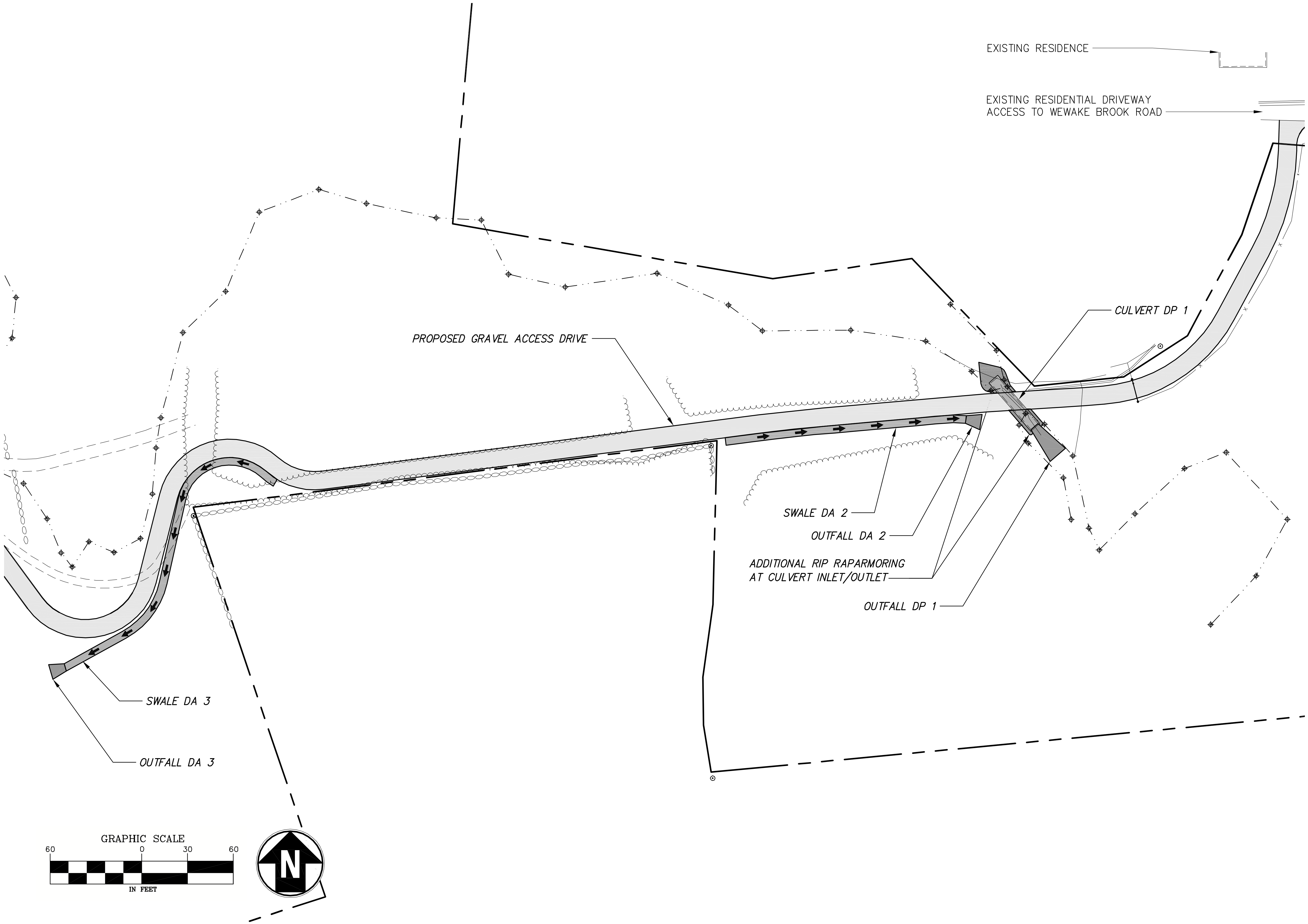
DESIGN TYPE:
RAW LAND

SHEET TITLE:
OVERALL DRAINAGE DESIGN

DRAWING NO.	REVISION:
FIGURE 4A	0



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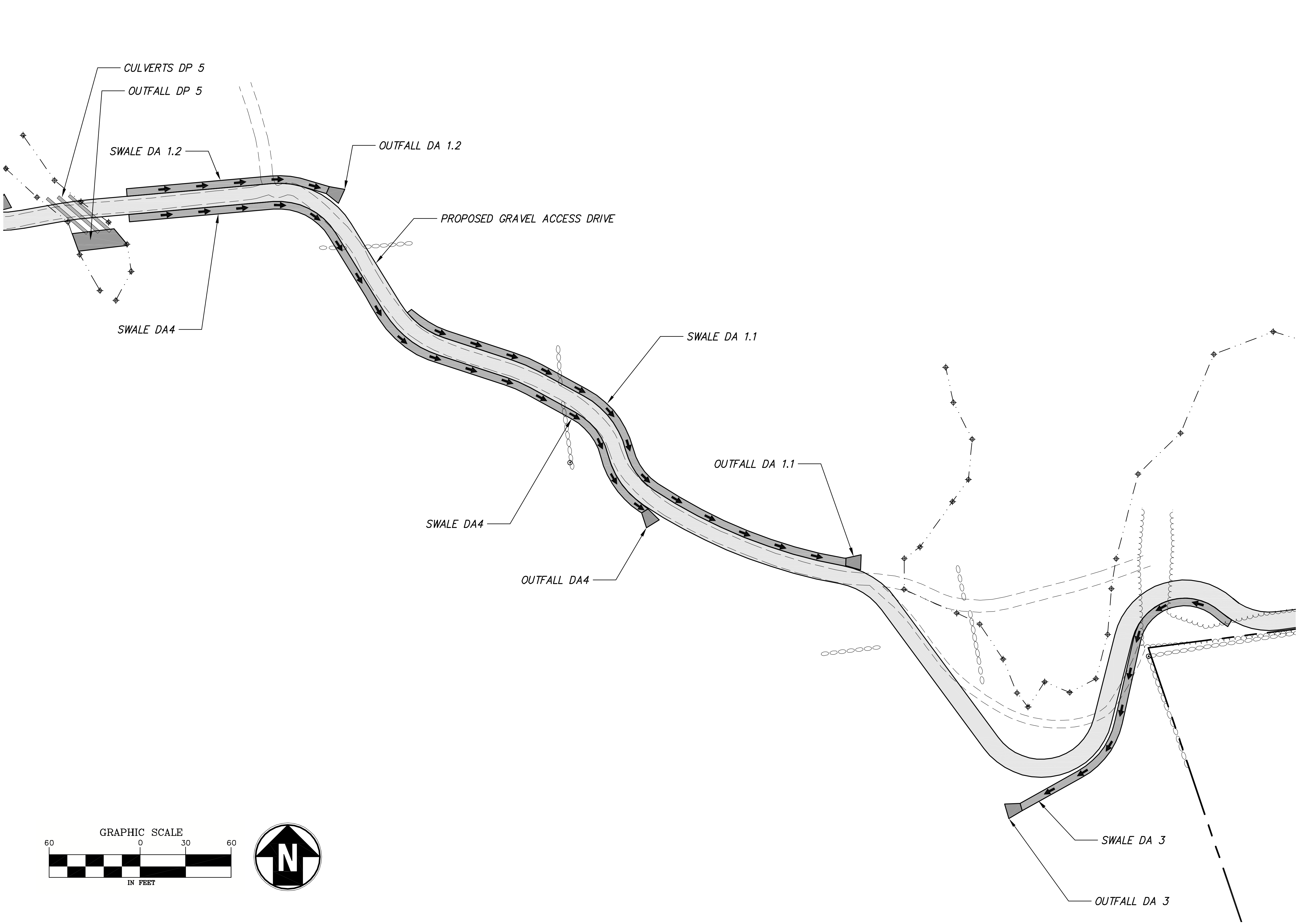
DESIGN TYPE:
RAW LAND

SHEET TITLE:
DRAINAGE DESIGN

DRAWING NO.	REVISION:
FIGURE 4B	0



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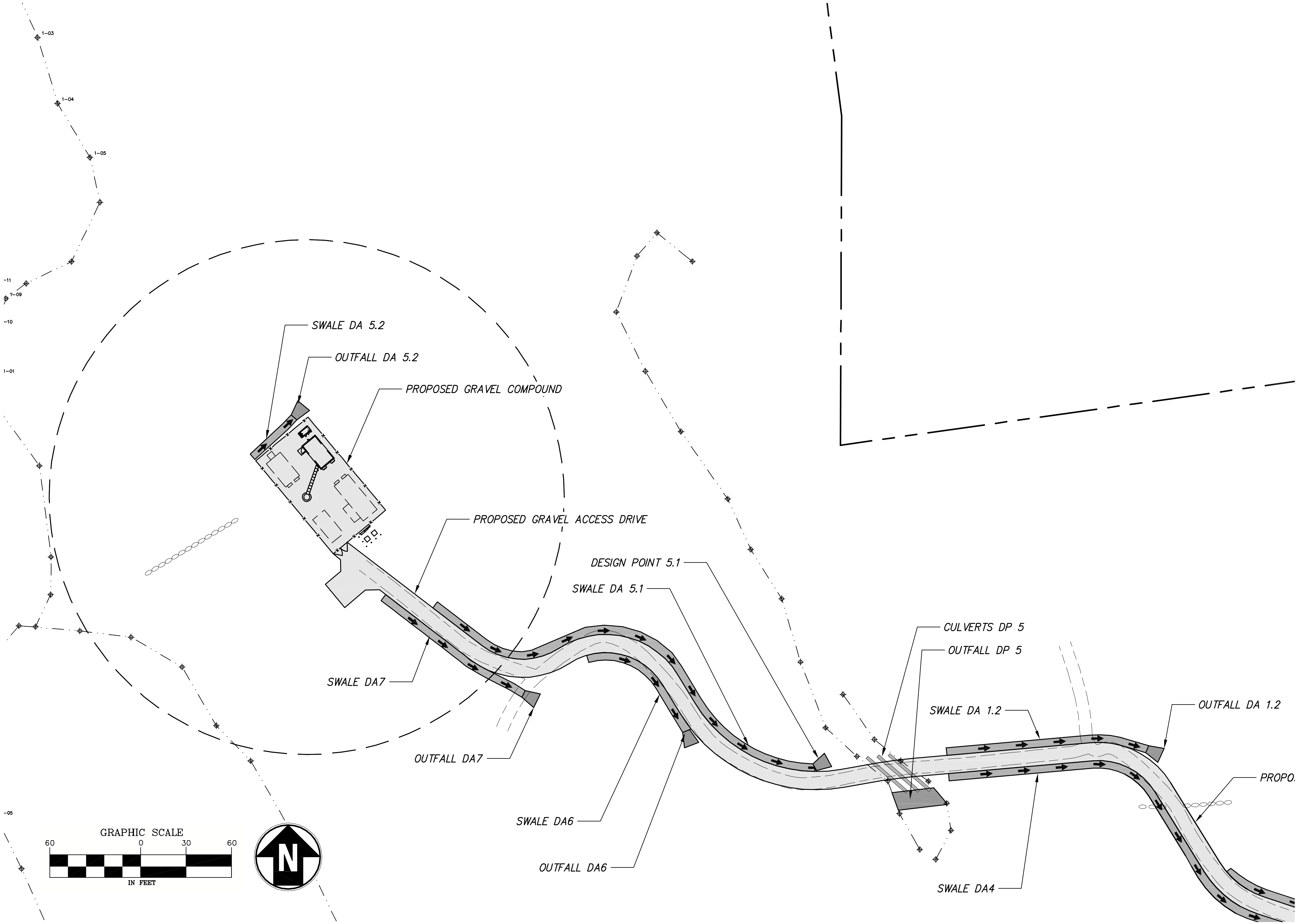
DESIGN TYPE:
RAW LAND

SHEET TITLE:
DRAINAGE DESIGN

DRAWING NO.	REVISION:
FIGURE 4C	0



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PROJECT No.
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DESIGN TYPE:
RAW LAND

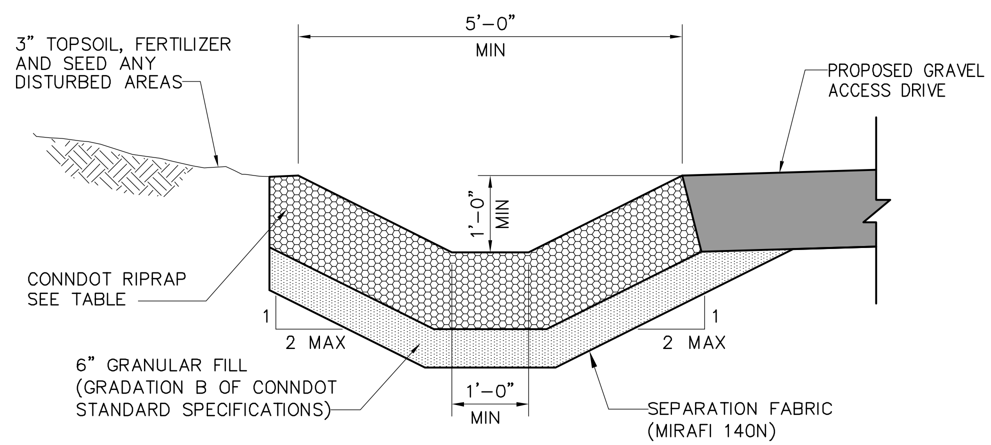
SHEET TITLE:
DRAINAGE DESIGN

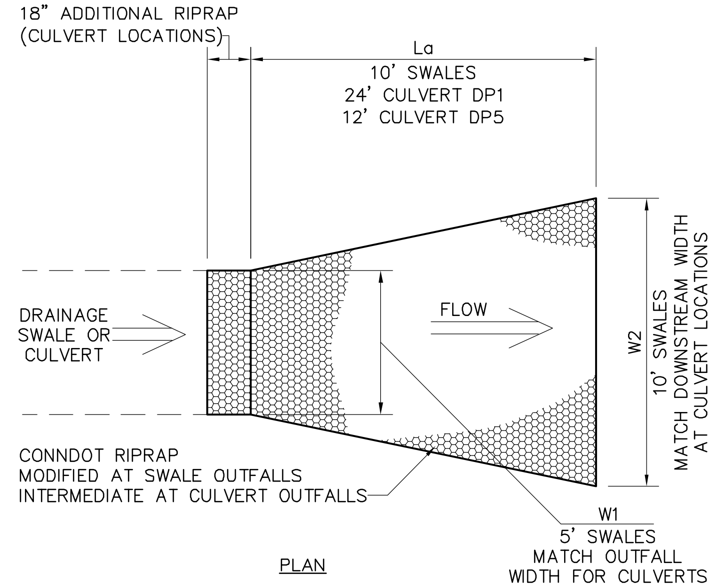
DRAWING NO.: FIGURE 4D

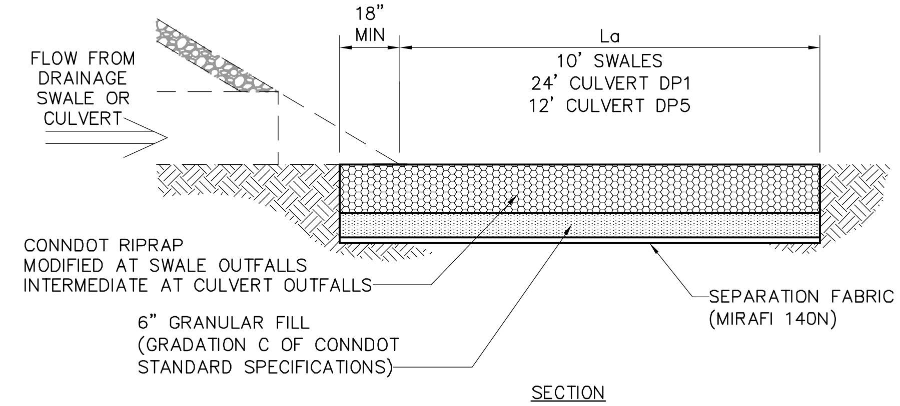
REVISION: 0

FIGURE 5

DRAINAGE DETAILS



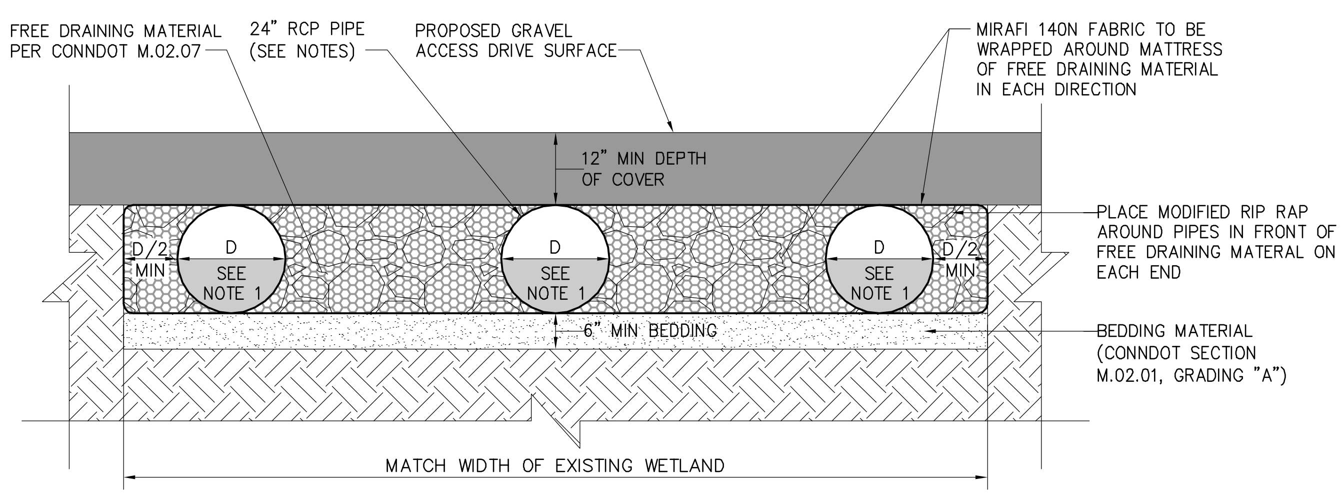




SWALE	CTDOT RIPRAP D50 (INCHES)	CTDOT RIPRAP SPECIFICATION	CTDOT RIPRAP LINING DEPTH
DA 1.1	8"	INTERMEDIATE	18"
DA 1.2	5"	MODIFIED	12"
DA 2	5"	MODIFIED	12"
DA 3	8"	INTERMEDIATE	18"
DA 4	8"	INTERMEDIATE	18"
DA 5.1	8"	INTERMEDIATE	18"
DA 5.2	5"	MODIFIED	12"
DA 6	5"	MODIFIED	12"
DA 7	5"	MODIFIED	12"

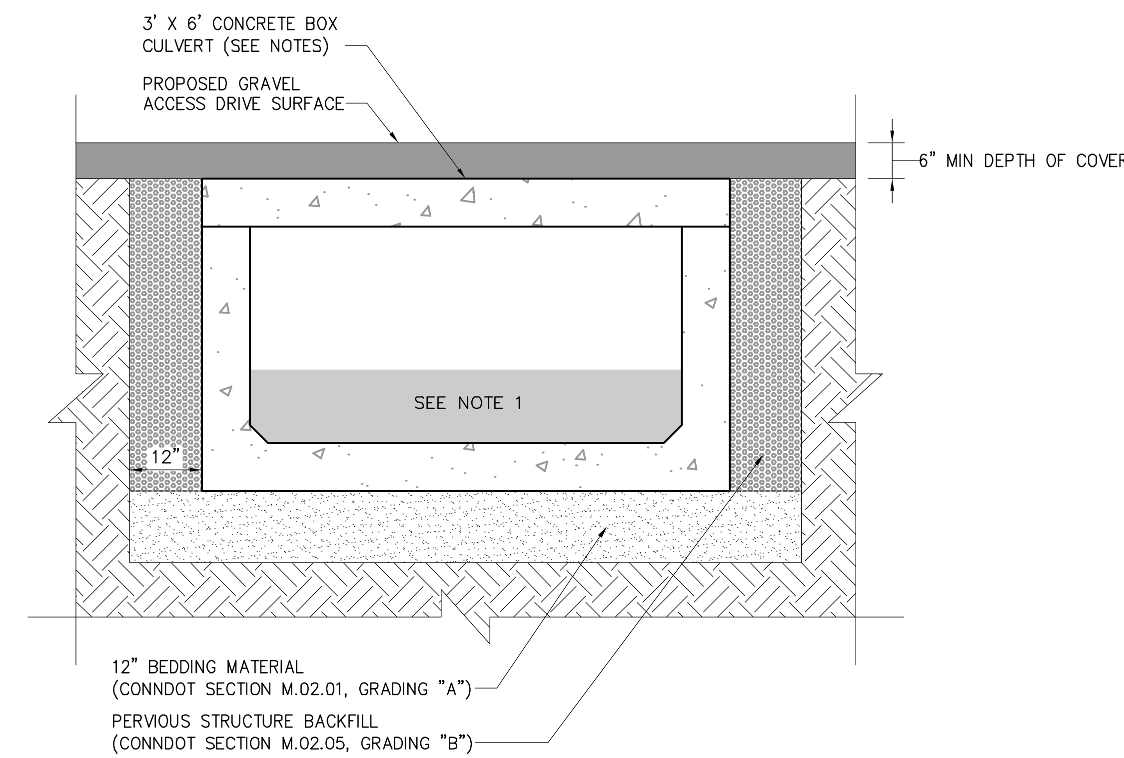
2 FIG 5 RIP RAP APRON END
NO SCALE

1 FIG 5 RIPRAP DRAINAGE SWALES
NO SCALE



NOTES:
1. BACKFILL CULVERT(S) WITH 12" NATURAL SUBSTRATE MATERIAL MATCHING THE UPSTREAM AND DOWNSTREAM STREAMBED SUBSTRATE. MATERIAL TO BE OBTAINED DURING EXCAVATION PRIOR TO INSTALLATION OF CULVERT AND SAVED REUSE.
2. PIPE CULVERTS TO BE CLASS V CONCRETE
3. CULVERTS TO BE CONSTRUCTED IN 10' LENGTH (MAX) SECTIONS TO FACILITATE BACKFILLING WITH NATURAL SUBSTRATE.
4. CULVERTS TO BE PRECAST UNITS DESIGNED AND FURNISHED BY OLDCASTLE PRECAST: OLDCASTLE PRECAST, NEW ENGLAND AVON PLANT, 151 FARMS ROAD, AVON, CT 06001-2253. (860) 673-3291.

CROSS SECTION @ DP5



NOTES:
1. BACKFILL CULVERT(S) WITH 12" NATURAL SUBSTRATE MATERIAL MATCHING THE UPSTREAM AND DOWNSTREAM STREAMBED SUBSTRATE. MATERIAL TO BE OBTAINED DURING EXCAVATION PRIOR TO INSTALLATION OF CULVERT AND SAVED REUSE.
2. CULVERT TO BE OF SUFFICIENT STRENGTH TO WITHSTAND H20 LOADING UNDER THE CONFIGURATION SHOWN (6" COVER), REFER TO ASTM C1433.
3. CULVERT TO HAVE "SLAB" TOP TO FACILITATE BACKFILLING WITH NATURAL SUBSTRATE.
4. CULVERT TO BE PRECAST UNIT DESIGNED AND FURNISHED BY OLDCASTLE PRECAST: OLDCASTLE PRECAST, NEW ENGLAND AVON PLANT, 151 FARMS ROAD, AVON, CT 06001-2253.(860) 673-3291.

CROSS SECTION @ DP 1

3 FIG 5 CULVERT SECTIONS
NO SCALE

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DRAINAGE DETAILS

DRAWING NO.	REVISION:
FIGURE 5	0