December 21, 2017

FINAL DRAINAGE REPORT

ELKTON ROAD, MD LINE TO CASHO MILL ROAD

DelDOT Contract # T201504401
JMT Contract # 14-0659-007
P3e ID # 15-00001

Submitted to:
Delaware Department of Transportation

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TABLE OF CONTENTS

PROJECT SUMMARY

The Delaware Department of Transportation proposes to improve existing capacity and safety deficiencies on Elkton Road between the Maryland State Line and Casho Mill Road in Newark, Delaware. Proposed improvements include pavement widening and reconstruction, pedestrian/bicycle improvements, drainage improvements and utility relocations. The increase in impervious cover and the undersized existing storm drain system creates the potential for storm drain capacity issues. As a result, runoff will be conveyed through a combination of closed and open drainage systems.

DESIGN METHODOLOGY

INLET SPACING

The proposed drainage conveyance along Elkton Road, from Casho Mill Road to the Delaware/Maryland State line consists of PCC Curb Type 2, Integral PCC Curb and Gutter Type 3, drainage inlets, and storm sewer pipes. Spread calculations were completed using StormCAD V8i in accordance with the design criteria provided in HEC-22, Chapter 6 of DelDOT's Road Design Manual and summarized in DelDOT's Figure 6B-12, Inlet Spacing Computation Form provided in Appendix C. Elkton Road is classified as an Arterial Roadway. Sag points and median drains were analyzed at the 50 and 25-year storm event respectively. All other storm drains were evaluated at the 10-year event. The computed and maximum allowable spread for each inlet is provided in Appendix C. Each individual inlet is immediately adjacent to the roadway with a small, mostly impervious contributing drainage area. The average computed Tc path was determined to be well below the minimum 5 minute value for a representative group of inlets. As such, the Tc value for the spread computations was set to the 5 minute minimum for each inlet.

ROADSIDE DITCHES

Roadside ditches along Elkton Road were analyzed at their downstream point. Elkton Road is classified as an Arterial Roadway and the ditches were analyzed using the 25-year storm event in accordance with Chapter 6 of DelDOT's Road Design Manual. A summary of the swale calculations can be found in Appendix D. The time of concentration for each drainage area can be seen in the Drainage Area Maps in Appendix A and supporting calculations are provided in Appendix D.1. The Tc includes the travel time in the upstream pipe network, and the travel time in the upstream swales where applicable. Additional backup calculations, including depth and shear stress analysis, were completed using FHWA's Hydraulic Toolbox Version 4.2. Swales 9, 18, 20, 24 and 25 are in the median and do not meet the minimum freeboard requirements due to clear zone grading requirements and available space. However, these swales were evaluated to ensure the 25-year storm event is contained within the swales and does not encroach on the roadway. This is a typical occurrence in vegetated median swales. The analysis in Appendix D demonstrates that each ditch can be adequately stabilized with Erosion Control Blanket Mulch until a substantial stand of grass is established.

STORM DRAIN SYSTEM

A closed drainage system was selected as the main conveyance system along Elkton Road. Storm drains were analyzed at the 10-year storm event per the guidance in Figure 6-1 Design Criteria – Frequency (Return Period in Years) in Chapter 6 of DelDOT's Road Design Manual. A 25-year storm event was used to analyze the median inlets. A 50-year storm event was used to evaluate inlets located at sag points. Calculations were completed using StormCAD V8i to ensure adequate capacity. The pipe sizing calculations are provided in Appendix E.

EGL AND HGL CALCULATIONS

The Energy Grade Line (EGL) and Hydraulic Grade Line (HGL) were calculated using the HEC-22 procedures in StormCAD V8i. The system was designed to meet the HGL requirements provided in Figure 6-3 Design Criteria – Miscellaneous in Chapter 6 of DelDOT's Road Design Manual. The EGL and HGL calculations are provided in Appendix F. Graphical profiles are provided in Appendix F.1.

CULVERT ANALYSIS

The existing 54" RCP culvert at station 7063+50 will need to be extended at the northwest, upstream opening by 13.0' to accommodate the roadway widening and sidewalk along westbound Elkton Road (Pipe P-156). This culvert conveys an un-named tributary to the Christina River near its point of origin. A StreamStats Analysis was completed at this location revealing a contributing drainage area boundary of 0.16 sq. miles. Because of the stream influence, the Delaware Regression Method was selected to analyze and develop the design storm flows. In accordance with Section 104 – Hydrology and Hydraulics of DelDOT's Bridge Design Manual, the design storm was selected to be the 50 Year Storm with a 67% Prediction Interval. Although the 54" RCP does not quite meet the 20-sq. foot opening requirements to be considered a structure, the Regression Method was used as a conservative measure to analyze the impacts of the culvert extension. This data was then included in an HY-8 analysis to evaluate the headwater impacts for the pre and post culvert extension. The table below summarizes the hydrologic data and culvert performance data for the pre and post conditions. See Appendix G for the backup Hydrologic computations (StreamStats and DelDOT's MathCAD worksheet), and HY-8 Analysis.

Condition	Q50 Flow (cfs)	Headwater Elevation (ft)
Existing	278	98.55
Proposed	278	98.55

To help reduce any expected impacts, the culvert extension maintained the existing culvert size and slope. In addition, the entrance conditions were improved by designing a headwall in place of the previous protruding pipe section. The result of the HY-8 Analysis concluded that there is no change in the headwater elevation for the design storm event, and therefore no adverse impact to the upstream floodplain.

DESIGN CRITERIA

The drainage improvements will be designed in accordance with the latest edition of the DelDOT Road Design Manual, Chapter 6. The corresponding section of the DelDOT Road Design Manual is referenced where applicable.

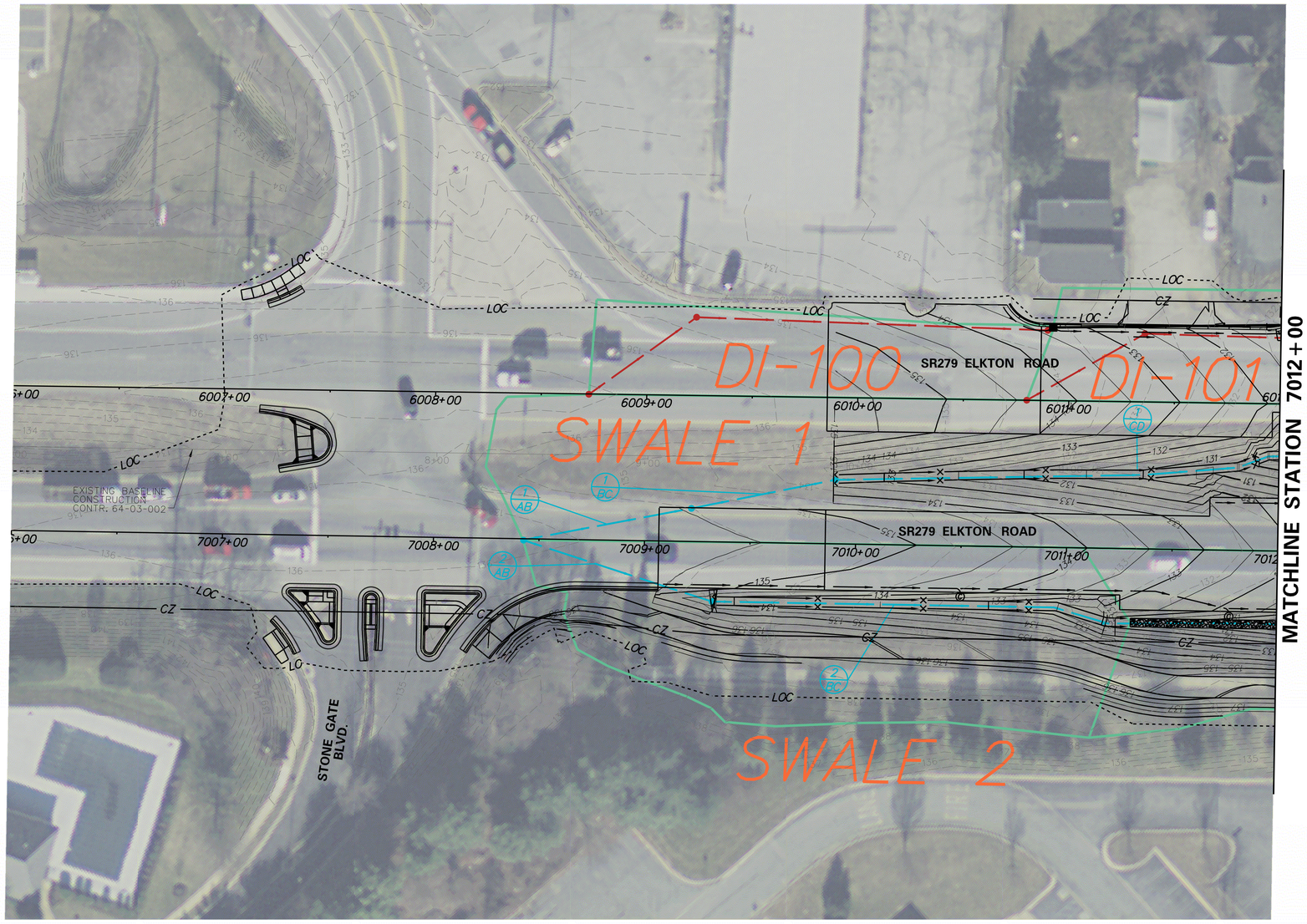
- Time of Concentration (Tc) calculations were performed using the NRCS method.
- Hydrologic analysis has been performed using the Rational Method in accordance with Section 6.6.3.
- All storm drain systems have been designed to safely convey stormwater runoff from proposed pavement widening for a 10-year storm frequency and 50-year storm frequency for sag points in accordance with Figure 6-1.
- Roadside ditches in accordance with Figure 6-3: Design Criteria Miscellaneous. The 25 year design storm event was used in accordance with Figure 6-1: Design Criteria – Frequency (Return Period in Years).
- Hydraulic grade line shall be no higher than one foot below the top of grate for drainage inlets in accordance with Figure 6-3.
- Maximum drainage inlet spread width in accordance with Figure 6-2: Design Criteria - Allowable Spread on the Pavement Cross Section.

Road Name	Traffic Group	Allowable Water Spread
Elkton Road	2-Urban Arterial w/ full shoulder	Full shoulder width

- Riprap outlet protection has been designed in accordance with the Delaware Erosion and Sediment Control Handbook

Appendix A

Drainage Area Map



LEGEND

	DRAINAGE AREA BOUNDARY
	TIME OF CONC. PATH FOR SWALES
	TIME OF CONC. PATH FOR INLETS
XX / XX	SWALE ID FOR Tc PATH / SEGMENT ID FOR Tc PATH (SEE APPENDIX D FOR CALCS)

DR-01

DELAWARE
DEPARTMENT OF TRANSPORTATION

ADDENDUMS / REVISIONS

SCALE
0 30 60 90
FEET

ELKTON ROAD
MD LINE TO
CASHO MILL ROAD

CONTRACT T201504401
COUNTY NEW CASTLE

BRIDGE NO. 1-322/1-322P/1-323P
DESIGNED BY: LB
CHECKED BY: BPH

DRAINAGE AREA MAP

SHEET NO. 25
TOTAL SHTS.

PLOTTED BY: DNOTVEST DATE: 8/7/2017
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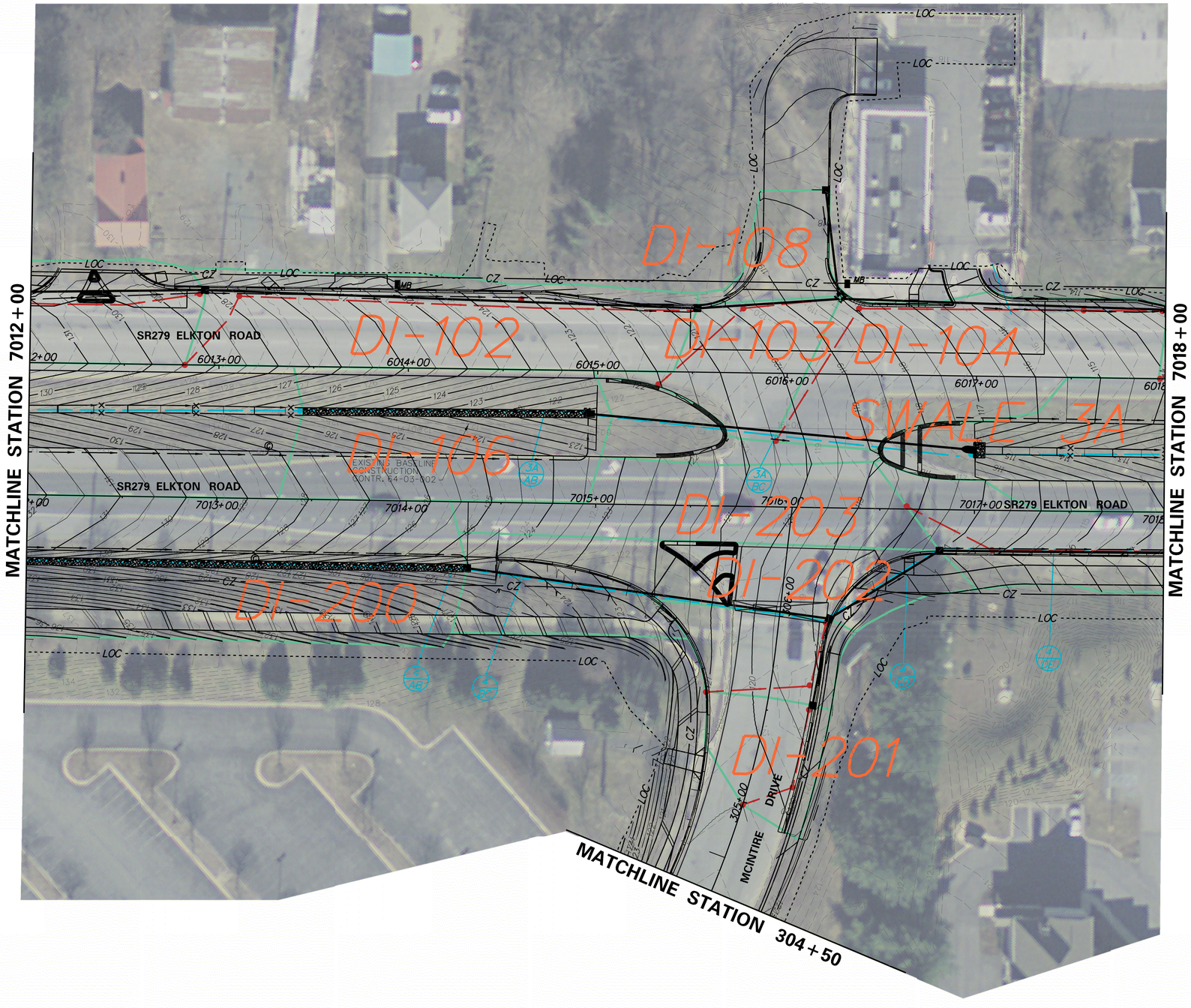


LEGEND	
	DRAINAGE AREA BOUNDARY
	TIME OF CONC. PATH FOR SWALES
	TIME OF CONC. PATH FOR INLETS
XX / XX	SWALE ID FOR Tc PATH / SEGMENT ID FOR Tc PATH (SEE APPENDIX D FOR CALCS)

DR-02

DELAWARE DEPARTMENT OF TRANSPORTATION

ADDENDUMS / REVISIONS

SCALE 0 30 60 90 FEET

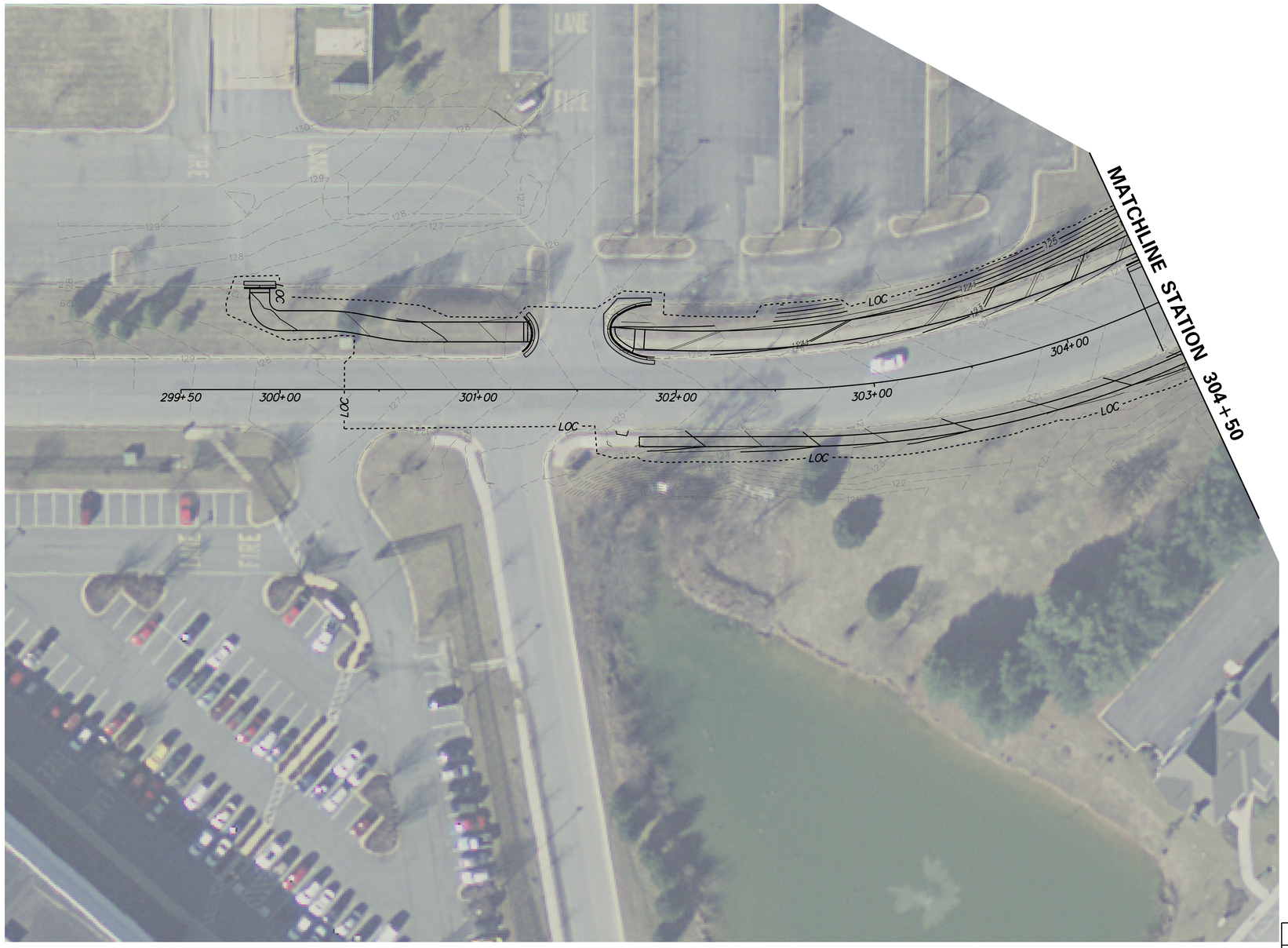
ELKTON ROAD
MD LINE TO
CASHO MILL ROAD

CONTRACT T201504401
COUNTY NEW CASTLE

BRIDGE NO. 1-322/1-322P/1-323P
DESIGNED BY: LB
CHECKED BY: BPH

DRAINAGE AREA MAP

SHEET NO. 26
TOTAL SHTS.



LEGEND	
	DRAINAGE AREA BOUNDARY
	TIME OF CONC. PATH FOR SWALES
	TIME OF CONC. PATH FOR INLETS
XX / XX	SWALE ID FOR Tc PATH / SEGMENT ID FOR Tc PATH (SEE APPENDIX D FOR CALCS)

DR-03

DELAWARE
DEPARTMENT OF TRANSPORTATION

ADDENDUMS / REVISIONS

SCALE
0 30 60 90
FEET

ELKTON ROAD
MD LINE TO
CASHO MILL ROAD

CONTRACT	BRIDGE NO. 1-322/1-322P/1-323P
T201504401	DESIGNED BY: LB
COUNTY	CHECKED BY: BPH
NEW CASTLE	

DRAINAGE AREA MAP

SHEET NO. 27
TOTAL SHTS.

PLOTTED BY: DNOTVEST DATE: 8/7/2017
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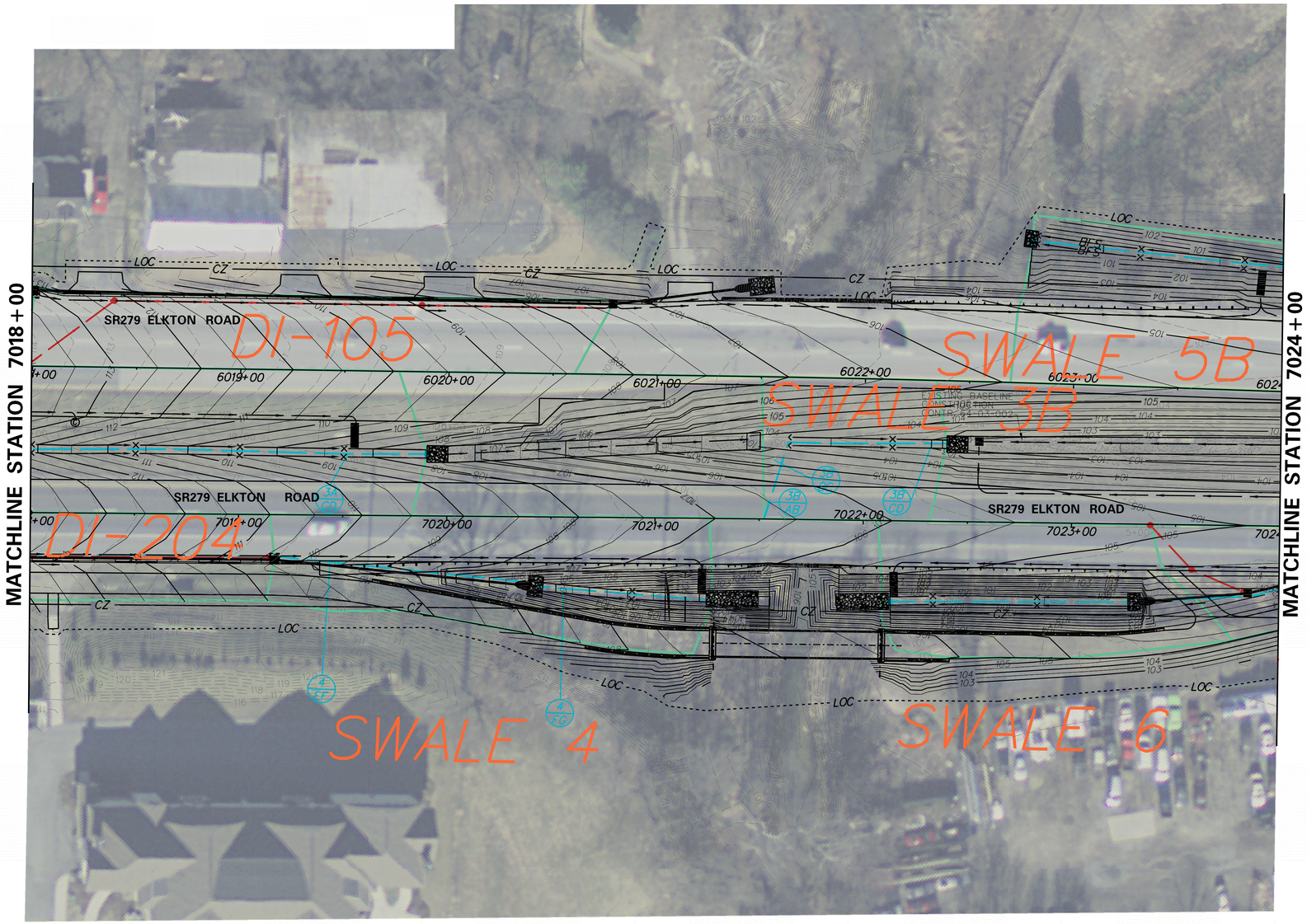

N

LEGEND

- DRAINAGE AREA BOUNDARY
- TIME OF CONC. PATH FOR SWALES
- TIME OF CONC. PATH FOR INLETS
- XX / XX — SWALE ID FOR Tc PATH / SEGMENT ID FOR Tc PATH (SEE APPENDIX D FOR CALCS)

DR-04

DELAWARE
DEPARTMENT OF TRANSPORTATION

ADDENDUMS / REVISIONS	

SCALE
0 30 60 90
FEET

ELKTON ROAD
MD LINE TO
CASHO MILL ROAD

CONTRACT	T201504401
COUNTY	NEW CASTLE
BRIDGE NO.	1-322/1-322P/1-323P
DESIGNED BY: LB	
CHECKED BY: BPH	

DRAINAGE AREA MAP

SHEET NO.	28
TOTAL SHTS.	

PLOTTED BY: DNOTVEST DATE: 8/7/2017
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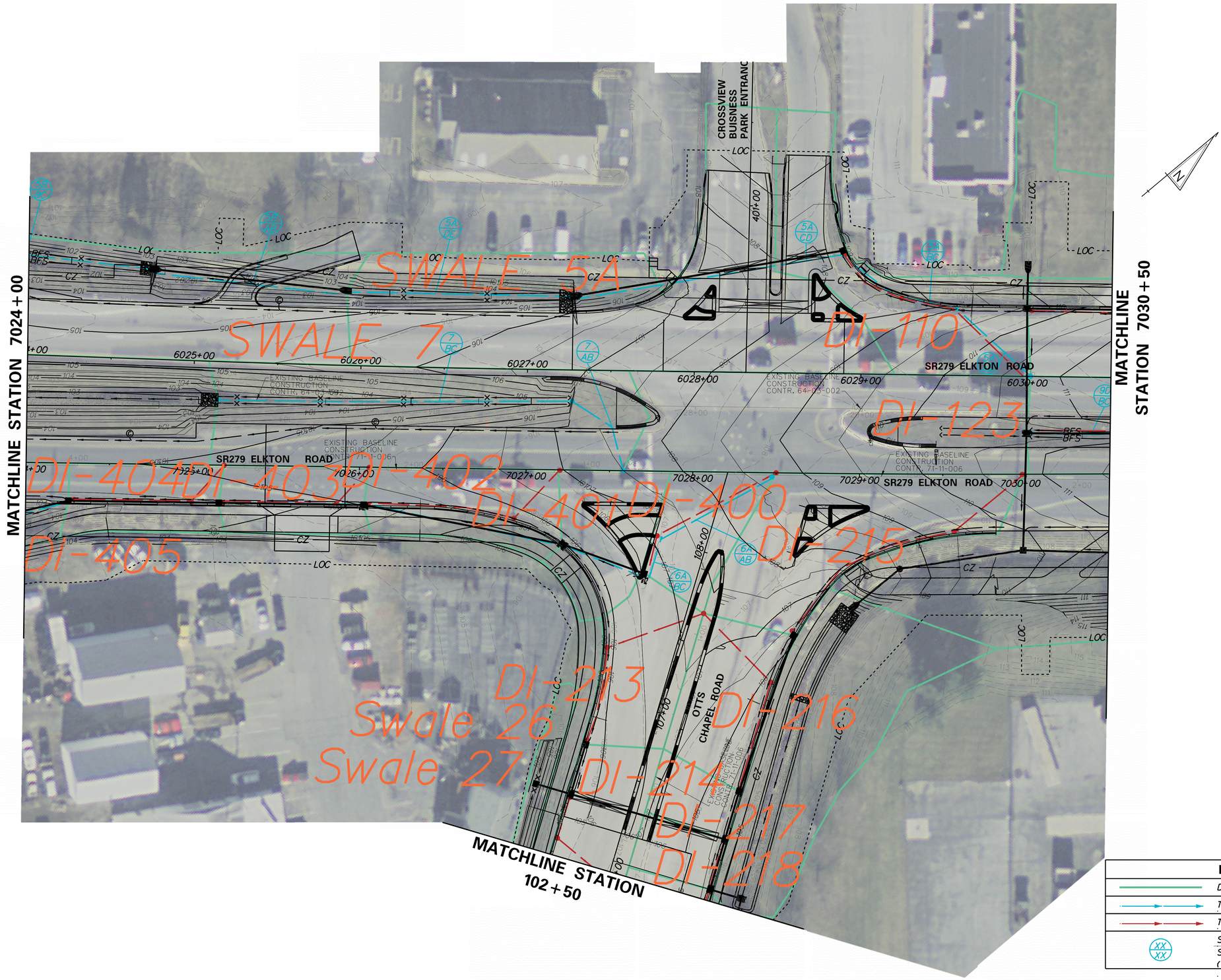

LEGEND	
	DRAINAGE AREA BOUNDARY
	TIME OF CONC. PATH FOR SWALES
	TIME OF CONC. PATH FOR INLETS
XX / XX	SWALE ID FOR Tc PATH / SEGMENT ID FOR Tc PATH (SEE APPENDIX D FOR CALCS)

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DELAWARE
DEPARTMENT OF TRANSPORTATION

ADDENDUMS / REVISIONS

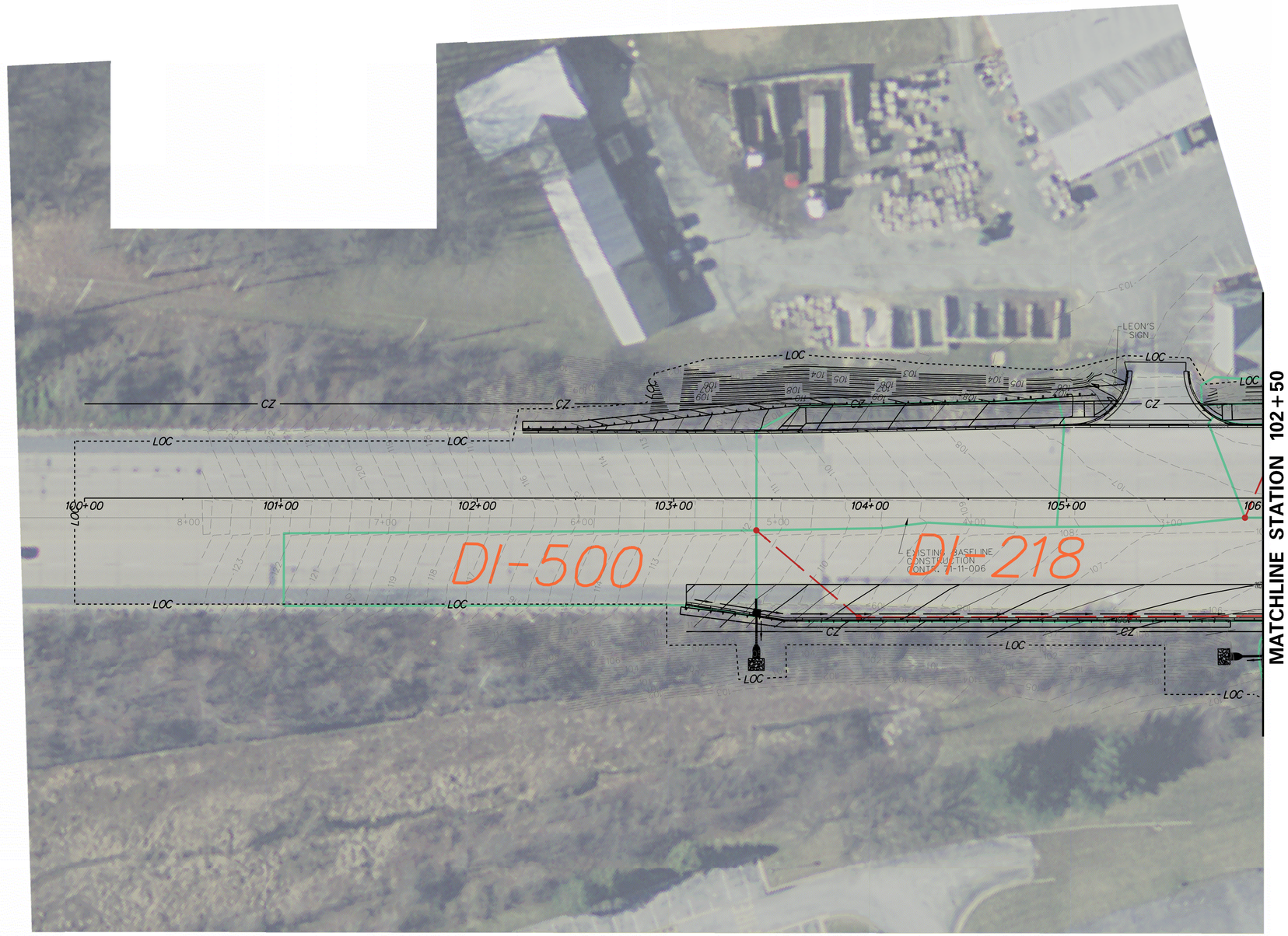
SCALE
0 30 60 90
FEET

ELKTON ROAD
MD LINE TO
CASHO MILL ROAD

CONTRACT T201504401
COUNTY NEW CASTLE
BRIDGE NO. 1-322/1-322P/1-323P
DESIGNED BY: LB
CHECKED BY: BPH

DRAINAGE AREA MAP

DR-05
SHEET NO. 29
TOTAL SHTS.



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LEGEND	
	DRAINAGE AREA BOUNDARY
	TIME OF CONC. PATH FOR SWALES
	TIME OF CONC. PATH FOR INLETS
XX / XX	SWALE ID FOR Tc PATH / SEGMENT ID FOR Tc PATH (SEE APPENDIX D FOR CALCS)

DR-06

DELAWARE
DEPARTMENT OF TRANSPORTATION

ADDENDUMS / REVISIONS

SCALE
0 30 60 90
FEET

ELKTON ROAD
MD LINE TO
CASHO MILL ROAD

CONTRACT	BRIDGE NO.	1-322/1-322P/1-323P
T201504401	DESIGNED BY: LB	
COUNTY	CHECKED BY: BPH	
NEW CASTLE		

DRAINAGE AREA MAP

SHEET NO.	30
TOTAL SHTS.	

PLOTTED BY: DNOTVEST DATE: 8/7/2017
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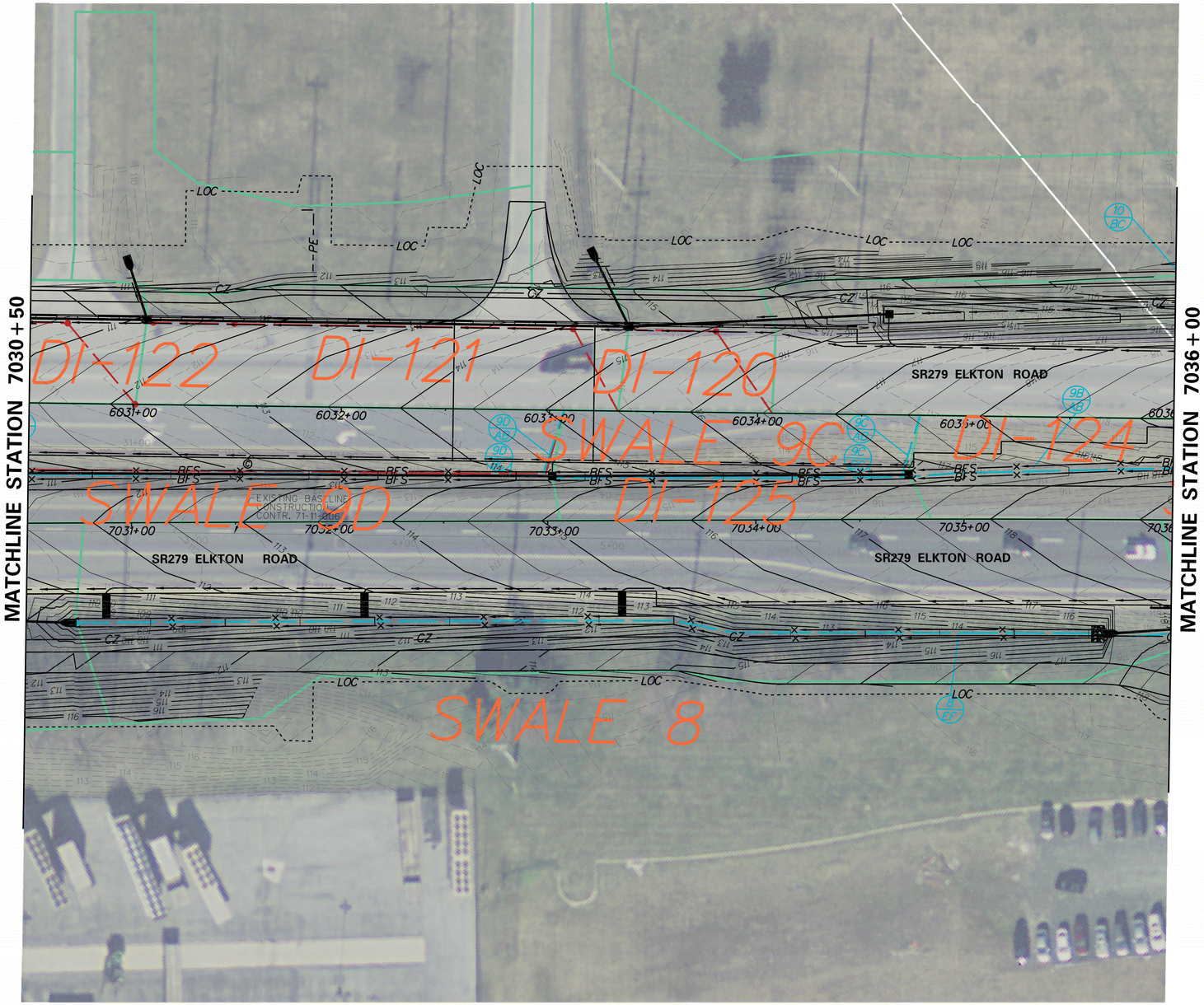

LEGEND	
	DRAINAGE AREA BOUNDARY
	TIME OF CONC. PATH FOR SWALES
	TIME OF CONC. PATH FOR INLETS
XX / XX	SWALE ID FOR Tc PATH / SEGMENT ID FOR Tc PATH (SEE APPENDIX D FOR CALCS)

DR-07

DELAWARE DEPARTMENT OF TRANSPORTATION

ADDENDUMS / REVISIONS	

SCALE
0 30 60 90
FEET

ELKTON ROAD
MD LINE TO
CASHO MILL ROAD

CONTRACT	T201504401
COUNTY	NEW CASTLE
BRIDGE NO.	1-322/1-322P/1-323P
DESIGNED BY: LB	
CHECKED BY: BPH	

DRAINAGE AREA MAP

SHEET NO.	31
TOTAL SHTS.	

PLOTTED BY: DNOTVEST DATE: 8/7/2017
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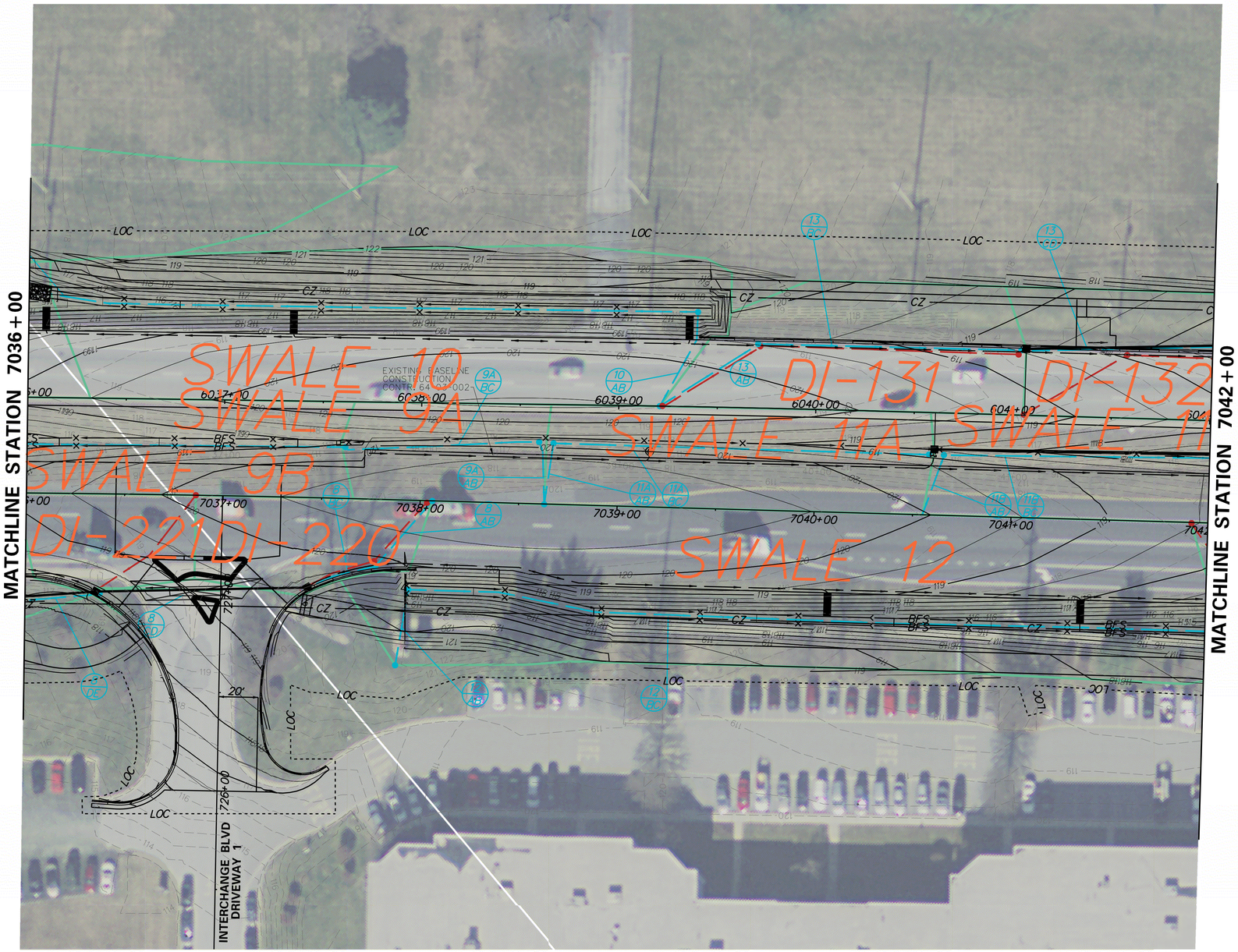

N

LEGEND	
	DRAINAGE AREA BOUNDARY
	TIME OF CONC. PATH FOR SWALES
	TIME OF CONC. PATH FOR INLETS
XX / XX	SWALE ID FOR Tc PATH / SEGMENT ID FOR Tc PATH (SEE APPENDIX D FOR CALCS)

DR-08

DELAWARE
DEPARTMENT OF TRANSPORTATION

ADDENDUMS / REVISIONS

SCALE
0 30 60 90
FEET

ELKTON ROAD
MD LINE TO
CASHO MILL ROAD

CONTRACT	BRIDGE NO. 1-322/1-322P/1-323P
T201504401	DESIGNED BY: LB
COUNTY: NEW CASTLE	CHECKED BY: BPH

DRAINAGE AREA MAP

SHEET NO. 32
TOTAL SHTS.

PLOTTED BY: DNOTVEST DATE: 8/7/2017
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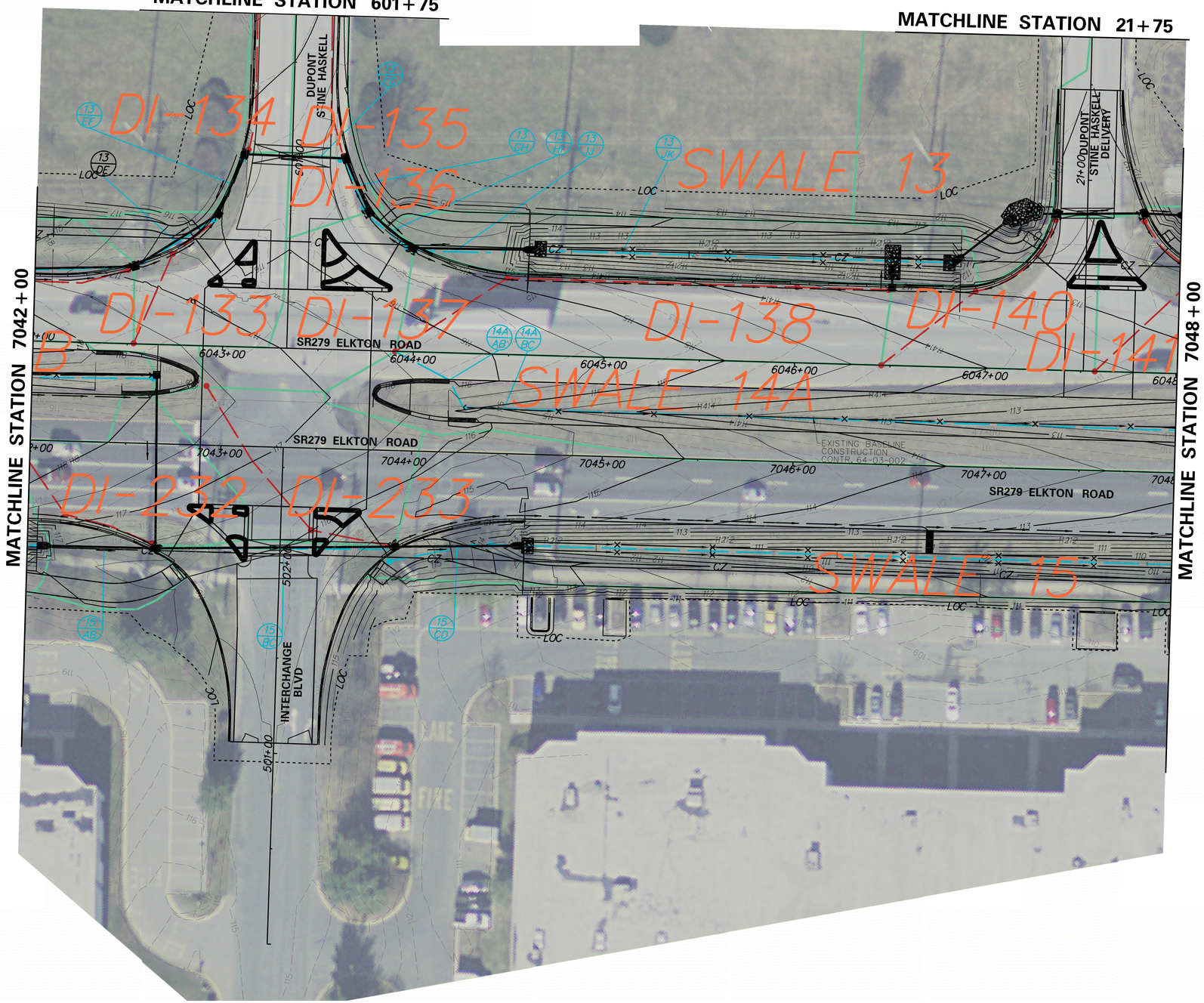

LEGEND

- DRAINAGE AREA BOUNDARY
- TIME OF CONC. PATH FOR SWALES
- TIME OF CONC. PATH FOR INLETS
- XX / XX — SWALE ID FOR Tc PATH / SEGMENT ID FOR Tc PATH (SEE APPENDIX D FOR CALCS)

PLOTTED BY: DNOTVEST DATE: 8/7/2017
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DELAWARE
DEPARTMENT OF TRANSPORTATION

ADDENDUMS / REVISIONS

SCALE
0 30 60 90
FEET

ELKTON ROAD
MD LINE TO
CASHO MILL ROAD

CONTRACT	BRIDGE NO.	1-322/1-322P/1-323P
T201504401	DESIGNED BY: LB	
COUNTY	CHECKED BY: BPH	
NEW CASTLE		

DRAINAGE AREA MAP

DR-09

SHEET NO. 33

TOTAL SHTS.

LEGEND	
	DRAINAGE AREA BOUNDARY
	TIME OF CONC. PATH FOR SWALES
	TIME OF CONC. PATH FOR INLETS
XX / XX	SWALE ID FOR Tc PATH / SEGMENT ID FOR Tc PATH (SEE APPENDIX D FOR CALCS)

DR-10

DELAWARE
DEPARTMENT OF TRANSPORTATION

ADDENDUMS / REVISIONS

SCALE
0 30 60 90
FEET

ELKTON ROAD
MD LINE TO
CASHO MILL ROAD

CONTRACT	BRIDGE NO. 1-322/1-322P/1-323P
T201504401	DESIGNED BY: LB
COUNTY	CHECKED BY: BPH
NEW CASTLE	

DRAINAGE AREA MAP

SHEET NO. 34
TOTAL SHTS.

PLOTTED BY: DNOTVEST DATE: 8/7/2017
FILE LOCATION: Q:\NDE\140659_007_ELKTON_RD_CASHO_MILL\CADD\WK_DRAINAGE.DGN [SHEET: CP10]

LEGEND	
	DRAINAGE AREA BOUNDARY
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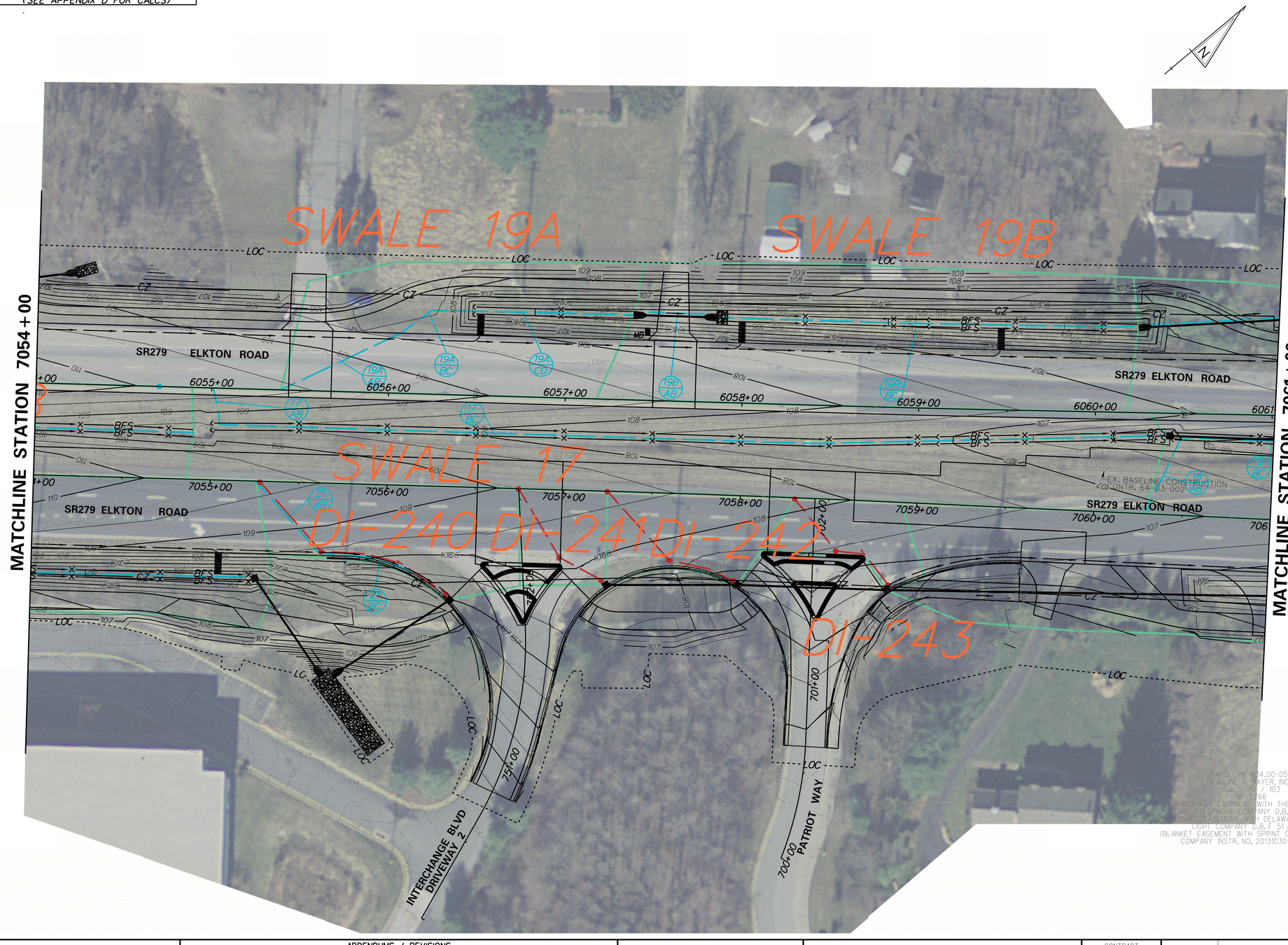
	TIME OF CONC. PATH FOR INLETS
XX / XX	SWALE ID FOR Tc PATH / SEGMENT ID FOR Tc PATH (SEE APPENDIX D FOR CALCS)



DELAWARE
DEPARTMENT OF TRANSPORTATION

ADDENDUMS / REVISIONS

SCALE
0 30 60 90
FEET

ELKTON ROAD
MD LINE TO
CASHO MILL ROAD

CONTRACT	T201504401
COUNTY	NEW CASTLE
BRIDGE NO.	1-322/1-322P/1-323P
DESIGNED BY:	L.B
CHECKED BY:	B.P.H

DRAINAGE AREA MAP

DR-11

SHEET NO.	35
TOTAL SHTS.	

MATCHLINE STATION 381+75

MATCHLINE STATION 7061+00

MATCHLINE STATION 7068+00

MATCHLINE STATION 1001+75

SUBURBAN DRIVE

SR279 ELKTON ROAD

SR279 ELKTON ROAD

SR 896 ELKTON ROAD

SR 4 CHRISTINA PKWY

SWALE 19C

SWALE 18

SWALE 21

SWALE 20

DI-152 DI-162

DI-165

DI-155 DI-154 DI-153

DI-164 DI-163

DI-263

DI-276 DI-275 DI-273 DI-272

DI-277 DI-274

DI-278 DI-279

LOC

CZ

BFS

MB

N

LEGEND

- DRAINAGE AREA BOUNDARY
- TIME OF CONC. PATH FOR SWALES
- TIME OF CONC. PATH FOR INLETS
- XX / XX — SWALE ID FOR Tc PATH / SEGMENT ID FOR Tc PATH (SEE APPENDIX D FOR CALCS)

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DELAWARE
DEPARTMENT OF TRANSPORTATION

ADDENDUMS / REVISIONS

SCALE
0 30 60 90
FEET

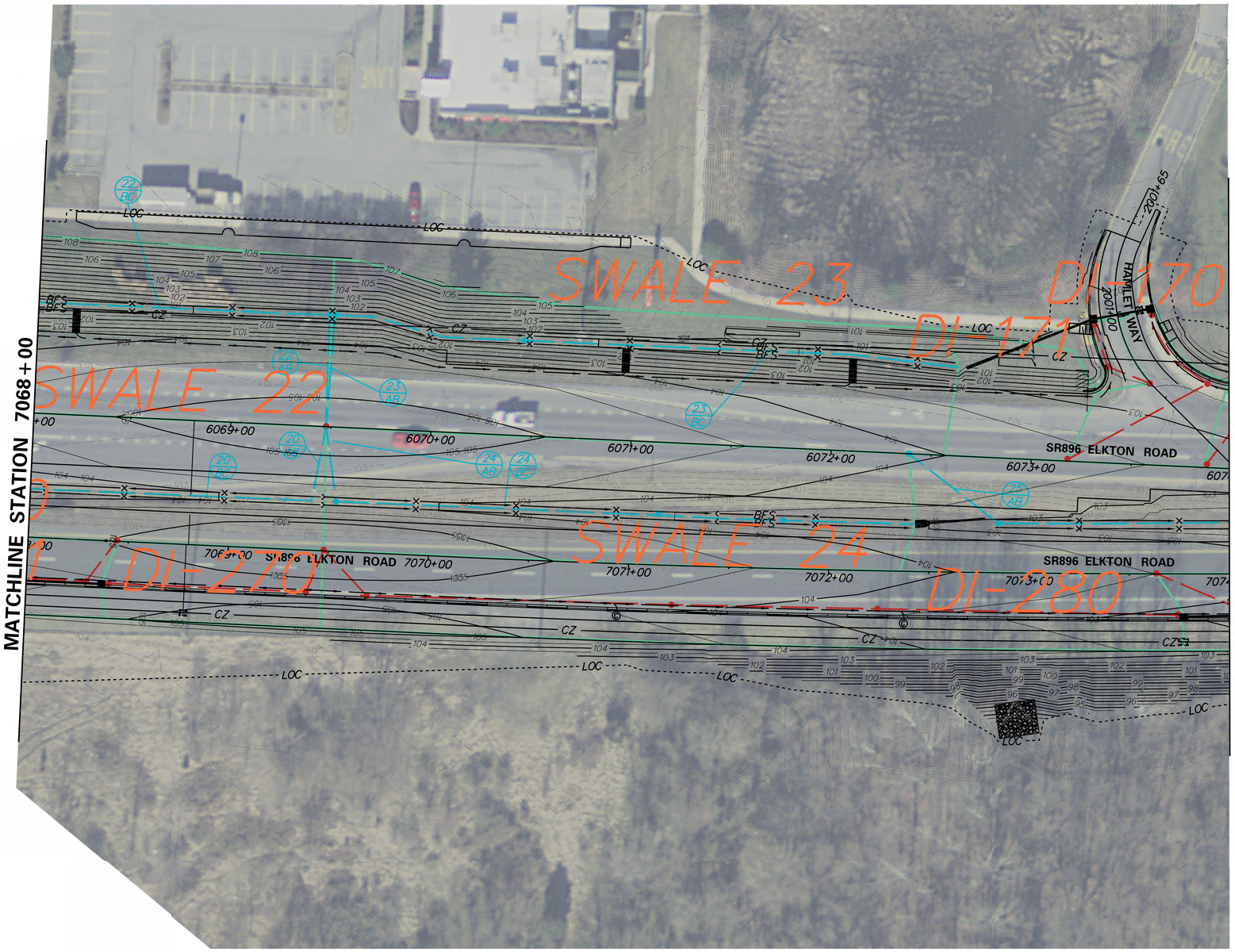
ELKTON ROAD
MD LINE TO
CASHO MILL ROAD

CONTRACT	BRIDGE NO.	1-322/1-322P/1-323P
T201504401	DESIGNED BY: LB	
COUNTY	CHECKED BY: BPH	
NEW CASTLE		

DRAINAGE AREA MAP

DR-12

SHEET NO. 36
TOTAL SHTS.



LEGEND	
	DRAINAGE AREA BOUNDARY
	TIME OF CONC. PATH FOR SWALES
	TIME OF CONC. PATH FOR INLETS
XX / XX	SWALE ID FOR Tc PATH / SEGMENT ID FOR Tc PATH (SEE APPENDIX D FOR CALCS)

DR-13

DELAWARE
DEPARTMENT OF TRANSPORTATION

ADDENDUMS / REVISIONS

SCALE
0 30 60 90
FEET

ELKTON ROAD
MD LINE TO
CASHO MILL ROAD

CONTRACT	BRIDGE NO.	1-322/1-322P/1-323P
T201504401	DESIGNED BY: LB	
COUNTY	CHECKED BY: BPH	
NEW CASTLE		

DRAINAGE AREA MAP

SHEET NO. 37
TOTAL SHTS.

PLOTTED BY: DNOTVEST DATE: 8/7/2017
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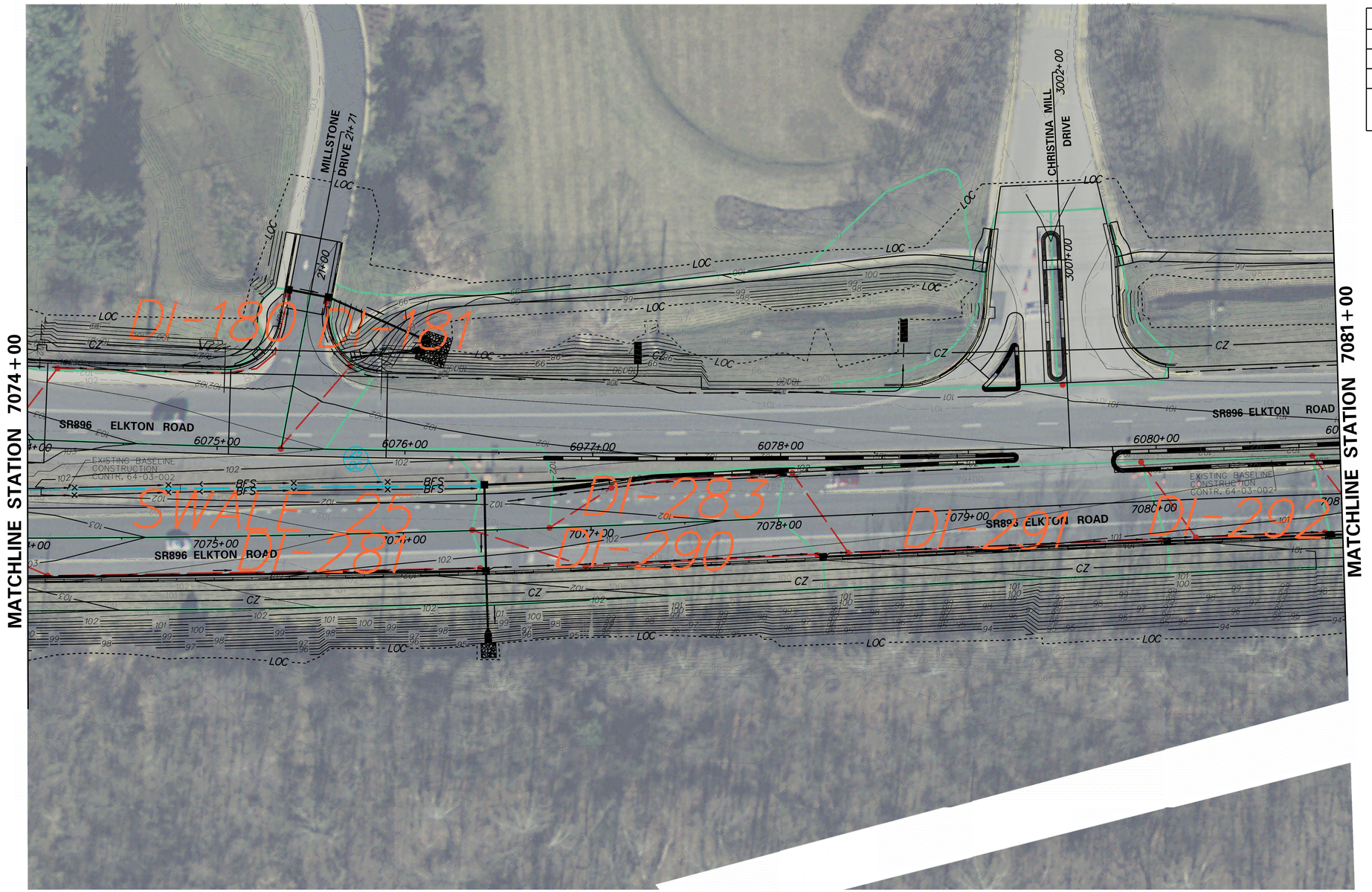

LEGEND	
	DRAINAGE AREA BOUNDARY
	TIME OF CONC. PATH FOR SWALES
	TIME OF CONC. PATH FOR INLETS
XX / XX	SWALE ID FOR Tc PATH / SEGMENT ID FOR Tc PATH (SEE APPENDIX D FOR CALCS)

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DELAWARE
DEPARTMENT OF TRANSPORTATION

ADDENDUMS / REVISIONS

SCALE
0 30 60 90
FEET

ELKTON ROAD
MD LINE TO
CASHO MILL ROAD

CONTRACT	BRIDGE NO.	1-322/1-322P/1-323P
T201504401	DESIGNED BY: LB	
COUNTY	CHECKED BY: BPH	
NEW CASTLE		

DRAINAGE AREA MAP

DR-14

SHEET NO. 38
TOTAL SHTS.

LEGEND	
	DRAINAGE AREA BOUNDARY
	TIME OF CONC. PATH FOR SWALES
	TIME OF CONC. PATH FOR INLETS
XX / XX	SWALE ID FOR Tc PATH SEGMENT ID FOR Tc PATH (SEE APPENDIX D FOR CALCS)

N

MATCHLINE STATION 7081+00

SR896 ELKTON ROAD

EXISTING BASELINE CONSTRUCTION CONTR. 24-044-01

EXISTING BASELINE CONSTRUCTION CONTR. 64-03-002

LOC

CZ

6082+00 6083+00 6084+00 6085+00 6086+00 6087+00 6088+00 6089+00

7083+00 7084+00 7085+00 7086+00 7087+00 7088+00 7089+00

DI-293

[SHEET: CP15]

PLOTTED BY: DNOTVEST DATE: 8/7/2017

FILE LOCATION: Q:\NDE\140659_007_ELKTON_RD_CASHO_MILL\CADD\WK_DRAINAGE.DGN

DELAWARE
DEPARTMENT OF TRANSPORTATION

ADDENDUMS / REVISIONS	

SCALE
0 30 60 90
FEET

ELKTON ROAD
MD LINE TO
CASHO MILL ROAD

CONTRACT	BRIDGE NO.	1-322/1-322P/1-323P
T201504401	DESIGNED BY: LB	
COUNTY		
NEW CASTLE	CHECKED BY: BPH	

DRAINAGE AREA MAP

DR-15

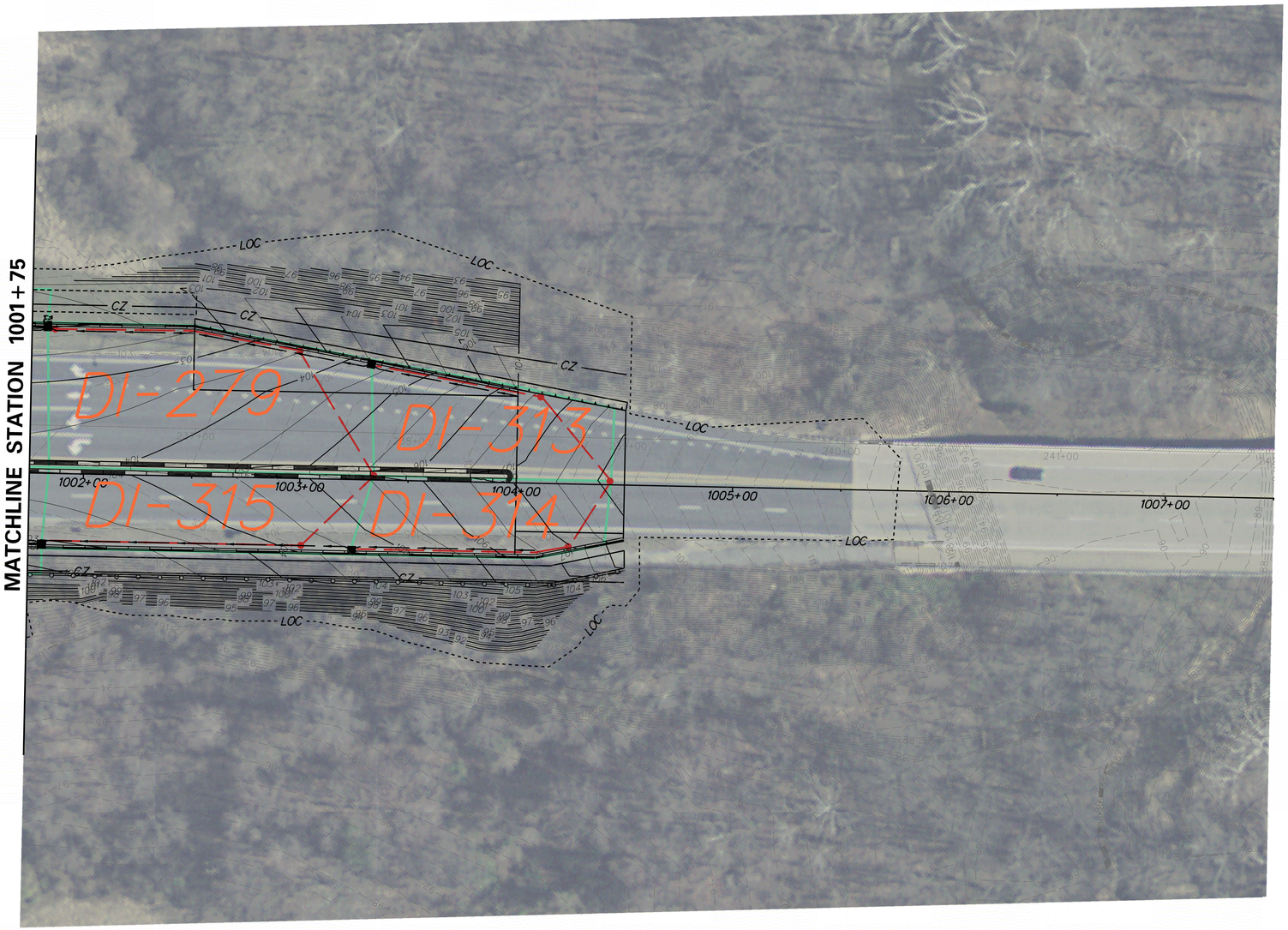
SHEET NO. 39

TOTAL SHTS.

LEGEND	
	DRAINAGE AREA BOUNDARY
	TIME OF CONC. PATH FOR SWALES
	TIME OF CONC. PATH FOR INLETS
XX / XX	SWALE ID FOR Tc PATH SEGMENT ID FOR Tc PATH (SEE APPENDIX D FOR CALCS)

N

MATCHLINE STATION 1001+75



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DELAWARE
DEPARTMENT OF TRANSPORTATION

ADDENDUMS / REVISIONS	

SCALE
0 30 60 90
FEET

ELKTON ROAD
MD LINE TO
CASHO MILL ROAD

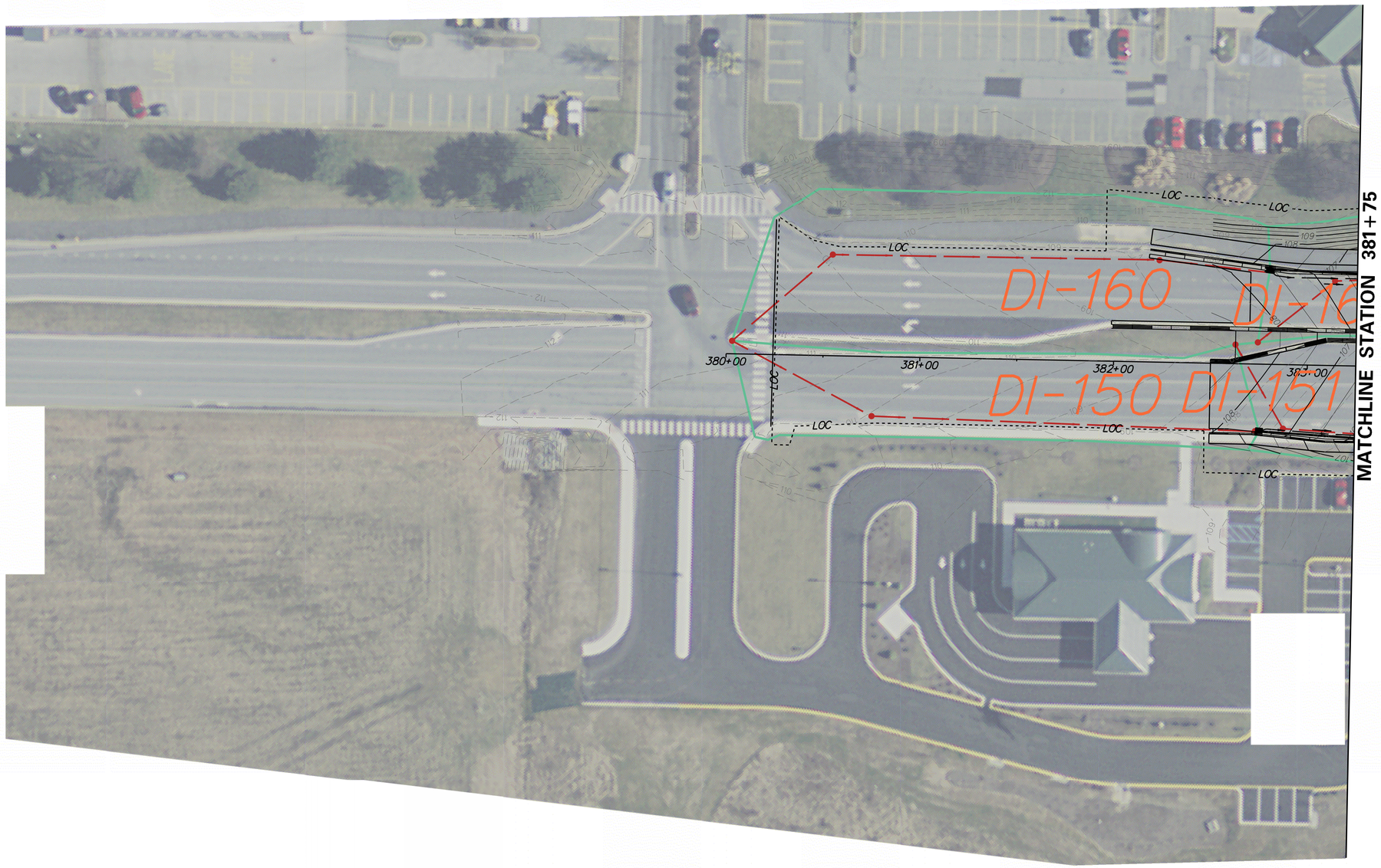
CONTRACT	BRIDGE NO.	1-322/1-322P/1-323P
T201504401	DESIGNED BY: LB	
COUNTY	CHECKED BY: BPH	
NEW CASTLE		

DRAINAGE AREA MAP

DR-16

SHEET NO.
40
TOTAL SHTS.

LEGEND	
	DRAINAGE AREA BOUNDARY
	TIME OF CONC. PATH FOR SWALES
	TIME OF CONC. PATH FOR INLETS
XX / XX	SWALE ID FOR Tc PATH SEGMENT ID FOR Tc PATH (SEE APPENDIX D FOR CALCS)



PLOTTED BY: DNOTVEST DATE: 8/7/2017
FILE LOCATION: Q:\NDE\140659_007_ELKTON_RD_CASHO_MILL\CADD\WK_DRAINAGE.DGN [SHEET: CP17]

DELAWARE
DEPARTMENT OF TRANSPORTATION

ADDENDUMS / REVISIONS	

SCALE
0 30 60 90
FEET

ELKTON ROAD
MD LINE TO
CASHO MILL ROAD

CONTRACT	T201504401
COUNTY	NEW CASTLE
BRIDGE NO.	1-322/1-322P/1-323P
DESIGNED BY: LB	
CHECKED BY: BPH	

DRAINAGE AREA MAP

DR-17

SHEET NO.	41
TOTAL SHTS.	

LEGEND	
	DRAINAGE AREA BOUNDARY
	TIME OF CONC. PATH FOR SWALES
	TIME OF CONC. PATH FOR INLETS
XX / XX	SWALE ID FOR Tc PATH / SEGMENT ID FOR Tc PATH (SEE APPENDIX D FOR CALCS)

DR-18

DELAWARE
DEPARTMENT OF TRANSPORTATION

ADDENDUMS / REVISIONS

SCALE
0 30 60 90
FEET

ELKTON ROAD
MD LINE TO
CASHO MILL ROAD

CONTRACT	BRIDGE NO.	1-322/1-322P/1-323P
T201504401	DESIGNED BY: LB	
COUNTY	CHECKED BY: BPH	
NEW CASTLE		

DRAINAGE AREA MAP

SHEET NO. 42
TOTAL SHTS.

Appendix B

Drainage Area Summary

Drainage Area	Outflow Element	Incremental		Weighted	Total Area	Time of Conc.	Rainfall Intensity	Flow
		C	A (acres)	C	A (acres)	Tc (min)	I (in/hr)	Q (cfs)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
DA-100	DI-100	0.10	0	0.95	0.193	5	6.415	1.18
		0.95	0.193					
DA-101	DI-101	0.10	0.064	0.73	0.245	5	6.415	1.14
		0.95	0.181					
DA-102	DI-102	0.10	0.047	0.81	0.291	5	6.415	1.52
		0.95	0.244					
DA-108	DI-108	0.10	0	0.95	0.061	5	6.415	0.37
		0.95	0.061					
DA-103	DI-103	0.10	0	0.95	0.110	5	6.415	0.67
		0.95	0.110					
DA-104	DI-104	0.10	0	0.95	0.260	5	6.415	1.58
		0.95	0.260					
DA-105	DI-105	0.10	0	0.95	0.223	5	6.415	1.36
		0.95	0.223					
DA-106	DI-106	0.10	0.624	0.46	1.074	5	6.415	3.14
		0.95	0.450					
DA-110	DI-110	0.10	0.143	0.47	0.252	5	6.415	0.76
		0.95	0.109					
DA-120	DI-120	0.10	0.021	0.79	0.115	5	6.415	0.59
		0.95	0.094					
DA-121	DI-121	0.10	0.058	0.79	0.306	5	6.415	1.55
		0.95	0.248					
DA-122	DI-122	0.10	0.027	0.79	0.140	5	6.415	0.71
		0.95	0.113					
DA-123	DI-123	0.10	0.100	0.73	0.39	5	6.415	1.83
		0.95	0.290					
DA-124	DI-124	0.10	0.164	0.52	0.324	5	6.415	1.08
		0.95	0.16					
DA-125	DI-125	0.10	0.042	0.78	0.204	5	6.415	1.01
		0.95	0.162					
DA-127	DI-127	0.10	0.01	0.10	0.010	5	6.415	0.01
		0.95	0					

Drainage Area	Outflow Element	Incremental		Weighted	Total Area	Time of Conc.	Rainfall Intensity	Flow
		C	A (acres)	C	A (acres)	Tc (min)	I (in/hr)	Q (cfs)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
DA-131	DI-131	0.10	0.092	0.63	0.245	5	6.415	0.99
		0.95	0.153					
DA-132	DI-132	0.10	0.084	0.63	0.222	5	6.415	0.89
		0.95	0.138					
DA-133	DI-133	0.10	0.018	0.84	0.137	5	6.415	0.74
		0.95	0.119					
DA-134	DI-134	0.10	0	0.95	0.058	5	6.415	0.35
		0.95	0.058					
DA-135	DI-135	0.10	0	0.95	0.071	5	6.415	0.43
		0.95	0.071					
DA-136	DI-136	0.10	0	0.95	0.036	5	6.415	0.22
		0.95	0.036					
DA-137	DI-137	0.10	0	0.95	0.151	5	6.415	0.92
		0.95	0.151					
DA-138	DI-138	0.10	0	0.95	0.253	5	6.415	1.54
		0.95	0.253					
DA-140	DI-140	0.10	0	0.95	0.146	5	6.415	0.89
		0.95	0.146					
DA-141	DI-141	0.10	0	0.95	0.104	5	6.415	0.63
		0.95	0.104					
DA-150	DI-150	0.10	0	0.95	0.270	5	6.415	1.65
		0.95	0.27					
DA-151	DI-151	0.10	0.006	0.91	0.118	5	6.415	0.69
		0.95	0.112					
DA-152	DI-152	0.10	0.003	0.92	0.074	5	6.415	0.43
		0.95	0.071					
DA-160	DI-160	0.10	0.085	0.80	0.480	5	6.415	2.46
		0.95	0.395					
DA-161	DI-161	0.10	0.024	0.74	0.097	5	6.415	0.46
		0.95	0.073					
DA-162	DI-162	0.10	0.036	0.65	0.103	5	6.415	0.43
		0.95	0.067					

Drainage Area	Outflow Element	Incremental		Weighted	Total Area	Time of Conc.	Rainfall Intensity	Flow
		C	A (acres)	C	A (acres)	Tc (min)	I (in/hr)	Q (cfs)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
DA-163	DI-163	0.10	0.061	0.61	0.151	5	7.594	0.70
		0.95	0.09					
DA-164	DI-164	0.10	0	0.95	0.105	5	7.124	0.71
		0.95	0.105					
DA-166	DI-166	0.10	0	0.95	0.010	5	7.124	0.07
		0.95	0.01					
DA-165	DI-165	0.10	0	0.95	0.182	5	7.124	1.23
		0.95	0.182					
DA-153	DI-153	0.10	0.019	0.81	0.116	5	7.594	0.71
		0.95	0.097					
DA-154	DI-154	0.10	0.011	0.87	0.117	5	6.415	0.65
		0.95	0.106					
DA-155	DI-155	0.10	0.012	0.87	0.124	5	6.415	0.69
		0.95	0.112					
DA-255	DI-255	0.10	0.370	0.47	0.650	5	6.415	1.94
		0.95	0.280					
DA-256	DI-256	0.10	0.180	0.63	0.480	5	6.415	1.94
		0.95	0.300					
DA-170	DI-170	0.10	0	0.95	0.075	5	6.415	0.46
		0.95	0.075					
DA-171	DI-171	0.10	0	0.95	0.014	5	6.415	0.09
		0.95	0.014					
DA-180	DI-180	0.10	0	0.95	0.145	5	7.594	1.05
		0.95	0.145					
DA-181	DI-181	0.10	0	0.95	0.050	5	7.594	0.36
		0.95	0.05					
DA-200	DI-200	0.10	0.55	0.49	1.02	5	6.415	3.22
		0.95	0.47					
DA-201	DI-201	0.10	0	0.95	0.079	5	6.415	0.48
		0.95	0.079					
DA-202	DI-202	0.10	0	0.95	0.084	5	6.415	0.51
		0.95	0.084					
DA-203	DI-203	0.10	0	0.95	0.190	5	6.415	1.16
		0.95	0.19					
DA-204	DI-204	0.10	0.028	0.84	0.216	5	6.415	1.16
		0.95	0.188					

Drainage Area	Outflow Element	Incremental		Weighted	Total Area	Time of Conc.	Rainfall Intensity	Flow
		C	A (acres)	C	A (acres)	Tc (min)	I (in/hr)	Q (cfs)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
DA-210	DI-210	0.10	0.04	0.10	0.040	5	6.415	0.03
		0.95	0					
DA-213	DI-213	0.10	0	0.95	0.105	5	6.415	0.64
		0.95	0.105					
DA-214	DI-214	0.10	0	0.95	0.103	5	7.594	0.74
		0.95	0.103					
DA-215	DI-215	0.10	0	0.95	0.230	5	6.415	1.40
		0.95	0.23					
DA-216	DI-216	0.10	0	0.95	0.113	5	6.415	0.69
		0.95	0.113					
DA-217	DI-217	0.10	0	0.95	0.040	5	7.594	0.29
		0.95	0.04					
DA-218	DI-218	0.10	0	0.95	0.290	5	6.415	1.77
		0.95	0.29					
DA-220	DI-220	0.10	0	0.95	0.113	5	6.415	0.69
		0.95	0.113					
DA-221	DI-221	0.10	0	0.95	0.095	5	6.415	0.58
		0.95	0.095					
DA-230	DI-230	0.10	0.042	0.79	0.230	5	6.415	1.17
		0.95	0.188					
DA-231	DI-231	0.10	0.052	0.78	0.259	5	6.415	1.29
		0.95	0.207					
DA-232	DI-232	0.10	0.036	0.80	0.199	5	6.415	1.02
		0.95	0.163					
DA-233	DI-233	0.10	0	0.95	0.18	5	6.415	1.10
		0.95	0.18					
DA-240	DI-240	0.10	0	0.95	0.167	5	6.415	1.02
		0.95	0.167					
DA-241	DI-241	0.10	0	0.95	0.061	5	6.415	0.37
		0.95	0.061					
DA-242	DI-242	0.10	0	0.95	0.096	5	6.415	0.59
		0.95	0.096					
DA-243	DI-243	0.10	0	0.95	0.063	5	6.415	0.38
		0.95	0.063					
DA-244	DI-244	0.10	0.05	0.84	0.370	5	6.415	1.98
		0.95	0.32					
DA-245	DI-245	0.10	0.114	0.48	0.204	5	6.415	0.62
		0.95	0.09					
DA-263	DI-263	0.10	0.16	0.65	0.458	5	7.594	2.27
		0.95	0.298					

Drainage Area	Outflow Element	Incremental		Weighted	Total Area	Time of Conc.	Rainfall Intensity	Flow
		C	A (acres)	C	A (acres)	Tc (min)	I (in/hr)	Q (cfs)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
DA-270	DI-270	0.10	0	0.95	0.100	5	6.415	0.61
		0.95	0.100					
DA-271	DI-271	0.10	0	0.95	0.122	5	6.415	0.74
		0.95	0.122					
DA-272	DI-272	0.10	0	0.95	0.059	5	6.415	0.36
		0.95	0.059					
DA-273	DI-273	0.10	0	0.95	0.065	5	6.415	0.40
		0.95	0.065					
DA-274	DI-274	0.10	0	0.95	0.194	5	6.415	1.18
		0.95	0.194					
DA-279	DI-279	0.10	0	0.95	0.220	5	6.415	1.34
		0.95	0.220					
DA-275	DI-275	0.10	0	0.95	0.190	5	7.594	1.37
		0.95	0.190					
DA-276	DI-276	0.10	0	0.95	0.192	5	6.415	1.17
		0.95	0.192					
DA-277	DI-277	0.10	0	0.95	0.080	5	6.415	0.49
		0.95	0.080					
DA-315	DI-315	0.10	0	0.95	0.125	5	6.415	0.76
		0.95	0.125					
DA-278	DI-278	0.10	0	0.95	0.110	5	7.594	0.79
		0.95	0.110					
DA-280	DI-280	0.10	0.050	0.84	0.380	7	6.021	1.92
		0.95	0.330					
DA-283	DI-283	0.10	0	0.95	0.075	5	7.124	0.51
		0.95	0.075					
DA-284	DI-284	0.10	0.218	0.55	0.461	8	5.668	1.43
		0.95	0.243					
DA-281	DI-281	0.10	0.031	0.84	0.241	5	6.415	1.30
		0.95	0.210					
DA-290	DI-290	0.10	0.020	0.85	0.162	5	6.415	0.88
		0.95	0.142					

Drainage Area	Outflow Element	Incremental		Weighted	Total Area	Time of Conc.	Rainfall Intensity	Flow
		C	A (acres)	C	A (acres)	Tc (min)	I (in/hr)	Q (cfs)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
DA-291	DI-291	0.10	0.021	0.89	0.275	5	6.415	1.56
		0.95	0.254					
DA-292	DI-292	0.10	0.010	0.88	0.121	5	6.415	0.68
		0.95	0.111					
DA-293	DI-293	0.10	0	0.95	0.181	5	6.415	1.10
		0.95	0.181					
DA-313	DI-313	0.10	0	0.95	0.113	5	6.415	0.69
		0.95	0.113					
DA-314	DI-314	0.10	0	0.95	0.092	5	6.415	0.56
		0.95	0.092					
DA-321	DI-321	0.10	0.112	0.65	0.314	5	6.415	1.30
		0.95	0.202					
DA-325	DI-325	0.10	2.31	0.69	7.55	18	4.09	21.30
		0.95	5.24					
DA-400	DI-400	0.10	0	0.95	0.089	5	6.415	0.54
		0.95	0.089					
DA-401	DI-401	0.10	0	0.95	0.105	5	6.415	0.64
		0.95	0.105					
DA-402	DI-402	0.10	0	0.95	0.119	5	6.415	0.73
		0.95	0.119					
DA-403	DI-403	0.10	0	0.95	0.082	5	6.415	0.50
		0.95	0.082					
DA-404	DI-404	0.10	0	0.95	0.089	5	7.594	0.64
		0.95	0.089					
DA-405	DI-405	0.10	0.024	0.70	0.082	5	6.415	0.37
		0.95	0.058					
DA-500	DI-500	0.10	0	0.95	0.210	5	6.415	1.28
		0.95	0.210					

Notes:

1. 50- year storm event was used for Inlets 153, 163, 180, 181, 214, 217, 275, 278 and 404 in accordance with Figure 6-1: Design Criteria - Frequency for sag areas.

2. 25- year storm event was used for Inlets 164, 165, 166 and 283 in accordance with Figure 6-1: Design Criteria - Frequency for median drains.

3. Inlets 106, 123, 124, 125, 127, 200, 210, 230, 231, 244, 245, 255, 256, 263, 284 & 405 are located in swales with no curb and gutter.

4. Runoff Coefficients,C, in accordance with Figure 6-8 of Chapter 6 Road Design Manual:

Earth Surface - Sandy soil, Light Vegetation C=0.10

Pavements - Concrete C=0.95

Appendix C

Drainage Inlet Spread Width Calculations

Inlet Spacing Calculations

Figure 6B-12 modified, Chapter 6 DelDOT Road Design Manual

INLET SPACING COMPUTATION SHEET									**Project No.** T201504401		**Sheet No.** 1		**of** 5							
									Computed By: DEN		**Chk. By:** JJK									
INLET		**GUTTER DISCHARGE** **Design Frequency:** varies, see column 3							**GUTTER DISCHARGE** **Allowable Spread:** varies, see column 16								**INLET DISCHARGE**				
No.	Sta.	Design Frequency (yr)	Drain Area ΔA (ac)	Runoff Coefficient C	Time of Concentration tt (min)	Rainfall Intensity I (in/hr)	ΔQ = ΔCIΔA (ft3/s)	Longitudinal Slope SL (%)	Cross Slope Sx or Sw (%)	Previous Bypass Flow (ft3 /s)	Total Gutter Flow (ft3/s)	Gutter Depth d (ft)	Grate or Gutter Width W (ft)	Spread T (ft)	Allowable Spread (ft)	W/T	Inlet Type	Interception Qi (ft3/s)	Bypass Flow Qb (ft3/s)	Efficiency (%)	Notes
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
DI-100	6010+92.14	10	0.193	0.95	5	6.415	1.18	1.42	4.00	0.00	1.18	0.18	1.67	4.3	10	0.39	4	0.96	0.23	80.7	
DI-101	6012+92.09	10	0.245	0.73	5	6.415	1.15	3.00	4.00	0.23	1.38	0.16	1.67	4.0	10	0.42	4	1.12	0.26	81.2	
DI-102	6015+52.13	10	0.291	0.81	5	6.415	1.51	3.00	4.00	0.26	1.77	0.18	1.67	4.4	10	0.38	4	1.38	0.41	77.1	
DI-108	6016+19.42	10	0.061	0.95	5	6.415	0.37	2.00	2.00	0.00	0.37	0.08	1.67	4.1	5	0.41	4	0.31	0.07	81.6	
DI-103	6016+28.37	10	0.110	0.95	5	6.415	0.67	3.00	4.00	0.41	1.08	0.13	1.67	3.0	10	0.56	4	0.61	0.09	87.1	
DI-104	6018+00.33	10	0.260	0.95	5	6.415	1.58	3.00	4.00	0.09	1.67	0.17	1.67	4.2	10	0.40	4	1.26	0.34	78.8	
DI-105	6020+78.30	10	0.223	0.95	5	6.415	1.36	3.00	4.00	0.34	1.70	0.16	1.67	4.0	10	0.42	4	1.11	0.26	81.0	
DI-106	6014+96.82	10	1.074	0.46	5	6.415	3.17	-	4.00	0.00	3.17	(N/A)	1.67	(N/A)	(N/A)	(N/A)	2	3.17	0.00	100.0	
DI-110	400+74.04	10	0.252	0.47	5	6.415	0.76	2.69	2.00	0.00	0.76	0.10	1.67	5.0	10	0.33	4	0.55	0.21	72.4	
DI-120	6033+37.63	10	0.115	0.79	5	6.415	0.58	1.44	4.00	0.00	0.58	0.13	1.67	3.3	10	0.51	4	0.53	0.06	89.8	
DI-121	6031+06.16	10	0.306	0.79	5	6.415	1.55	1.44	4.00	0.06	1.61	0.19	1.67	4.8	10	0.3479	4	1.23	0.39	75.9	
DI-122	6029+99.19	10	0.140	0.79	5	6.415	0.71	1.44	4.00	0.39	1.10	0.17	1.67	4.2	10	0.3976	4	0.90	0.20	81.8	
DI-124	6034+73.00	10	0.324	0.52	5	6.415	1.08	-	4.00	0.00	1.08	(N/A)	1.67	(N/A)	(N/A)	(N/A)	2	1.09	0.00	100.0	
DI-125	6033+01.79	10	0.204	0.78	5	6.415	1.02	-	4.00	0.00	1.02	(N/A)	1.67	(N/A)	(N/A)	(N/A)	2	1.02	0.00	100.0	
DI-123	6029+99.81	10	0.390	0.73	5	6.415	1.83	-	4.00	0.00	1.83	(N/A)	1.67	(N/A)	(N/A)	(N/A)	2	1.85	0.00	100.0	
DI-127	7029+98.12	10	0.010	0.10	5	6.415	0.01	-	4.00	0.00	0.01	(N/A)	1.67	(N/A)	(N/A)	(N/A)	2	0.01	0.00	100.0	
DI-131	6041+06.00	10	0.245	0.63	5	6.415	0.99	1.07	4.00	0.00	0.99	0.17	1.67	4.3	10	0.3884	4	0.83	0.17	83.0	
DI-132	600+40.69	10	0.222	0.63	5	6.415	0.90	1.07	4.00	0.17	1.07	0.18	1.67	4.4	10	0.38	4	0.88	0.20	81.5	
DI-133	600+69.81	10	0.137	0.85	5	6.415	0.75	2.00	2.00	0.20	0.95	0.12	1.67	5.7	7	0.29	4	0.64	0.3	68.1	
DI-134	601+01.36	10	0.058	0.95	5	6.415	0.35	2.00	2.00	0.30	0.65	0.08	1.67	4.0	7	0.42	4	0.30	0.06	83.3	
DI-135	601+00.65	10	0.071	0.95	5	6.415	0.43	2.00	2.00	0.00	0.43	0.08	1.67	4.3	7	0.39	4	0.35	0.09	79.5	
DI-136	600+73.35	10	0.036	0.95	5	6.415	0.22	2.00	2.00	0.09	0.31	0.08	1.67	3.8	7	0.44	4	0.26	0.05	83.9	
DI-137	600+54.60	10	0.151	0.95	5	6.415	0.92	2.00	2.00	0.05	0.97	0.12	1.67	5.8	7	0.29	4	0.66	0.32	67.3	

Figure 6B-12 modified, Chapter 6 DelDOT Road Design Manual

INLET SPACING COMPUTATION SHEET — **Project No.** T201504401 **Sheet No.** 2 **of** 5 — **Computed By:** DEN **Chk. By:** JJK

INLET		GUTTER DISCHARGE **Design Frequency:** varies, see column 3							GUTTER DISCHARGE **Allowable Spread:** varies, see column 16								INLET DISCHARGE				Notes
No.	Sta.	Design Frequency (yr)	Drain Area ΔA (ac)	Runoff Coefficient C	Time of Concentration tt (min)	Rainfall Intensity I (in/hr)	ΔQ = ΔCIΔA (ft3/s)	Longitudinal Slope SL (%)	Cross Slope Sx or Sw (%)	Previous Bypass Flow (ft3 /s)	Total Gutter Flow (ft3/s)	Gutter Depth d (ft)	Grate or Gutter Width W (ft)	Spread T (ft)	Allowable Spread (ft)	W/T	Inlet Type	Interception Qi (ft3/s)	Bypass Flow Qb (ft3/s)	Efficiency (%)	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
DI-138	6046+50.01	10	0.253	0.95	5	6.415	1.54	1.07	4.00	0.00	1.54	0.20	1.67	5.0	10	0.33	4	1.19	0.37	76.3	
DI-140	20+81.96	10	0.146	0.95	5	6.415	0.89	2.00	4.00	0.00	0.89	0.14	1.67	3.6	7	0.46	4	0.77	0.13	85.6	
DI-141	20+83.51	10	0.104	0.95	5	6.415	0.63	2.00	4.00	0.00	0.63	0.13	1.67	3.2	7	0.52	4	0.57	0.06	90.5	
DI-150	382+75.65	10	0.270	0.95	5	6.415	1.65	3.11	2.00	0.00	1.65	0.13	1.67	6.5	10	0.26	4	1.00	0.66	60.2	
DI-151	381+49.67	10	0.118	0.91	5	6.415	0.69	3.11	2.00	0.66	1.35	0.12	1.67	6.0	10	0.28	4	0.86	0.49	63.7	
DI-152	384+14.52	10	0.074	0.92	5	6.415	0.44	3.11	2.00	0.49	0.93	0.11	1.67	5.2	10	0.32	4	0.65	0.28	69.9	
DI-160	382+79.76	10	0.480	0.80	5	6.415	2.46	3.11	2.00	0.00	2.46	0.15	1.67	7.6	10	0.22	4	1.34	1.14	54.0	
DI-161	383+51.19	10	0.097	0.74	5	6.415	0.46	3.11	2.00	1.14	1.60	0.13	1.67	6.4	10	0.26	4	0.98	0.63	60.9	
DI-162	384+14.47	10	0.103	0.65	5	6.415	0.43	3.11	2.00	0.63	1.06	0.11	1.67	5.5	10	0.30	4	0.72	0.35	67.3	
DI-163	384+49.18	50	0.151	0.61	5	7.594	0.70	-	2.00	0.35	1.05	0.18	1.67	9.2	10	0.18	1	1.19	0.00	100.0	
DI-164	384+47.39	25	0.105	0.95	5	7.124	0.71	3.11	2.00	0.00	0.71	0.09	1.67	4.8	10	0.35	4	0.53	0.19	73.6	
DI-166	384+43.04	25	0.010	0.95	5	7.124	0.07	3.11	2.00	0.00	0.07	0.04	1.67	2.0	10	0.84	4	0.07	0.00	100.0	
DI-165	384+48.77	25	0.182	0.95	5	7.124	1.23	3.11	2.00	0.00	1.23	0.12	1.67	5.8	10	0.29	4	0.81	0.44	64.8	
DI-153	384+43.50	50	0.116	0.81	5	7.594	0.71	-	2.00	0.36	1.07	0.18	1.67	9.3	10	0.18	1	1.23	0.00	100.0	
DI-154	384+60.33	10	0.117	0.87	5	6.415	0.65	0.50	4.00	0.09	0.74	0.17	1.67	4.2	10	0.40	4	0.58	0.08	87.9	
DI-155	6063+05.90	10	0.124	0.87	5	6.415	0.69	0.50	4.00	0.00	0.69	0.18	1.67	4.3	10	0.39	4	0.61	0.09	87.1	
DI-255	6060+42.27	10	0.650	0.47	5	6.415	1.96	-	2.00	0.00	1.96	(N/A)	1.67	(N/A)	(N/A)	(N/A)	4	1.96	0.00	100.0	
DI-256	6063+27.65	10	0.480	0.63	5	6.415	1.94	-	2.00	0.00	1.94	(N/A)	1.67	(N/A)	(N/A)	(N/A)	4	1.96	0.00	100.0	
DI-170	2000+98.98	10	0.075	0.95	5	6.415	0.46	0.70	4.00	0.00	0.46	0.13	1.67	3.4	6	0.49	4	0.42	0.04	91.3	
DI-171	2000+98.87	10	0.014	0.95	5	6.415	0.09	0.70	4.00	0.00	0.09	0.08	1.67	1.8	6	0.93	4	0.09	0.00	100.0	

Figure 6B-12 modified, Chapter 6 DelDOT Road Design Manual

INLET SPACING COMPUTATION SHEET — **Project No.** T201504401 **Sheet No.** 3 **of** 5 — **Computed By:** DEN **Chk. By:** JJK

INLET		GUTTER DISCHARGE **Design Frequency:** varies, see column 3							GUTTER DISCHARGE **Allowable Spread:** varies, see column 16								INLET DISCHARGE				Notes
No.	Sta.	Design Frequency (yr)	Drain Area ΔA (ac)	Runoff Coefficient C	Time of Concentration tt (min)	Rainfall Intensity I (in/hr)	ΔQ = ΔCIΔA (ft3/s)	Longitudinal Slope SL (%)	Cross Slope Sx or Sw (%)	Previous Bypass Flow (ft3 /s)	Total Gutter Flow (ft3/s)	Gutter Depth d (ft)	Grate or Gutter Width W (ft)	Spread T (ft)	Allowable Spread (ft)	W/T	Inlet Type	Interception Qi (ft3/s)	Bypass Flow Qb (ft3/s)	Efficiency (%)	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
DI-180	20+83.59	50	0.145	0.95	5	7.594	1.05	-	4.00	0.00	1.05	0.19	1.67	4.9	6	0.34	1	1.05	0.00	100.0	
DI-181	20+83.57	50	0.050	0.95	5	7.594	0.36	-	4.00	0.00	0.36	0.12	1.67	3.0	6	0.56	1	0.36	0.00	100.0	
DI-200	7014+32.73	10	1.020	0.49	5	6.415	3.21	-	4.00	0.00	3.21	(N/A)	1.67	(N/A)	(N/A)	(N/A)	2	3.21	0.00	100.0	
DI-201	305+56.57	10	0.079	0.95	5	6.415	0.48	1.21	2.00	0.00	0.48	0.10	1.67	4.9	7.5	0.34	4	0.38	0.11	77.6	
DI-202	306+01.68	10	0.084	0.95	5	6.415	0.51	1.21	2.00	0.11	0.62	0.10	1.67	5.0	7.5	0.33	4	0.40	0.12	76.9	
DI-203	7016+81.86	10	0.190	0.95	5	6.415	1.16	3.10	4.00	0.12	1.28	0.15	1.67	3.7	10	0.45	4	0.98	0.19	83.8	
DI-204	7019+17.37	10	0.216	0.84	5	6.415	1.16	3.10	4.00	0.19	1.35	0.15	1.67	3.7	10	0.45	4	0.98	0.19	83.8	
DI-210	106+38.04	10	0.040	0.10	5	6.415	0.03	-	4.00	0.00	0.03	(N/A)	1.67	(N/A)	(N/A)	(N/A)	2	0.03	0.00	100.0	
DI-213	106+69.10	10	0.105	0.95	5	6.415	0.64	0.70	4.00	0.00	0.64	0.16	1.67	3.9	10	0.43	4	0.57	0.08	87.7	
DI-214	106+38.01	50	0.103	0.95	5	7.594	0.74	-	4.00	0.08	0.82	0.18	1.67	4.4	10	0.38	4	0.85	0.00	100.0	
DI-215	107+67.25	10	0.230	0.95	5	6.415	1.40	0.70	4.00	0.00	1.40	0.21	1.67	5.3	6.5	0.32	4	1.10	0.32	77.5	
DI-216	106+68.28	10	0.113	0.95	5	6.415	0.69	0.70	4.00	0.32	1.01	0.18	1.67	4.6	6.5	0.36	4	0.83	0.18	82.2	
DI-217	106+38.22	50	0.040	0.95	5	7.594	0.29	-	4.00	0.64	0.93	0.20	1.67	5.1	6.5	0.33	4	1.14	0.00	100.0	
DI-218	106+06.89	10	0.290	0.95	5	6.415	1.77	0.70	4.00	0.00	1.77	0.23	1.67	5.7	6.5	0.29	4	1.32	0.46	74.2	
DI-220	727+03.97	10	0.113	0.95	5	6.415	0.69	1.40	4.00	0.00	0.69	0.14	1.67	3.5	10	0.4771	4	0.61	0.08	88.4	
DI-221	726+99.86	10	0.095	0.95	5	6.415	0.58	1.40	4.00	0.00	0.58	0.13	1.67	3.3	10	0.51	4	0.53	0.06	89.8	
DI-230	6040+60.82	10	0.230	0.79	5	6.415	1.17	-	4.00	0.00	1.17	(N/A)	1.67	(N/A)	(N/A)	(N/A)	2	1.18	0.00	100.0	
DI-231	6042+66.02	10	0.259	0.78	5	6.415	1.30	-	4.00	0.00	1.30	(N/A)	1.67	(N/A)	(N/A)	(N/A)	2	1.31	0.00	100.0	
DI-232	502+05.21	10	0.199	0.80	5	6.415	1.02	1.97	4.00	0.00	1.02	0.15	1.67	3.8	10	0.44	4	0.86	0.17	83.5	
DI-233	502+10.06	10	0.180	0.95	5	6.415	1.10	1.97	4.00	0.00	1.10	0.16	1.67	4.0	10	0.42	4	0.91	0.19	82.7	

Figure 6B-12 modified, Chapter 6 DelDOT Road Design Manual

INLET SPACING COMPUTATION SHEET — **Project No.** T201504401 **Sheet No.** 4 **of** 5 — **Computed By:** DEN **Chk. By:** JJK

INLET		GUTTER DISCHARGE **Design Frequency:** varies, see column 3							GUTTER DISCHARGE **Allowable Spread:** varies, see column 16								INLET DISCHARGE				Notes
No.	Sta.	Design Frequency (yr)	Drain Area ΔA (ac)	Runoff Coefficient C	Time of Concentration tt (min)	Rainfall Intensity I (in/hr)	ΔQ = ΔCIΔA (ft3/s)	Longitudinal Slope SL (%)	Cross Slope Sx or Sw (%)	Previous Bypass Flow (ft3 /s)	Total Gutter Flow (ft3/s)	Gutter Depth d (ft)	Grate or Gutter Width W (ft)	Spread T (ft)	Allowable Spread (ft)	W/T	Inlet Type	Interception Qi (ft3/s)	Bypass Flow Qb (ft3/s)	Efficiency (%)	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
DI-240	751+95.02	10	0.167	0.95	5	6.415	1.02	2.03	2.00	0.00	1.02	0.12	1.67	5.9	8	0.28	4	0.68	0.34	66.7	
DI-241	751+99.32	10	0.061	0.95	5	6.415	0.37	2.03	2.00	0.00	0.37	0.08	1.67	4.0	8	0.42	4	0.31	0.07	81.6	
DI-242	701+54.66	10	0.096	0.95	5	6.415	0.59	2.00	2.00	0.00	0.59	0.10	1.67	4.8	8	0.35	4	0.45	0.14	76.3	
DI-243	701+54.98	10	0.063	0.95	5	6.415	0.38	2.00	2.00	0.00	0.38	0.08	1.67	4.1	8	0.41	4	0.32	0.07	82.1	
DI-244	7061+41.10	10	0.370	0.84	5	6.415	1.99	-	2.00	0.00	1.99	(N/A)	1.67	(N/A)	(N/A)	(N/A)	2	2.00	0.00	100.0	
DI-245	7062+58.20	10	0.204	0.48	5	6.415	0.63	-	2.00	0.00	0.63	(N/A)	1.67	(N/A)	(N/A)	(N/A)	2	0.63	0.00	100.0	
DI-263	6067+02.32	10	0.458	0.65	5	6.415	1.91	-	4.00	0.00	1.91	(N/A)	1.67	(N/A)	(N/A)	(N/A)	2	1.93	0.00	100.0	
DI-270	7068+37.56	10	0.100	0.95	5	6.415	0.61	0.50	4.00	0	0.61	0.17	1.67	4.1	10	0.41	4	0.54	0.07	88.5	
DI-271	7067+02.34	10	0.122	0.95	5	6.415	0.74	1.01	4.00	0.07	0.81	0.16	1.67	4.0	10	0.42	4	0.70	0.12	85.4	
DI-272	1000+32.46	10	0.059	0.95	5	6.415	0.36	1.01	4.00	0.12	0.48	0.13	1.67	3.2	10	0.52	4	0.44	0.04	91.7	
DI-273	1000+51.99	10	0.065	0.95	5	6.415	0.40	1.01	4.00	0.04	0.44	0.13	1.67	3.2	10	0.52	4	0.41	0.03	93.2	
DI-274	1000+89.63	10	0.194	0.95	5	6.415	1.18	1.01	4.00	0.03	1.21	0.18	1.67	4.7	10	0.36	4	0.98	0.25	79.7	
DI-279	001+81.18	10	0.220	0.95	5	6.415	1.34	3.94	4.00	0.00	1.34	0.15	1.67	3.7	10	0.45	4	1.12	0.23	83.0	
DI-275	1001+42.22	50	0.190	0.95	5	7.594	1.37	-	4.00	0.48	1.85	0.28	1.67	6.9	10	0.24	1	2.03	0.00	100.0	
DI-276	1000+49.92	10	0.192	0.95	5	6.415	1.17	1.01	4.00	0.00	1.17	0.18	1.67	4.6	10	0.36	4	0.95	0.23	80.5	
DI-277	1000+89.46	10	0.080	0.95	5	6.415	0.49	1.01	4.00	0.23	0.72	0.15	1.67	3.8	10	0.44	4	0.63	0.09	87.5	
DI-315	1001+81.23	10	0.125	0.95	5	6.415	0.76	3.94	4.00	0.00	0.76	0.13	1.67	3.0	10	0.56	4	0.70	0.07	90.9	
DI-278	1001+42.22	50	0.110	0.95	5	7.594	0.79	-	4.00	0.16	0.95	0.19	1.67	4.8	10	0.35	1	1.05	0.00	100.0	
DI-280	7073+77.09	10	0.380	0.84	7	6.021	1.92	0.50	4.00	0.00	1.92	0.25	1.67	6.3	10	0.27	4	1.42	0.51	73.6	
DI-283	7078+03.46	25	0.075	0.95	5	7.124	0.51	0.24	4.00	0.00	0.51	0.17	1.67	4.2	10	0.40	4	0.42	0.04	91.3	
DI-284	6076+42.54	10	0.461	0.55	8	5.668	1.44	-	2.00	0.00	1.44	(N/A)	1.67	(N/A)	(N/A)	(N/A)	2	1.44	0.00	100.0	
DI-281	7076+43.35	10	0.241	0.84	5	6.415	1.30	0.50	4.00	0.51	1.81	0.22	1.67	5.4	10	0.31	4	1.04	0.27	79.4	

Figure 6B-12 modified, Chapter 6 DelDOT Road Design Manual

INLET SPACING COMPUTATION SHEET — **Project No.** T201504401 **Sheet No.** 5 **of** 5 — **Computed By:** DEN **Chk. By:** JJK

INLET		GUTTER DISCHARGE **Design Frequency:** varies, see column 3							GUTTER DISCHARGE **Allowable Spread:** varies, see column 16								INLET DISCHARGE				Notes
No.	Sta.	Design Frequency (yr)	Drain Area ΔA (ac)	Runoff Coefficient C	Time of Concentration tt (min)	Rainfall Intensity I (in/hr)	ΔQ = ΔCIΔA (ft3/s)	Longitudinal Slope SL (%)	Cross Slope Sx or Sw (%)	Previous Bypass Flow (ft3 /s)	Total Gutter Flow (ft3/s)	Gutter Depth d (ft)	Grate or Gutter Width W (ft)	Spread T (ft)	Allowable Spread (ft)	W/T	Inlet Type	Interception Qi (ft3/s)	Bypass Flow Qb (ft3/s)	Efficiency (%)	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
DI-290	7078+22.76	10	0.162	0.85	5	6.415	0.88	0.24	4.00	0.00	0.88	0.22	1.67	5.4	10	0.31	4	0.76	0.13	85.4	
DI-291	7080+06.13	10	0.275	0.89	5	6.415	1.57	0.24	4.00	0.13	1.70	0.28	1.67	6.9	10	0.24	4	1.33	0.38	77.8	
DI-292	7080+93.30	10	0.121	0.88	5	6.415	0.68	0.24	4.00	0.38	1.06	0.23	1.67	5.8	10	0.29	4	0.89	0.17	84.0	
DI-293	7082+69.59	10	0.181	0.95	5	6.415	1.10	0.24	4.00	0.17	1.27	0.25	1.67	6.2	10	0.27	4	1.05	0.24	81.4	
DI-313	1003+32.07	10	0.113	0.95	5	6.415	0.69	3.94	4.00	0.00	0.69	0.12	1.67	2.9	10	0.58	4	0.64	0.06	91.4	
DI-314	1003+24.61	10	0.092	0.95	5	6.415	0.56	3.94	4.00	0.00	0.56	0.11	1.67	2.7	10	0.62	4	0.53	0.03	94.6	
DI-321	6053+24.14	10	0.314	0.65	5	6.415	1.31	-	2.00	0.00	1.31	(N/A)	1.67	(N/A)	(N/A)	(N/A)	2	1.31	0.00	100.0	
DI-325	7055+26.71	10	7.55	0.69	18	4.09	21.31	-	2.00	0.00	21.31	(N/A)	1.67	(N/A)	(N/A)	(N/A)	2	21.48	0.00	100.0	
DI-400	107+77.43	10	0.089	0.95	5	6.415	0.54	1.39	4.00	0.00	0.54	0.13	1.67	3.3	6	0.51	4	0.50	0.05	90.9	
DI-401	107+80.29	10	0.105	0.95	5	6.415	0.64	1.39	4.00	0.05	0.69	0.14	1.67	3.5	6	0.48	4	0.57	0.07	89.1	
DI-402	7026+02.88	10	0.119	0.95	5	6.415	0.73	1.39	4.00	0.07	0.80	0.14	1.67	3.6	10	0.46	4	0.64	0.09	87.7	
DI-403	7025+15.93	10	0.082	0.95	5	6.415	0.50	1.39	4.00	0.09	0.59	0.13	1.67	3.3	10	0.51	4	0.54	0.06	90.0	
DI-404	7024+25.62	50	0.089	0.95	5	7.594	0.64	1.39	4.00	0.06	0.70	0.14	1.67	3.6	10	0.46	1	0.64	0.09	87.7	
DI-405	7023+85.05	10	0.082	0.70	5	6.415	0.37	-	4.00	0.09	0.46	(N/A)	1.67	(N/A)	(N/A)	(N/A)	2	0.37	0.00	100.0	
DI-500	103+42.26	10	0.210	0.95	5	6.415	1.28	0.7	4.00	0.00	1.28	0.2	1.67	5.1	6.5	0.33	4	1.02	0.27	79.1	

Notes:
1. **50- year storm event was used for Inlets 153, 163, 180, 181, 214, 217, 275, 278 and 404 in accordance with Figure 6-1: Design Criteria - Frequency for sag areas.**
2. **25- year storm event was used for Inlets 164, 165, 166 and 283 in accordance with Figure 6-1: Design Criteria - Frequency for median drains.**
3. **Inlets 106, 123, 124, 125, 127, 200, 210, 230, 231, 244, 245, 255, 256, 263, 284 & 405 are located in swales with no curb and gutter.**

Appendix C.1

Flanking Inlet Calculations

Flanking Inlet Calculations

Inlet	Length of Vertical Curve (ft)	Grade 1 (%)	Grade 2 (%)	Algebraic Difference in Approach Grades	Spacing Distance X (ft)
153	110	-1.00	3.11	4.11	327.19
163	110	-1.00	3.11	4.11	327.19
180	80	-2.06	1.25	3.31	310.93
181	80	-2.06	1.25	3.31	310.93
214	500	-0.70	5.00	5.70	592.35
217	500	-0.70	5.00	5.70	592.35
275	480	-1.01	3.94	4.95	622.80
278	480	-1.01	3.94	4.95	622.80
404	970	-3.10	1.39	4.49	929.59

Notes: 1. Flanking Inlet Calculations completed in accordance with Section 6.8.2.6.8.1 Design Criteria of Chapter 6 Road Design Manual.

Appendix C.2

Example Spread Width Calculations (Hydraulic Toolbox 4.2)

Hydraulic Analysis Report

Project Data

Project Title: Elkton Road, Casho Mill Road to State Line

Designer: JMT

Project Date: Friday, August 11, 2017

Project Units: U.S. Customary Units

Notes:

Curb and Gutter Analysis: DI-105

Notes:

Gutter Input Parameters

Longitudinal Slope of Road: 0.0300 ft/ft

Cross-Slope of Pavement: 0.0400 ft/ft

Uniform Gutter Geometry

Manning's n: 0.0130

Gutter Width: 1.0000 ft

Design Flow: 1.3600 cfs

Gutter Result Parameters

Width of Spread: 3.9490 ft

Gutter Depression: 0.0000 in

Area of Flow: 0.3119 ft^2

Eo (Gutter Flow to Total Flow): 0.5414

Gutter Depth at Curb: 1.8955 in

Inlet Input Parameters

Inlet Location: Inlet on Grade

Inlet Type: Grate

Grate Type: Curved vane

Grate Width: 1.6670 ft

Grate Length: 3.0000 ft

Local Depression: 0.0625 in

Inlet Result Parameters

Intercepted Flow: 1.1055 cfs

Bypass Flow: 0.2545 cfs

Approach Velocity: 4.3605 ft/s

Splash-over Velocity: 7.5684 ft/s

Efficiency: 0.8128

Curb and Gutter Analysis: DI-217

Notes:

Gutter Input Parameters

Longitudinal Slope of Road: 0.0070 ft/ft

Cross-Slope of Pavement: 0.0400 ft/ft

Uniform Gutter Geometry

Manning's n: 0.0130

Gutter Width: 1.0000 ft

Design Flow: 1.1400 cfs

Gutter Result Parameters

Width of Spread: 4.8557 ft

Gutter Depression: 0.0000 in

Area of Flow: 0.4716 ft^2

Eo (Gutter Flow to Total Flow): 0.4597

Gutter Depth at Curb: 2.3307 in

Inlet Input Parameters

Inlet Location: Inlet in Sag

Percent Clogging: 1.5000 %

Inlet Type: Grate

Grate Type: Curved vane

Grate Width: 1.6670 ft

Grate Length: 3.0000 ft

Local Depression: 0.0625 in

Inlet Result Parameters

Perimeter: 6.3340 ft

Effective Perimeter: 6.2390 ft

Area: 1.7504 ft^2

Effective Area: 1.7241 ft^2

Depth at center of grate: 0.1548 ft

Computed Width of Spread at Sag: 4.7036 ft

Flow type: Weir Flow

Efficiency: 1.0000

Curb and Gutter Analysis: DI-278

Notes:

Gutter Input Parameters

Longitudinal Slope of Road: 0.0101 ft/ft

Cross-Slope of Pavement: 0.0400 ft/ft

Uniform Gutter Geometry

Manning's n: 0.0130

Gutter Width: 1.0000 ft

Design Flow: 1.0500 cfs

Gutter Result Parameters

Width of Spread: 4.3955 ft

Gutter Depression: 0.0000 in

Area of Flow: 0.3864 ft^2

Eo (Gutter Flow to Total Flow): 0.4980

Gutter Depth at Curb: 2.1098 in

Inlet Input Parameters

Inlet Location: Inlet in Sag

Percent Clogging: 1.5000 %

Inlet Type: Grate

Grate Type: Curved vane

Grate Width: 1.6670 ft

Grate Length: 3.0000 ft

Local Depression: 0.0625 in

Inlet Result Parameters

Perimeter: 6.3340 ft

Effective Perimeter: 6.2390 ft

Area: 1.7504 ft^2

Effective Area: 1.7241 ft^2

Depth at center of grate: 0.1465 ft

Computed Width of Spread at Sag: 4.4971 ft

Flow type: Weir Flow

Efficiency: 1.0000

Curb and Gutter Analysis: DI-314

Notes:

Gutter Input Parameters

Longitudinal Slope of Road: 0.0394 ft/ft

Cross-Slope of Pavement: 0.0400 ft/ft

Uniform Gutter Geometry

Manning's n: 0.0130

Gutter Width: 1.0000 ft

Design Flow: 0.5600 cfs

Gutter Result Parameters

Width of Spread: 2.6902 ft

Gutter Depression: 0.0000 in

Area of Flow: 0.1447 ft^2

Eo (Gutter Flow to Total Flow): 0.7109

Gutter Depth at Curb: 1.2913 in

Inlet Input Parameters

Inlet Location: Inlet on Grade

Inlet Type: Grate

Grate Type: Curved vane

Grate Width: 1.6670 ft

Grate Length: 3.0000 ft

Local Depression: 0.0625 in

Inlet Result Parameters

Intercepted Flow: 0.5272 cfs

Bypass Flow: 0.0328 cfs

Approach Velocity: 3.8689 ft/s

Splash-over Velocity: 7.5684 ft/s

Efficiency: 0.9414

Curb and Gutter Analysis: DI-403

Notes:

Gutter Input Parameters

Longitudinal Slope of Road: 0.0139 ft/ft

Cross-Slope of Pavement: 0.0400 ft/ft

Uniform Gutter Geometry

Manning's n: 0.0130

Gutter Width: 1.0000 ft

Design Flow: 0.5900 cfs

Gutter Result Parameters

Width of Spread: 3.3352 ft

Gutter Depression: 0.0000 in

Area of Flow: 0.2225 ft^2

Eo (Gutter Flow to Total Flow): 0.6139

Gutter Depth at Curb: 1.6009 in

Inlet Input Parameters

Inlet Location: Inlet on Grade

Inlet Type: Grate

Grate Type: Curved vane

Grate Width: 1.6670 ft

Grate Length: 3.0000 ft

Local Depression: 0.0625 in

Inlet Result Parameters

Intercepted Flow: 0.5311 cfs

Bypass Flow: 0.0589 cfs

Approach Velocity: 2.6520 ft/s

Splash-over Velocity: 7.5684 ft/s

Efficiency: 0.9002

Appendix D

Swale Capacity Calculations

Swale Capacity Calculations

Drainage Area ID	From	To	Contributing Drainage Area	Incremental		Total		Weighted C	Total Area (acres)	Time of Conc. (min)	I (in/hr)	Q (cfs)	Ditch Bottom (ft)	Longitudinal Slope (ft/ft)	Front Slope (ft:ft)	Back Slope (ft:ft)	Depth of Flow (ft)	Velocity (ft/s)	Shear Stress (psf)	Stabilization	Notes
				C	A (acres)	C	A (acres)														
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
WB Elkton Swale 1	6009+85 RT	6013+45 RT	-	0.10	0.45	0.10	0.45	0.48	0.82	5.00	7.13	2.83	4.00	0.023	8:1	8:1	0.27	1.71	0.39	ECB	
				0.95	0.37	0.95	0.37														
EB Elkton Swale 2	7009+32 RT	7011+31 RT	-	0.10	0.28	0.10	0.28	0.45	0.48	5.00	7.13	1.56	4.00	0.012	4:1	4:1	0.25	1.26	0.19	ECB	
				0.95	0.20	0.95	0.20														
WB Elkton Swale 3A	6017+00 RT	6019+90 RT	Swale 1, DA-106	0.10	0.23	0.10	0.83	0.49	1.54	9.48	5.78	4.38	4.00	0.028	8:1	8:1	0.32	2.07	0.56	ECB	
				0.95	0.23	0.95	0.71														
WB Elkton Swale 3B	6021+63 RT	6022+40 RT	-	0.10	0.10	0.10	0.10	0.30	0.13	5.00	7.13	0.27	4.00	0.014	8:1	8:1	0.09	0.68	0.07	ECB	
				0.95	0.03	0.95	0.03														
EB Elkton Swale 4	7020+40 RT	7021+25 RT	Swale 2, DA-200, 201, 202, 203, 204	0.10	0.10	0.10	0.75	0.64	2.05	6.06	6.73	8.84	4.00	0.044	2:1	2:1	0.48	3.69	1.32	ECB	
				0.95	0.16	0.95	1.30														
WB Elkton Swale 5A	6027+25 LT	6025+93 LT	DA-110	0.10	0.14	0.10	0.30	0.64	0.81	5.00	7.13	3.73	4.00	0.012	4:1	4:1	0.40	1.65	0.30	ECB	
				0.95	0.16	0.95	0.52														
WB Elkton Swale 5B	6024+71 LT	6022+80 LT	Swale 5A	0.10	0.22	0.10	0.52	0.62	1.32	5.00	7.13	5.82	4.00	0.009	4:1	4:1	0.56	1.70	0.31	ECB	
				0.95	0.29	0.95	0.80														
EB Elkton Swale 6	7023+24 RT	7022+12 RT	DA-400, 401, 402, 403, 404, 405	0.10	0.10	0.10	0.12	0.82	0.78	5.00	7.13	4.51	4.00	0.005	2:1	2:1	0.61	1.42	0.19	ECB	
				0.95	0.11	0.95	0.65														
WB Elkton Swale 7	6027+25 RT	6025+15 RT	-	0.10	0.18	0.10	0.18	0.53	0.36	5.00	7.13	1.35	4.00	0.011	8:1	8:1	0.22	1.06	0.15	ECB	
				0.95	0.18	0.95	0.18														
EB Elkton Swale 8	7035+67 RT	7030+73 RT	DA-220, 221	0.10	0.40	0.10	0.40	0.66	1.18	7.26	6.34	4.94	4.00	0.013	4:1	4:1	0.46	1.85	0.37	ECB	
				0.95	0.57	0.95	0.78														
WB Elkton Swale 9A	6038+63 RT	6037+60 RT	-	0.10	0.03	0.10	0.03	0.73	0.12	5.00	7.13	0.62	-	0.005	13:1	8:1	0.30	0.66	0.09	ECB	
				0.95	0.09	0.95	0.09														
WB Elkton Swale 9B	6037+60 RT	6034+75 RT	Swale 9A	0.10	0.16	0.10	0.19	0.58	0.44	7.44	6.29	1.61	4.00	0.007	14:1	8:1	0.26	0.89	0.11	ECB	
				0.95	0.16	0.95	0.25														
WB Elkton Swale 9C	6034+71 RT	6033+04 RT	-	0.10	0.04	0.10	0.04	0.78	0.20	5.00	7.13	1.11	4.00	0.015	18:1	8:1	0.17	1.03	0.16	ECB	
				0.95	0.16	0.95	0.16														
WB Elkton Swale 9D	6033+00 RT	6030+02 RT	-	0.10	0.10	0.10	0.10	0.73	0.39	5.00	7.13	2.04	4.00	0.014	16:1	8:1	0.24	1.20	0.21	ECB	
				0.95	0.29	0.95	0.29														
WB Elkton Swale 10	6039+46 LT	6036+10 LT	-	0.10	0.29	0.10	0.29	0.52	0.57	6.42	6.60	1.95	4.00	0.005	4:1	4:1	0.36	1.00	0.11	ECB	
				0.95	0.28	0.95	0.28														

Drainage Area ID	From	To	Contributing Drainage Area	Incremental		Total		Weighted C	Total Area (acres)	Time of Conc. (min)	I (in/hr)	Q (cfs)	Ditch Bottom (ft)	Longitudinal Slope (ft/ft)	Front Slope (ft:ft)	Back Slope (ft:ft)	Depth of Flow (ft)	Velocity (ft/s)	Shear Stress (psf)	Stabilization	Notes
				C	A (acres)	C	A (acres)														
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
WB Elkton Swale 11A	6038+63 RT	6040+59 RT	-	0.10	0.10	0.10	0.10	0.58	0.23	5.00	7.13	0.95	-	0.005	13:1	8:1	0.35	0.73	0.11	ECB	
				0.95	0.13	0.95	0.13														
WB Elkton Swale 11B	6040+63 RT	6042+64 RT	-	0.10	0.11	0.10	0.11	0.54	0.23	5.00	7.13	0.89	-	0.008	13:1	8:1	0.31	0.87	0.16	ECB	
				0.95	0.12	0.95	0.12														
EB Elkton Swale 12	7037+94 RT	7042+06 RT	-	0.10	0.30	0.10	0.30	0.62	0.77	7.56	6.26	2.98	4.00	0.008	4:1	4:1	0.40	1.34	0.20	ECB	
				0.95	0.47	0.95	0.47														
WB Elkton Swale 13	6044+63 LT	6046+82 LT	DA-131-138	0.10	0.17	0.10	0.37	0.73	1.40	6.78	6.49	6.60	4.00	0.008	4:1	4:1	0.61	1.69	0.30	ECB	
				0.95	0.03	0.95	1.03														
WB Elkton Swale 14A	6044+27 RT	6053+26 RT	-	0.10	0.55	0.10	0.55	0.53	1.11	18.90	4.32	2.53	-	0.007	13:1	8:1	0.48	1.06	0.21	ECB	
				0.95	0.56	0.95	0.56														
WB Elkton Swale 14B	6053+26 RT	6054+90 RT	Swale 14A	0.10	0.12	0.10	0.67	0.51	1.30	22.38	3.96	2.64	4.00	0.004	14:1	8:1	0.38	0.84	0.10	ECB	
				0.95	0.07	0.95	0.63														
EB Elkton Swale 15	7044+59 RT	7055+28 RT	Swale 11A,11B, Swale 12,DA 232-233	0.10	0.63	0.10	1.17	0.66	3.41	25.44	3.69	8.27	4.00	0.006	4:1	4:1	0.73	1.62	0.28	ECB	
				0.95	1.20	0.95	2.24														
WB Elkton Swale 16	6052+00 LT	6053+22 LT	-	0.10	0.10	0.10	0.10	0.65	0.28	5.00	7.13	1.29	4.00	0.007	4:1	4:1	0.26	0.99	0.11	ECB	
				0.95	0.18	0.95	0.18														
WB Elkton Swale 17	6055+00 RT	6060+40 RT	-	0.10	0.38	0.10	0.38	0.47	0.67	10.68	5.53	1.73	4.00	0.005	14:1	8:1	0.30	0.81	0.09	ECB	
				0.95	0.29	0.95	0.29														
WB Elkton Swale 18	6060+44 RT	6063+26 RT	-	0.10	0.13	0.10	0.13	0.67	0.39	6.30	6.64	1.73	4.00	0.005	14:1	8:1	0.30	0.81	0.09	ECB	
				0.95	0.26	0.95	0.26														
WB Elkton Swale 19A	6056+46 LT	6057+37 LT	-	0.10	0.15	0.10	0.15	0.55	0.32	5.00	7.13	1.26	4.00	0.009	4:1	4:1	0.24	1.07	0.13	ECB	
				0.95	0.17	0.95	0.17														
WB Elkton Swale 19B	6057+84 LT	6060+23 LT	Swale 19A	0.10	0.26	0.10	0.41	0.54	0.84	7.08	6.40	2.88	4.00	0.005	4:1	4:1	0.44	1.13	0.14	ECB	
				0.95	0.26	0.95	0.43														
WB Elkton Swale 19C	6061+74 LT	6062+70 LT	Swale 19B	0.10	0.16	0.10	0.57	0.53	1.16	8.16	6.10	3.76	4.00	0.025	3:1	3:1	0.71	2.52	1.10	ECB	
				0.95	0.16	0.95	0.59														
WB Elkton Swale 20	6069+48 RT	6067+04 RT	-	0.10	0.12	0.10	0.12	0.65	0.34	6.48	6.59	1.46	4.00	0.003	14:1	8:1	0.31	0.64	0.06	ECB	
				0.95	0.22	0.95	0.22														
EB Elkton Swale 21	7061+44 RT	7062+56 RT	-	0.10	0.08	0.10	0.08	0.57	0.18	5.00	7.13	0.73	4.00	0.005	4:1	4:1	0.21	0.73	0.07	ECB	
				0.95	0.10	0.95	0.10														
WB Elkton Swale 22	6069+48 LT	6066+85 LT	-	0.10	0.28	0.10	0.28	0.50	0.53	5.64	6.88	1.83	4.00	0.004	4:1	4:1	0.37	0.91	0.09	ECB	
				0.95	0.25	0.95	0.25														

Drainage Area ID	From	To	Contributing Drainage Area	Incremental		Total		Weighted C	Total Area (acres)	Time of Conc. (min)	I (in/hr)	Q (cfs)	Ditch Bottom (ft)	Longitudinal Slope (ft/ft)	Front Slope (ft:ft)	Back Slope (ft:ft)	Depth of Flow (ft)	Velocity (ft/s)	Shear Stress (psf)	Stabilization	Notes
				C	A (acres)	C	A (acres)														
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
WB Elkton Swale 23	6069+48 LT	6072+61 LT	-	0.10	0.24	0.10	0.24	0.53	0.49	7.26	6.34	1.66	4.00	0.003	4:1	4:1	0.38	0.80	0.07	ECB	
				0.95	0.25	0.95	0.25														
WB Elkton Swale 24	6069+48 RT	6072+44 RT	-	0.10	0.14	0.10	0.14	0.66	0.41	7.32	6.33	1.71	4.00	0.004	15:1	8:1	0.31	0.74	0.08	ECB	
				0.95	0.27	0.95	0.27														
WB Elkton Swale 25	6072+83 RT	6076+40 RT	-	0.10	0.22	0.10	0.22	0.54	0.46	7.92	6.16	1.54	4.00	0.005	14:1	8:1	0.28	0.78	0.09	ECB	
				0.95	0.24	0.95	0.24														
Otts Chapel Swale 26	106+64 LT	106+38 LT	-	0.10	0.02	0.10	0.02	0.10	0.02	5.00	7.13	0.01	-	0.002	4:1	4:1	0.11	0.21	0.01	ECB	
				0.95	0.00	0.95	0.00														
Otts Chapel Swale 27	105+91 LT	106+38 LT	-	0.10	0.02	0.10	0.02	0.10	0.02	5.00	7.13	0.01	-	0.002	4:1	4:1	0.11	0.21	0.01	ECB	
				0.95	0.00	0.95	0.00														

Note: **1. Elkton Road is classified as a Principal Arterial. Swales calculations were completed using 25- year storm event (Figure 6-1 in DelDOT Road Design Manual)**

2. For Swale 9B, 9C, 9D, 18, 20, 24, 25, calculations were run to ensure the 25-year storm is contained within the swale. However, due to the road geometry the freeboard minimum depth is not met.

3. Incremental drainage area values for the contributing drainage areas in Column (4) can be found in the Drainage Area Summary, Appendix B. Column 5 and 6 include the incremental C A values for the local ditch section listed in Column 1. Columns 7 and 8 include the total drainage areas incluing the incremental areas and the contributing areas listed in Column 4.

4. Runoff Coefficients,C, in accordance with Figure 6-8 of Chapter 6 Road Design Manual:

Earth Surface - Sandy soil, Light Vegetation	**C=0.10**
Pavements - Concrete	**C=0.95**

Appendix D.1

Swale Time of Concentration Calculations

Worksheet 3: Time of concentration (Tc) or travel time (Tt)

Project : **Elkton Road, MD Line to Casho M** By **DEN** Date **8/11/2017**

Location : **Swale 1 (6009+85 - 6013+45 RT)** Checked _____ Date _____

County : **New Castle County, DE**

Circle one: Present [Developed] **ULTIMATE CONDITIONS**

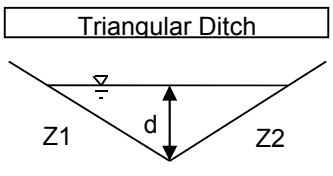
NOTE : Space for as many as three segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments

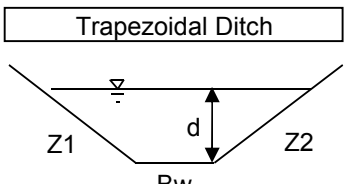
Sheet flow (Applicable to Tc only)		Segment ID	1-AB			
1. Surface Description (table 3-1)			Concrete			
2. Manning's roughness coeff., n (table 3-1)			0.011			
3. Flow length, L (total L ≤ 100 ft)	ft		82			
4. Two-yr 24-hr rainfall, P_2	in		3.2			
5. Upstream elevation			136			
6. Downstream elevation			135.44			
7. Land slope, s	ft/ft		0.007			
8. $T_t = 0.007\ (nL)^{0.8} / [(P_2^{0.5})(s^{0.4})]$	hr		0.026			= 0.026

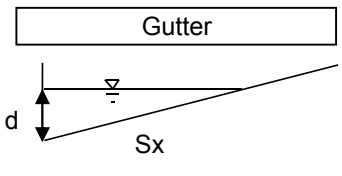
Shallow concentrated flow		Segment ID	1-BC			
9. Surface description (Cerrelli Chart)			Unpaved Area			
10. Flow length, L	ft		70			
11. Upstream elevation			135.44			
12. Downstream elevation			133.3			
13. Watercourse slope, s	ft/ft		0.0306			
14. Average velocity, V	ft/s		2.621			
15. T_t = L / 3600*V	hr		0.007			= 0.007

Channel Flow		Segment ID	1-CD			
16. Channel Geometry			Trapezoidal Ditch; Assume Depth = 0.33; Z1 = 8; Z2 = 8; Bw = 4			
17. Cross-sectional flow area, A	ft^2		2.1912			
18. Wetted perimeter, P_W	ft^2		9.3211			
19. Hydraulic radius, R	ft		0.2351			
20. Upstream elevation			133.3			
21. Downstream elevation			125.24			
22. Channel slope, S	ft/ft		0.0227			
23. Manning's roughness coeff., n			0.045			
24. Velocity	ft/s		1.90			
25. Flow length, L	ft		355			
26. T_t = L / 3600*V	hr		0.052			= 0.052

27. Watershed or subarea Tc or Tt hr 0.086







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Engineering A Brighter Future
30 YEARS OF EXCELLENCE

Worksheet 3: Time of concentration (Tc) or travel time (Tt)

Project : **Elkton Road, MD Line to Casho M** By **DEN** Date **8/11/2017**

Location : **Swale 2 (7009+32 - 7011+31 RT)** Checked _____ Date _____

County : **New Castle County, DE**

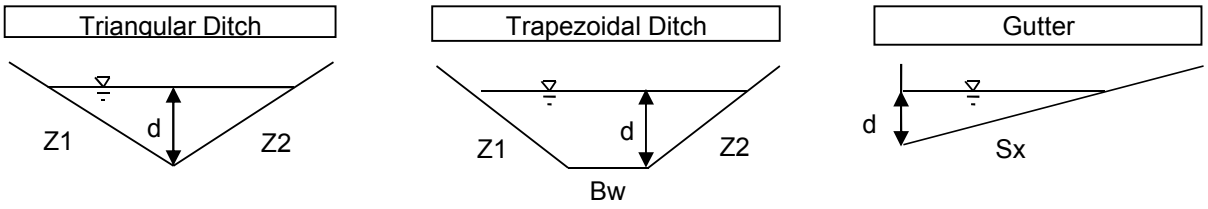
Circle one: Present [Developed] **ULTIMATE CONDITIONS**

NOTE : Space for as many as three segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments

Sheet flow (Applicable to Tc only)		Segment ID	2-AB			
1. Surface Description (table 3-1)			Concrete			
2. Manning's roughness coeff., n (table 3-1)			0.011			
3. Flow length, L (total L ≤ 100 ft)	ft		95			
4. Two-yr 24-hr rainfall, P_2	in		3.2			
5. Upstream elevation			136			
6. Downstream elevation			134.14			
7. Land slope, s	ft/ft		0.020			
8. $T_t = 0.007\ (nL)^{0.8} / [(P_2^{0.5})(s^{0.4})]$	hr		0.020			= 0.020

Channel Flow		Segment ID	2-BC			
16. Channel Geometry			Trapezoidal Ditch; Assume Depth = .33; Z1 = 4; Z2 = 4; Bw = 4			
17. Cross-sectional flow area, A	ft²		1.7556			
18. Wetted perimeter, P_W	ft²		6.7212			
19. Hydraulic radius, R	ft		0.2612			
20. Upstream elevation			134.15			
21. Downstream elevation			131.73			
22. Channel slope, S	ft/ft		0.0121			
23. Manning's roughness coeff., n			0.045			
24. Velocity	ft/s		1.49			
25. Flow length, L	ft		200			
26. $T_t = L / 3600*V$	hr		0.037			= 0.037

27. Watershed or subarea Tc or Tt ..... hr 0.057
0.083



Worksheet 3: Time of concentration (Tc) or travel time (Tt)

Project : **Elkton Road, MD Line to Casho M** By **DEN** Date **8/11/2017**

Location : **Swale 3A (6017+00- 6019+90 RT)** Checked _____ Date _____

County : **New Castle County, DE**

Circle one: Present [Developed] **ULTIMATE CONDITIONS**

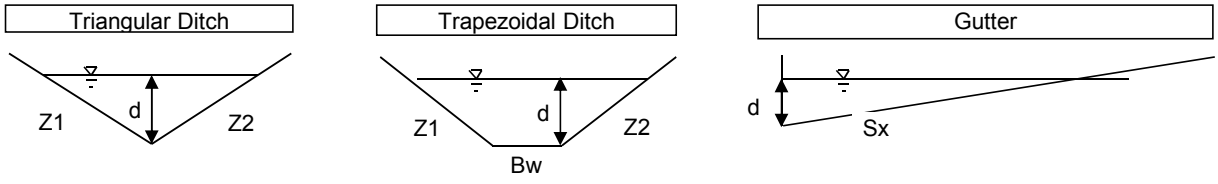
NOTE : Space for as many as three segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments

Sheet flow (Applicable to Tc only)		Segment ID	1-AB			
1. Surface Description (table 3-1)			Concrete			
2. Manning's roughness coeff., n (table 3-1)			0.011			
3. Flow length, L (total L ≤ 100 ft)	ft		82			
4. Two-yr 24-hr rainfall, P_2	in		3.2			
5. Upstream elevation			136			
6. Downstream elevation			135.44			
7. Land slope, s	ft/ft		0.007			
8. $T_t = 0.007\ (nL)^{0.8} / [(P_2^{0.5})(s^{0.4})]$	hr		0.026			= 0.026

Shallow concentrated flow		Segment ID	1-BC			
9. Surface description (Cerrelli Chart)			Unpaved Area			
10. Flow length, L	ft		70			
11. Upstream elevation			134.44			
12. Downstream elevation			133.3			
13. Watercourse slope, s	ft/ft		0.0163			
14. Average velocity, V	ft/s		1.913			
15. $T_t = L / 3600*V$	hr		0.010			= 0.010

Channel Flow		Segment ID	1-CD	3A-AB	3A-BC	3A-CD	
16. Channel Geometry			Trapezoidal Ditch; Assume Depth = .33; Z1 = 8; Z2 = 8; Bw = 4	Trapezoidal Ditch; Assume Depth = .33; Z1 = 8; Z2 = 8; Bw = 4	Pipe 107	Trapezoidal Ditch; Assume Depth = .33; Z1 = 8; Z2 = 8; Bw = 4	
17. Cross-sectional flow area, A	ft^2		2.1912	2.1912		2.1912	
18. Wetted perimeter, P_W	ft^2		9.3211	9.321090114		9.321090114	
19. Hydraulic radius, R	ft		0.2351	0.2351		0.2351	
20. Upstream elevation			133.3	125.24		115.5	
21. Downstream elevation			125.24	121		107.49	
22. Channel slope, S	ft/ft		0.0227	0.0283		0.0276	
23. Manning's roughness coeff., n			0.045	0.045	0.013	0.045	
24. Velocity	ft/s		1.90	2.12	4.97	2.10	
25. Flow length, L	ft		355	150	204	290	
26. $T_t = L / 3600*V$	hr		0.052	0.020	0.011	0.038	= 0.121

27. Watershed or subarea Tc or Tt hr 0.158



Worksheet 3: Time of concentration (Tc) or travel time (Tt)

Project : **Elkton Road, MD Line to Casho M** By **DEN** Date **8/11/2017**

Location : **Swale 3B (6021+63- 6022+40 RT)** Checked _____ Date _____

County : **New Castle County, DE**

Circle one: Present [Developed] **ULTIMATE CONDITIONS**

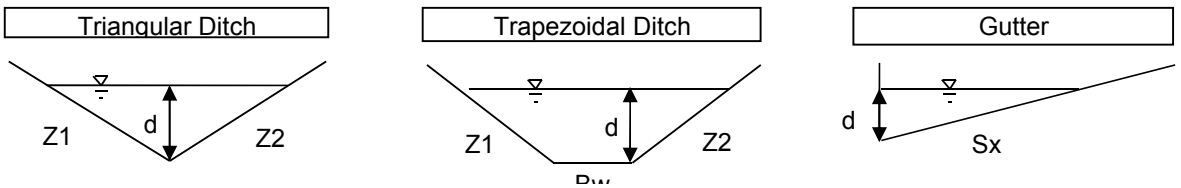
NOTE : Space for as many as three segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments

Sheet flow (Applicable to Tc only)		Segment ID	3B-AB			
1. Surface Description (table 3-1)			Concrete			
2. Manning's roughness coeff., n (table 3-1)			0.011			
3. Flow length, L (total L ≤ 100 ft)	ft		16			
4. Two-yr 24-hr rainfall, P_2	in		3.2			
5. Upstream elevation			106.69			
6. Downstream elevation			106.26			
7. Land slope, s	ft/ft		0.027			
8. $T_t = 0.007\ (nL)^{0.8} / [(P_2^{0.5})(s^{0.4})]$	hr		0.004			= 0.004

Shallow concentrated flow		Segment ID	3B-BC			
9. Surface description (Cerrelli Chart)			Unpaved Area			
10. Flow length, L	ft		22			
11. Upstream elevation			106.26			
12. Downstream elevation			103.73			
13. Watercourse slope, s	ft/ft		0.1150			
14. Average velocity, V	ft/s		5.083			
15. T_t = L / 3600*V	hr		0.001			= 0.001

Channel Flow		Segment ID	3B-CD		
16. Channel Geometry			Trapezoidal Ditch; Assume Depth = .33; Z1 = 8; Z2 = 8; Bw = 4		
17. Cross-sectional flow area, A	ft^2		2.1912		
18. Wetted perimeter, P_W	ft^2		9.321090114		
19. Hydraulic radius, R	ft		0.2351		
20. Upstream elevation			103.9		
21. Downstream elevation			102.82		
22. Channel slope, S	ft/ft		0.0142		
23. Manning's roughness coeff., n			0.045		
24. Velocity	ft/s		1.50		
25. Flow length, L	ft		76		
26. T_t = L / 3600*V	hr		0.014		= 0.014

27. Watershed or subarea Tc or Tt ..... hr 0.019
0.083



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Engineering A Brighter Future
30 YEARS OF EXCELLENCE

Worksheet 3: Time of concentration (Tc) or travel time (Tt)

Project : **Elkton Road, MD Line to Casho Mill** By **DEN** **8/11/2017**

Location : **Swale 4 (7020+40 - 7021+25 RT)** Checked

County : **New Castle County, DE**

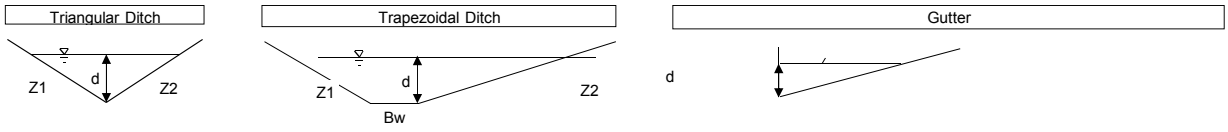
Circle one: Present [Developed] **ULTIMATE CONDITIONS**

NOTE : Space for as many as three segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments

Sheet flow (Applicable to Tc only)	Segment ID	2-AB						
1. Surface Description (table 3-1)		Concrete						
2. Manning's roughness coeff., n (table 3-1)		0.011						
3. Flow length, L (total L ≤ 100 ft)	ft	95						
4. Two-yr 24-hr rainfall, P_2	in	3.2						
5. Upstream elevation		136						
6. Downstream elevation		134.14						
7. Land slope, s	ft/ft	0.020						
8. $T_t = 0.007\ (nL)^{0.8} / [(P_2^{0.5})(s^{0.4})]$	hr	0.020						= 0.020

Channel Flow	Segment ID	2-BC	4-AB	4-BC	4-CD	4-DE	4-EF	4-FG	
16. Channel Geometry		Trapezoidal Ditch; Assume Depth = .33; Z1 = 4; Z2 = 4; Bw = 4	Trapezoidal Ditch; Assume Depth = .33; Z1 = 4; Z2 = 4; Bw = 4	P-200	P-202	P-203	P-204	Trapezoidal Ditch; Assume Depth = .33; Z1 = 2; Z2 = 2; Bw = 4	
17. Cross-sectional flow area, A	ft^2	1.7556	1.7556					1.5378	
18. Wetted perimeter, P_W	ft^2	6.7212	6.7212					5.475804865	
19. Hydraulic radius, R	ft	0.2612	0.2612					0.2808	
20. Upstream elevation		134.15	131.73					104.81	
21. Downstream elevation		131.73	123.5					101.07	
22. Channel slope, S	ft/ft	0.0121	0.0549					0.0435	
23. Manning's roughness coeff., n		0.045	0.045	0.013	0.013	0.013	0.013	0.045	
24. Velocity	ft/s	1.49	3.17	7.14	7.44	8.21	6.88	2.96	
25. Flow length, L	ft	200	150	190	65	233	122	86	
26. $T_t = L / 3600*V$	hr	0.037	0.013	0.007	0.002	0.008	0.005	0.008	= 0.081

27. Watershed or subarea Tc or Tt hr **0.101**



Worksheet 3: Time of concentration (Tc) or travel time (Tt)

Project : **Elkton Road, MD Line to Casho Mill R** By **DEN** Date **8/11/2017**

Location : **Swale 5A (6027+25- 6025+93 LT)** Checked _____ Date _____

County : **New Castle County, DE**

Circle one: Present [Developed] **ULTIMATE CONDITIONS**

NOTE : Space for as many as three segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments

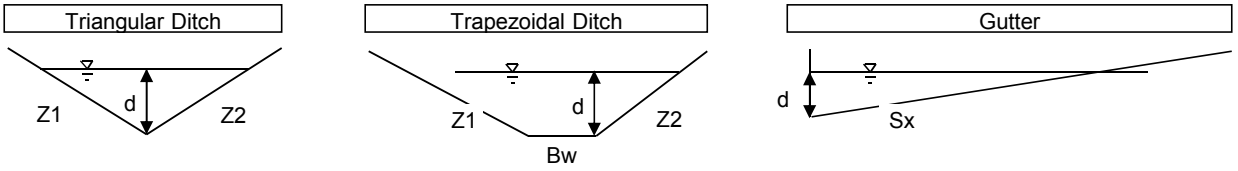
Sheet flow (Applicable to Tc only)		Segment ID	5A-AB					
1. Surface Description (table 3-1)			Concrete					
2. Manning's roughness coeff., n (table 3-1)			0.011					
3. Flow length, L (total L ≤ 100 ft)	ft		60					
4. Two-yr 24-hr rainfall, P_2	in		3.2					
5. Upstream elevation			110.75					
6. Downstream elevation			108.98					
7. Land slope, s	ft/ft		0.029					
8. $T_t = 0.007\ (nL)^{0.8} / [(P_2^{0.5})(s^{0.4})]$	hr		0.011				=	0.011

Shallow concentrated flow		Segment ID	5A-BC					
9. Surface description (Cerrelli Chart)			Paved Areas					
10. Flow length, L	ft		35					
11. Upstream elevation			108.98					
12. Downstream elevation			108.52					
13. Watercourse slope, s	ft/ft		0.0131					
14. Average velocity, V	ft/s		2.328					
15. $T_t = L / 3600*V$	hr		0.004				=	0.004

Pipe Flow		Segment ID	5A-CD	5A-DE				
16. Surface Description			P-111	Trapezoidal Ditch; Assume Depth = .33; Z1 = 4; Z2 = 4; Bw = 4				
17. Cross-sectional flow area, A	ft^2			1.7556				
18. Wetted perimeter, P_W	ft^2			6.721249713				
19. Hydraulic radius, R	ft			0.2612				
20. Upstream elevation				104				
21. Downstream elevation				102.5				
22. Channel slope, S	ft/ft			0.0115				
17. Manning's roughness coeff., n			0.013	0.045				
18. Velocity	ft/s		3.00	1.45				
19. Flow length, L	ft		164	131				
20. $T_t = L / 3600*V$	hr		0.015	0.025			=	0.040

27. Watershed or subarea Tc or Tt ..... hr 0.056

0.083



Worksheet 3: Time of concentration (Tc) or travel time (Tt)

Project : **Elkton Road, MD Line to Casho Mill R** By **DEN** Date **8/11/2017**

Location : **Swale 5B (6024+71 - 6022+80 LT)** Checked _____ Date _____

County : **New Castle County, DE**

Circle one: Present [Developed] **ULTIMATE CONDITIONS**

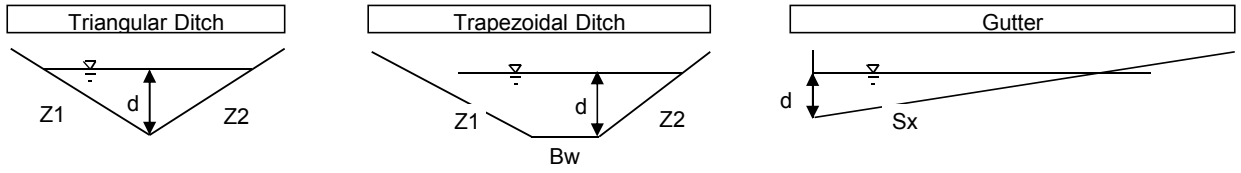
NOTE : Space for as many as three segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments

Sheet flow (Applicable to Tc only)		Segment ID	5A-AB					
1. Surface Description (table 3-1)			Concrete					
2. Manning's roughness coeff., n (table 3-1)			0.011					
3. Flow length, L (total L ≤ 100 ft)	ft		60					
4. Two-yr 24-hr rainfall, P_2	in		3.2					
5. Upstream elevation			110.75					
6. Downstream elevation			108.98					
7. Land slope, s	ft/ft		0.029					
8. $T_t = 0.007\ (nL)^{0.8} / [(P_2^{0.5})(s^{0.4})]$	hr		0.011				=	0.011

Shallow concentrated flow		Segment ID	5A-BC					
9. Surface description (Cerrelli Chart)			Paved Areas					
10. Flow length, L	ft		35					
11. Upstream elevation			108.98					
12. Downstream elevation			108.52					
13. Watercourse slope, s	ft/ft		0.0131					
14. Average velocity, V	ft/s		2.328					
15. $T_t = L / 3600*V$	hr		0.004				=	0.004

Pipe Flow		Segment ID	5A-CD	5A-DE	5B-AB	5B-BC		
16. Surface Description			P-111	Trapezoidal Ditch; Assume Depth = .33; Z1 = 4; Z2 = 4; Bw = 4	P-115	Trapezoidal Ditch; Assume Depth = .33; Z1 = 4; Z2 = 4; Bw = 4		
17. Cross-sectional flow area, A	ft^2			1.7556		1.7556		
18. Wetted perimeter, P_W	ft^2			6.721249713		6.721249713		
19. Hydraulic radius, R	ft			0.2612		0.2612		
20. Upstream elevation				104		101.41		
21. Downstream elevation				102.5		99.72		
22. Channel slope, S	ft/ft			0.0115		0.0088		
17. Manning's roughness coeff., n			0.013	0.013	0.013	0.045		
18. Velocity	ft/s		3.00	5.01	5.08	1.27		
19. Flow length, L	ft		164	131	122	192		
20. $T_t = L / 3600*V$	hr		0.015	0.007	0.007	0.042	=	0.071

27. Watershed or subarea Tc or Tt hr **0.087**



Worksheet 3: Time of concentration (Tc) or travel time (Tt)

Project : **Elkton Road, MD Line to Casho Mill R** By **DEN** Date **8/11/2017**

Location : **Swale 6 (7023+24 - 7022+12 RT)** Checked _____ Date _____

County : **New Castle County, DE**

Circle one: Present [Developed] **ULTIMATE CONDITIONS**

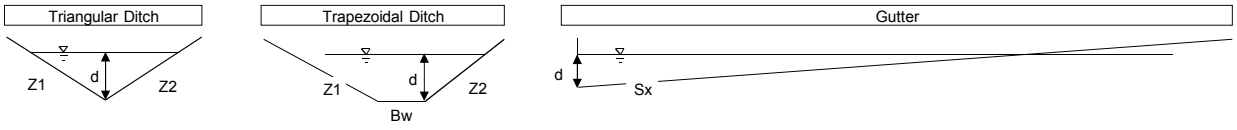
NOTE : Space for as many as three segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments

Sheet flow (Applicable to Tc only)		Segment ID	6-AB					
1. Surface Description (table 3-1)			Concrete					
2. Manning's roughness coeff., n (table 3-1)			0.011					
3. Flow length, L (total L ≤ 100 ft)		ft	75					
4. Two-yr 24-hr rainfall, P_2		in	3.2					
5. Upstream elevation			108.77					
6. Downstream elevation			107.05					
7. Land slope, s		ft/ft	0.023					
8. $T_t = 0.007\ (nL)^{0.8} / [(P_2^{0.5})(s^{0.4})]$		hr	0.015					= 0.015

Shallow concentrated flow		Segment ID	6-BC					
9. Surface description (Cerrelli Chart)			Paved Areas					
10. Flow length, L		ft	25					
11. Upstream elevation			107.05					
12. Downstream elevation			106.59					
13. Watercourse slope, s		ft/ft	0.0184					
14. Average velocity, V		ft/s	2.754					
15. $T_t = L / 3600*V$		hr	0.003					= 0.003

Channel Flow		Segment ID	6-CD	6-DE	6-EF	6-FG	6-GH	6-HI	6-IJ	
16. Surface Description			Pipe 401	Pipe 402	Pipe 403	Pipe 404	Pipe 405	Pipe 406	Trapezoidal Ditch; Assume Depth = .33; Z1 = 2; Z2 = 2; Bw = 4	
17. Cross-sectional flow area, A		ft^2							1.5378	
18. Wetted perimeter, P_W		ft^2							5.475804865	
19. Hydraulic radius, R		ft							0.2808	
20. Upstream elevation									99.2	
21. Downstream elevation									98.64	
22. Channel slope, S		ft/ft							0.0051	
17. Manning's roughness coeff., n			0.013	0.013	0.013	0.013	0.013	0.013	0.045	
18. Velocity		ft/s	3.18	3.84	3.84	3.65	4.87	3.94	1.01	
19. Flow length, L		ft	51	117	84	87	39	60	110	
20. $T_t = L / 3600*V$		hr	0.004	0.008	0.006	0.007	0.002	0.004	0.030	= 0.062

27. Watershed or subarea Tc or Tt hr 0.080
0.083



Worksheet 3: Time of concentration (Tc) or travel time (Tt)

Project : **Elkton Road, MD Line to Casho Mill** By **DEN** **8/11/2017**

Location : **Swale 7 (6027+25 - 6025+15 RT)** Checked

County : **New Castle County, DE**

Circle one: Present [Developed] **ULTIMATE CONDITIONS**

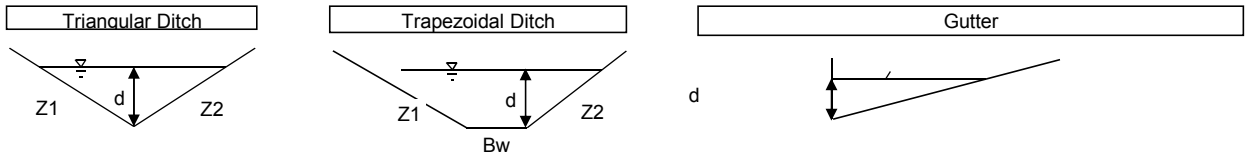
NOTE : Space for as many as three segments per flow type can be used for each worksheet. Include a map, schematic, or description of flow segments

Sheet flow (Applicable to Tc only)		Segment ID	7-AB					
1. Surface Description (table 3-1)			Concrete					
2. Manning's roughness coeff., n (table 3-1)			0.011					
3. Flow length, L (total L ≤ 100 ft)	ft		55					
4. Two-yr 24-hr rainfall, P_2	in		3.2					
5. Upstream elevation			107.5					
6. Downstream elevation			105.36					
7. Land slope, s	ft/ft		0.039					
8. $T_t = 0.007\ (nL)^{0.8} / [(P_2^{0.5})(s^{0.4})]$	hr		0.010					= 0.010

Channel Flow		Segment ID	7-BC					
16. Channel Geometry			Trapezoidal Ditch; Assume Depth = .33; Z1 = 8; Z2 = 8; Bw = 4					
17. Cross-sectional flow area, A	ft^2		2.1912					
18. Wetted perimeter, P_W	ft^2		9.3211					
19. Hydraulic radius, R	ft		0.2351					
20. Upstream elevation			105.36					
21. Downstream elevation			103					
22. Channel slope, S	ft/ft		0.0112					
23. Manning's roughness coeff., n			0.045					
24. Velocity	ft/s		1.34					
25. Flow length, L	ft		210					
26. $T_t = L / 3600 * V$	hr		0.044					= 0.044

27. Watershed or subarea Tc or Tt hr 0.053

0.083



Worksheet 3: Time of concentration (Tc) or travel time (Tt)

Project : **Elkton Road, MD Line to Casho Mill** By **DEN** **8/11/2017**

Location : **Swale 8 (7035+67 - 7030+73 RT)** Checked

County : **New Castle County, DE**

Circle one: Present [Developed] **ULTIMATE CONDITIONS**

NOTE : Space for as many as three segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments

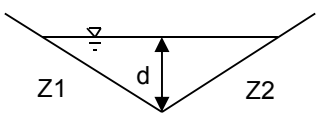
Sheet flow (Applicable to Tc only)		Segment ID	8-AB				
1. Surface Description (table 3-1)			Concrete				
2. Manning's roughness coeff., n (table 3-1)			0.011				
3. Flow length, L (total L ≤ 100 ft)	ft		45				
4. Two-yr 24-hr rainfall, P_2	in		3.2				
5. Upstream elevation			120.87				
6. Downstream elevation			119.79				
7. Land slope, s	ft/ft		0.024				
8. $T_t = 0.007 (nL)^{0.8} / [(P_2^{0.5})(s^{0.4})]$	hr		0.010			=	0.010

Shallow concentrated flow		Segment ID	8-BC				
9. Surface description (Cerrelli Chart)			Paved Area				
10. Flow length, L	ft		35				
11. Upstream elevation			119.79				
12. Downstream elevation			119.5				
13. Watercourse slope, s	ft/ft		0.0083				
14. Average velocity, V	ft/s		1.848				
15. T_t = L / 3600*V	hr		0.005			=	0.005

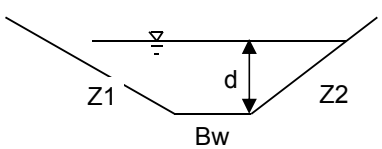
Channel Flow		Segment ID	8-CD	8-DE	8-EF		
16. Channel Geometry			Pipe 221	Pipe 222	Trapezoidal Ditch; Assume Depth = .33; Z1 = 4; Z2 = 4; Bw = 4		
17. Cross-sectional flow area, A	ft^2				1.7556		
18. Wetted perimeter, P_W	ft^2				6.721249713		
19. Hydraulic radius, R	ft				0.2612		
20. Upstream elevation					114.66		
21. Downstream elevation					108		
22. Channel slope, S	ft/ft				0.0134		
23. Manning's roughness coeff., n			0.013	0.013	0.045		
24. Velocity	ft/s		2.51	2.83	1.57		
25. Flow length, L	ft		105	60	496		
26. T_t = L / 3600*V	hr		0.012	0.006	0.088	=	0.105

27. Watershed or subarea Tc or Tt ..... hr 0.121

Triangular Ditch



Trapezoidal Ditch



Gutter

JOHNSON, MIRMIRAN & THOMPSON
Engineering A Brighter Future
30 YEARS OF EXCELLENCE

Worksheet 3: Time of concentration (Tc) or travel time (Tt)

Project : **Elkton Road, MD Line to Casho Mill** By **DEN** **8/11/2017**

Location : **Swale 9A (6038+63 - 6037+60 RT)** Checked

County : **New Castle County, DE**

Circle one: Present [Developed] **ULTIMATE CONDITIONS**

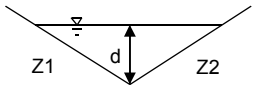
NOTE : Space for as many as three segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments

Sheet flow (Applicable to Tc only)		Segment ID	9A-AB					
1. Surface Description (table 3-1)			Concrete					
2. Manning's roughness coeff., n (table 3-1)			0.011					
3. Flow length, L (total L ≤ 100 ft)	ft		31					
4. Two-yr 24-hr rainfall, P_2	in		3.2					
5. Upstream elevation			120.95					
6. Downstream elevation			119.39					
7. Land slope, s	ft/ft		0.050					
8. $T_t = 0.007\ (nL)^{0.8} / [(P_2^{0.5})(s^{0.4})]$	hr		0.005					= 0.005

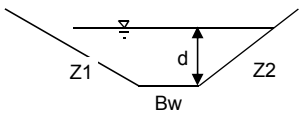
Channel Flow		Segment ID	9A-BC					
16. Channel Geometry			Triangular Ditch; Assume Depth = .33; Z1 = 13; Z2 = 8					
17. Cross-sectional flow area, A	ft^2		1.14345					
18. Wetted perimeter, P_W	ft^2		6.9632					
19. Hydraulic radius, R	ft		0.1642					
20. Upstream elevation			119.39					
21. Downstream elevation			118.9					
22. Channel slope, S	ft/ft		0.0047					
23. Manning's roughness coeff., n			0.045					
24. Velocity	ft/s		0.68					
25. Flow length, L	ft		104					
26. $T_t = L / 3600 * V$	hr		0.042					= 0.042

27. Watershed or subarea Tc or Tt hr 0.048
0.083

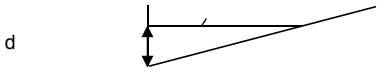
Triangular Ditch



Trapezoidal Ditch



Gutter



Worksheet 3: Time of concentration (Tc) or travel time (Tt)

Project : **Elkton Road, MD Line to Casho Mill** By **DEN** **8/11/2017**

Location : **Swale 9B (6037+60 - 6034+75 RT)** Checked

County : **New Castle County, DE**

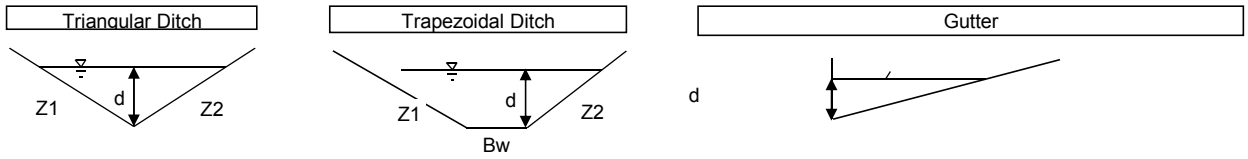
Circle one: Present [Developed] **ULTIMATE CONDITIONS**

NOTE : Space for as many as three segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments

Sheet flow (Applicable to Tc only)		Segment ID	9A-AB					
1. Surface Description (table 3-1)			Concrete					
2. Manning's roughness coeff., n (table 3-1)			0.011					
3. Flow length, L (total L ≤ 100 ft)	ft		31					
4. Two-yr 24-hr rainfall, P_2	in		3.2					
5. Upstream elevation			120.95					
6. Downstream elevation			119.39					
7. Land slope, s	ft/ft		0.050					
8. $T_t = 0.007\ (nL)^{0.8} / [(P_2^{0.5})(s^{0.4})]$	hr		0.005					= 0.005

Channel Flow		Segment ID	9A-BC	9B-AB				
16. Channel Geometry			Triangular Ditch; Assume Depth = .33; Z1 = 13; Z2 = 8	Trapezoidal Ditch; Assume Depth = .33; Z1 = 14; Z2 = 8; Bw = 4				
17. Cross-sectional flow area, A	ft^2		1.14345	2.5179				
18. Wetted perimeter, P_W	ft^2		6.9632	11.29231578				
19. Hydraulic radius, R	ft		0.1642	0.2230				
20. Upstream elevation			119.39	118.9				
21. Downstream elevation			118.9	116.85				
22. Channel slope, S	ft/ft		0.0047	0.0072				
23. Manning's roughness coeff., n			0.045	0.045				
24. Velocity	ft/s		0.68	1.03				
25. Flow length, L	ft		104	284				
26. $T_t = L / 3600 * V$	hr		0.042	0.076				= 0.119

27. Watershed or subarea Tc or Tt hr 0.124



Worksheet 3: Time of concentration (Tc) or travel time (Tt)

Project : **Elkton Road, MD Line to Casho Mill** By **DEN** **8/11/2017**

Location : **Swale 9C (6034+71 6033+04 RT)** Checked

County : **New Castle County, DE**

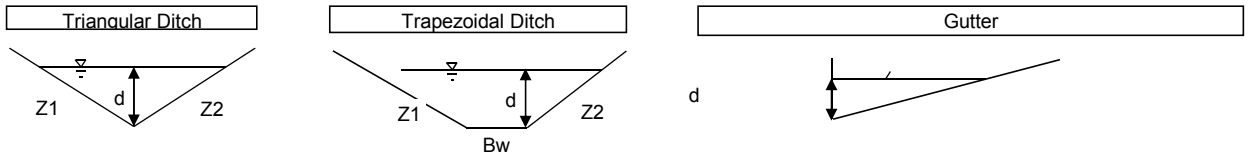
Circle one: Present [Developed] **ULTIMATE CONDITIONS**

NOTE : Space for as many as three segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments

Sheet flow (Applicable to Tc only)		Segment ID	9C-AB					
1. Surface Description (table 3-1)			Concrete					
2. Manning's roughness coeff., n (table 3-1)			0.011					
3. Flow length, L (total L ≤ 100 ft)	ft		30					
4. Two-yr 24-hr rainfall, P_2	in		3.2					
5. Upstream elevation			117.58					
6. Downstream elevation			116.82					
7. Land slope, s	ft/ft		0.025					
8. $T_t = 0.007\ (nL)^{0.8} / [(P_2^{0.5})(s^{0.4})]$	hr		0.007					= 0.007

Channel Flow		Segment ID	9C-BC					
16. Channel Geometry			Trapezoidal Ditch; Assume Depth = .33; Z1 = 18; Z2 = 8; Bw = 4					
17. Cross-sectional flow area, A	ft^2		2.7357					
18. Wetted perimeter, P_W	ft^2		12.60970466					
19. Hydraulic radius, R	ft		0.2170					
20. Upstream elevation			116.82					
21. Downstream elevation			114.29					
22. Channel slope, S	ft/ft		0.0153					
23. Manning's roughness coeff., n			0.045					
24. Velocity	ft/s		1.48					
25. Flow length, L	ft		165					
26. $T_t = L / 3600 * V$	hr		0.031					= 0.031

27. Watershed or subarea Tc or Tt hr 0.038
0.083



Worksheet 3: Time of concentration (Tc) or travel time (Tt)

Project : **Elkton Road, MD Line to Casho Mill** By **DEN** **8/11/2017**

Location : **Swale 9D (6033+00 - 6030+02 RT)** Checked

County : **New Castle County, DE**

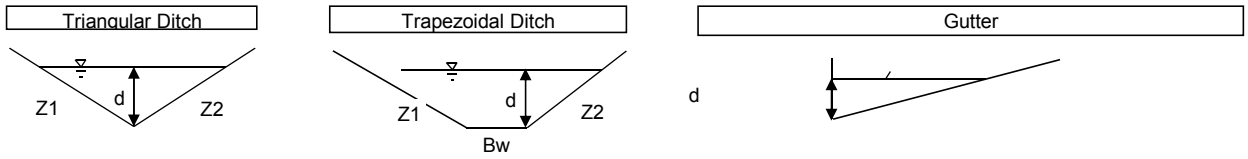
Circle one: Present [Developed] **ULTIMATE CONDITIONS**

NOTE : Space for as many as three segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments

Sheet flow (Applicable to Tc only)		Segment ID	9D-AB					
1. Surface Description (table 3-1)			Concrete					
2. Manning's roughness coeff., n (table 3-1)			0.011					
3. Flow length, L (total L ≤ 100 ft)	ft		30					
4. Two-yr 24-hr rainfall, P_2	in		3.2					
5. Upstream elevation			115.12					
6. Downstream elevation			114.23					
7. Land slope, s	ft/ft		0.030					
8. $T_t = 0.007\ (nL)^{0.8} / [(P_2^{0.5})(s^{0.4})]$	hr		0.007					= 0.007

Channel Flow		Segment ID	9C-BC					
16. Channel Geometry			Trapezoidal Ditch; Assume Depth = .33; Z1 = 16; Z2 = 8; Bw = 4					
17. Cross-sectional flow area, A	ft^2		2.6268					
18. Wetted perimeter, P_W	ft^2		11.95084751					
19. Hydraulic radius, R	ft		0.2198					
20. Upstream elevation			114.23					
21. Downstream elevation			110.1					
22. Channel slope, S	ft/ft		0.0139					
23. Manning's roughness coeff., n			0.045					
24. Velocity	ft/s		1.42					
25. Flow length, L	ft		298					
26. $T_t = L / 3600 * V$	hr		0.058					= 0.058

27. Watershed or subarea Tc or Tt hr 0.065
0.083



Worksheet 3: Time of concentration (Tc) or travel time (Tt)

Project : **Elkton Road, MD Line to Casho Mill** By **DEN** **8/11/2017**

Location : **Swale 10 (6039+46 - 6036+10 LT)** Checked

County : **New Castle County, DE**

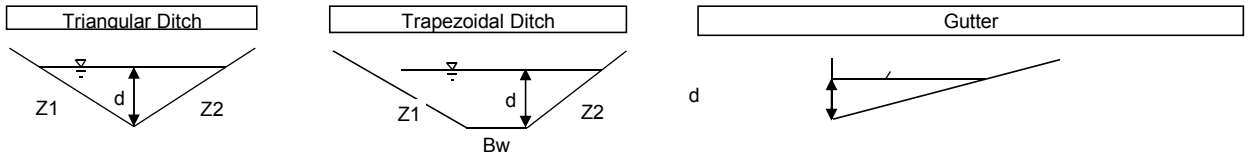
Circle one: Present [Developed] **ULTIMATE CONDITIONS**

NOTE : Space for as many as three segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments

Sheet flow (Applicable to Tc only)		Segment ID	10-AB					
1. Surface Description (table 3-1)			Concrete					
2. Manning's roughness coeff., n (table 3-1)			0.011					
3. Flow length, L (total L ≤ 100 ft)	ft		52					
4. Two-yr 24-hr rainfall, P_2	in		3.2					
5. Upstream elevation			120.48					
6. Downstream elevation			116.52					
7. Land slope, s	ft/ft		0.076					
8. $T_t = 0.007\ (nL)^{0.8} / [(P_2^{0.5})(s^{0.4})]$	hr		0.007					= 0.007

Channel Flow		Segment ID	10-BC					
16. Channel Geometry			Trapezoidal Ditch; Assume Depth = .33; Z1 = 4; Z2 = 4; Bw = 4					
17. Cross-sectional flow area, A	ft^2		1.7556					
18. Wetted perimeter, P_W	ft^2		6.7212					
19. Hydraulic radius, R	ft		0.2612					
20. Upstream elevation			116.52					
21. Downstream elevation			114.93					
22. Channel slope, S	ft/ft		0.0047					
23. Manning's roughness coeff., n			0.045					
24. Velocity	ft/s		0.93					
25. Flow length, L	ft		335					
26. $T_t = L / 3600 * V$	hr		0.100					= 0.100

27. Watershed or subarea Tc or Tt hr 0.107



Worksheet 3: Time of concentration (Tc) or travel time (Tt)

Project : **Elkton Road, MD Line to Casho Mill** By **DEN** **8/11/2017**

Location : **Swale 11A (6038+63 - 6040+59 RT)** Checked

County : **New Castle County, DE**

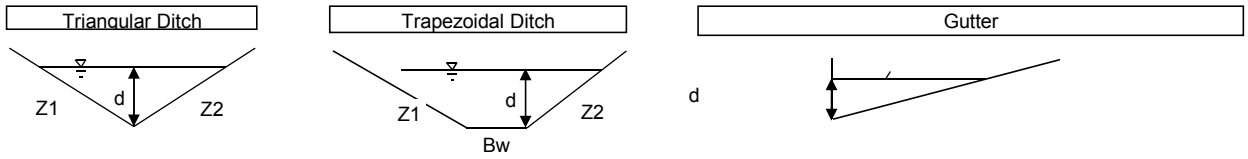
Circle one: Present [Developed] **ULTIMATE CONDITIONS**

NOTE : Space for as many as three segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments

Sheet flow (Applicable to Tc only)		Segment ID	11A-AB					
1. Surface Description (table 3-1)			Concrete					
2. Manning's roughness coeff., n (table 3-1)			0.011					
3. Flow length, L (total L ≤ 100 ft)	ft		32					
4. Two-yr 24-hr rainfall, P_2	in		3.2					
5. Upstream elevation			120.95					
6. Downstream elevation			119.76					
7. Land slope, s	ft/ft		0.037					
8. $T_t = 0.007\ (nL)^{0.8} / [(P_2^{0.5})(s^{0.4})]$	hr		0.006					= 0.006

Channel Flow		Segment ID	11A-BC					
16. Channel Geometry			Triangular Ditch; Assume Depth = .33; Z1 = 13; Z2 = 8					
17. Cross-sectional flow area, A	ft^2		1.14345					
18. Wetted perimeter, P_W	ft^2		6.9632					
19. Hydraulic radius, R	ft		0.1642					
20. Upstream elevation			119.39					
21. Downstream elevation			118.41					
22. Channel slope, S	ft/ft		0.0050					
23. Manning's roughness coeff., n			0.045					
24. Velocity	ft/s		0.70					
25. Flow length, L	ft		195					
26. $T_t = L / 3600 * V$	hr		0.077					= 0.077

27. Watershed or subarea Tc or Tt hr 0.083



Worksheet 3: Time of concentration (Tc) or travel time (Tt)

Project : **Elkton Road, MD Line to Casho Mill** By **DEN** **8/11/2017**

Location : **Swale 11B (6040+63 - 6042+64 RT)** Checked

County : **New Castle County, DE**

Circle one: Present [Developed] **ULTIMATE CONDITIONS**

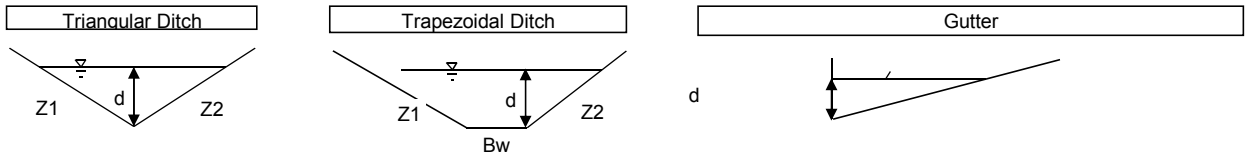
NOTE : Space for as many as three segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments

Sheet flow (Applicable to Tc only)		Segment ID	11B-AB					
1. Surface Description (table 3-1)			Concrete					
2. Manning's roughness coeff., n (table 3-1)			0.011					
3. Flow length, L (total L ≤ 100 ft)	ft		32					
4. Two-yr 24-hr rainfall, P_2	in		3.2					
5. Upstream elevation			120.04					
6. Downstream elevation			118.38					
7. Land slope, s	ft/ft		0.052					
8. $T_t = 0.007\ (nL)^{0.8} / [(P_2^{0.5})(s^{0.4})]$	hr		0.006					= 0.006

Channel Flow		Segment ID	11B-BC					
16. Channel Geometry			Triangular Ditch; Assume Depth = .33; Z1 = 13; Z2 = 8					
17. Cross-sectional flow area, A	ft^2		1.14345					
18. Wetted perimeter, P_W	ft^2		6.9632					
19. Hydraulic radius, R	ft		0.1642					
20. Upstream elevation			118.38					
21. Downstream elevation			116.71					
22. Channel slope, S	ft/ft		0.0083					
23. Manning's roughness coeff., n			0.045					
24. Velocity	ft/s		0.90					
25. Flow length, L	ft		202					
26. $T_t = L / 3600 * V$	hr		0.062					= 0.062

27. Watershed or subarea Tc or Tt hr 0.068

0.083



Worksheet 3: Time of concentration (Tc) or travel time (Tt)

Project : **Elkton Road, MD Line to Casho Mill** By **DEN** **8/11/2017**

Location : **Swale 12 (7037+94- 7042+06 RT)** Checked

County : **New Castle County, DE**

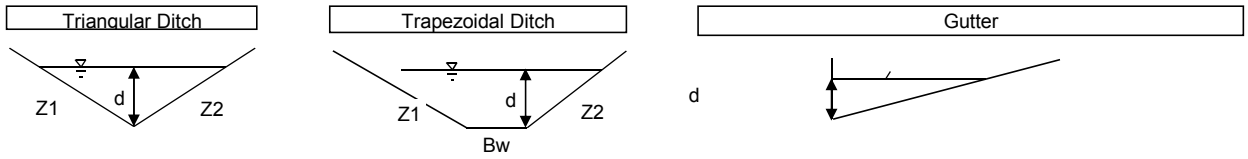
Circle one: Present [Developed] **ULTIMATE CONDITIONS**

NOTE : Space for as many as three segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments

Sheet flow (Applicable to Tc only)		Segment ID	12-AB					
1. Surface Description (table 3-1)			Range (natural)					
2. Manning's roughness coeff., n (table 3-1)			0.130					
3. Flow length, L (total L ≤ 100 ft)	ft		38					
4. Two-yr 24-hr rainfall, P_2	in		3.2					
5. Upstream elevation			122					
6. Downstream elevation			117.67					
7. Land slope, s	ft/ft		0.114					
8. $T_t = 0.007\ (nL)^{0.8} / [(P_2^{0.5})(s^{0.4})]$	hr		0.033					= 0.033

Channel Flow		Segment ID	12-BC					
16. Channel Geometry			Trapezoidal Ditch; Assume Depth = .33; Z1 = 4; Z2 = 4; Bw = 4					
17. Cross-sectional flow area, A	ft^2		1.7556					
18. Wetted perimeter, P_W	ft^2		6.7212					
19. Hydraulic radius, R	ft		0.2612					
20. Upstream elevation			117.67					
21. Downstream elevation			114.24					
22. Channel slope, S	ft/ft		0.0083					
23. Manning's roughness coeff., n			0.045					
24. Velocity	ft/s		1.23					
25. Flow length, L	ft		412					
26. $T_t = L / 3600 * V$	hr		0.093					= 0.093

27. Watershed or subarea Tc or Tt hr **0.126**



Worksheet 3: Time of concentration (Tc) or travel time (Tt)

Project : **Elkton Road, MD Line to Casho Mill Rd** By **DEN** Date **8/11/2017**

Location : **Swale 13 (6044+63 - 6046+82 LT)** Checked _____ Date _____

County : **New Castle County, DE**

Circle one: Present [Developed] **ULTIMATE CONDITIONS**

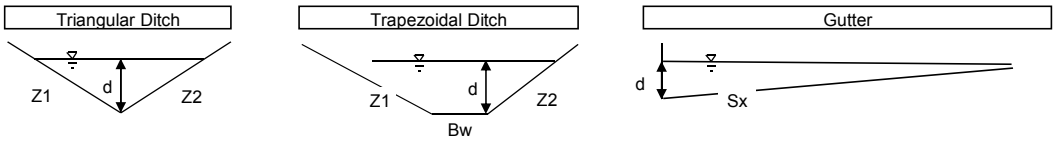
NOTE : Space for as many as three segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments

Sheet flow (Applicable to Tc only)		Segment ID	13-AB								
1. Surface Description (table 3-1)			Concrete								
2. Manning's roughness coeff., n (table 3-1)			0.011								
3. Flow length, L (total L ≤ 100 ft)		ft	60								
4. Two-yr 24-hr rainfall, P_2		in	3.2								
5. Upstream elevation			120.48								
6. Downstream elevation			119.48								
7. Land slope, s		ft/ft	0.017								
8. $T_t = 0.007\ (nL)^{0.8} / [(P_2^{0.5})(s^{0.4})]$		hr	0.014								= 0.014

Shallow concentrated flow		Segment ID	13-BC								
9. Surface description (Cerrelli Chart)			Paved Areas								
10. Flow length, L		ft	135								
11. Upstream elevation			119.48								
12. Downstream elevation			118.4								
13. Watercourse slope, s		ft/ft	0.0080								
14. Average velocity, V		ft/s	1.816								
15. $T_t = L / 3600*V$		hr	0.021								= 0.021

Pipe Flow		Segment ID	13-CD	13-DE	13-EF	13-FG	13-GH	13-HI	13-IJ	13-JK	
16. Surface Description			Pipe 132	Pipe 133	Pipe 134	Pipe 135	Pipe 136	Pipe 137	Pipe 138	Trapezoidal Ditch; Assume Depth = .33; Z1 = 4; Z2 = 4; Bw = 4	
17. Cross-sectional flow area, A		ft^2								1.7556	
18. Wetted perimeter, P_W		ft^2								6.7212	
19. Hydraulic radius, R		ft								0.2612	
20. Upstream elevation										111.65	
21. Downstream elevation										109.98	
22. Channel slope, S		ft/ft								0.0076	
17. Manning's roughness coeff., n			0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.045	
18. Velocity		ft/s	3.86	4.68	5.67	4.83	3.60	3.55	3.82	1.18	
19. Flow length, L		ft	144	48	31	50	28	27	63	220	
20. $T_t = L / 3600*V$		hr	0.010	0.003	0.002	0.003	0.002	0.002	0.005	0.052	= 0.078

27. Watershed or subarea Tc or Tt hr **0.113**



Worksheet 3: Time of concentration (Tc) or travel time (Tt)

Project : **Elkton Road, MD Line to Casho Mill** By **DEN** **8/11/2017**

Location : **Swale 14A (6044+27 -6053+26 RT)** Checked

County : **New Castle County, DE**

Circle one: Present [Developed] **ULTIMATE CONDITIONS**

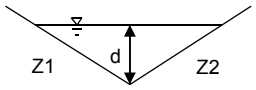
NOTE : Space for as many as three segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments

Sheet flow (Applicable to Tc only)		Segment ID	14A-AB					
1. Surface Description (table 3-1)			Concrete					
2. Manning's roughness coeff., n (table 3-1)			0.011					
3. Flow length, L (total L ≤ 100 ft)		ft	48					
4. Two-yr 24-hr rainfall, P_2		in	3.2					
5. Upstream elevation			116.44					
6. Downstream elevation			115.11					
7. Land slope, s		ft/ft	0.028					
8. $T_t = 0.007\ (nL)^{0.8} / [(P_2^{0.5})(s^{0.4})]$		hr	0.010					= 0.010

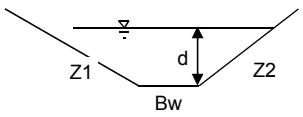
Channel Flow		Segment ID	14A-BC					
16. Channel Geometry			Triangular Ditch; Assume Depth = .33; Z1 = 13; Z2 = 8					
17. Cross-sectional flow area, A		ft^2	1.14345					
18. Wetted perimeter, P_W		ft^2	6.9632					
19. Hydraulic radius, R		ft	0.1642					
20. Upstream elevation			115.11					
21. Downstream elevation			109					
22. Channel slope, S		ft/ft	0.0068					
23. Manning's roughness coeff., n			0.045					
24. Velocity		ft/s	0.82					
25. Flow length, L		ft	900					
26. $T_t = L / 3600*V$		hr	0.306					= 0.306

27. Watershed or subarea Tc or Tt hr 0.315

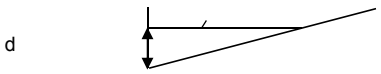
Triangular Ditch



Trapezoidal Ditch



Gutter



Worksheet 3: Time of concentration (Tc) or travel time (Tt)

Project : **Elkton Road, MD Line to Casho Mill** By **DEN** **8/11/2017**

Location : **Swale 14B (6053+26 -6054+90 RT)** Checked

County : **New Castle County, DE**

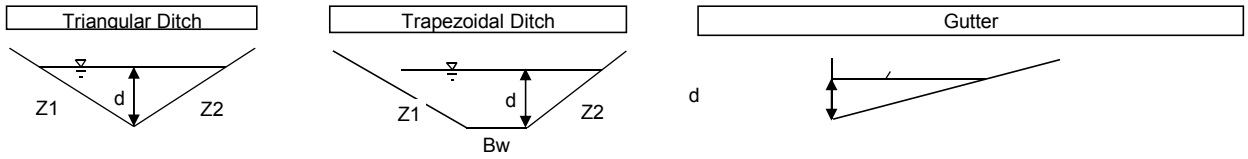
Circle one: Present [Developed] **ULTIMATE CONDITIONS**

NOTE : Space for as many as three segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments

Sheet flow (Applicable to Tc only)		Segment ID	14A-AB					
1. Surface Description (table 3-1)			Concrete					
2. Manning's roughness coeff., n (table 3-1)			0.011					
3. Flow length, L (total L ≤ 100 ft)	ft		48					
4. Two-yr 24-hr rainfall, P_2	in		3.2					
5. Upstream elevation			116.44					
6. Downstream elevation			115.11					
7. Land slope, s	ft/ft		0.028					
8. $T_t = 0.007\ (nL)^{0.8} / [(P_2^{0.5})(s^{0.4})]$	hr		0.010					= 0.010

Channel Flow		Segment ID	14A-BC	14B-AB				
16. Channel Geometry			Triangular Ditch; Assume Depth = .33; Z1 = 13; Z2 = 8	Trapezoidal Ditch; Assume Depth = .33; Z1 = 14; Z2 = 8; Bw = 4				
17. Cross-sectional flow area, A	ft^2		1.14345	2.5179				
18. Wetted perimeter, P_W	ft^2		6.9632	11.29231578				
19. Hydraulic radius, R	ft		0.1642	0.2230				
20. Upstream elevation			115.11	109				
21. Downstream elevation			109	108.31				
22. Channel slope, S	ft/ft		0.0068	0.0042				
23. Manning's roughness coeff., n			0.045	0.045				
24. Velocity	ft/s		0.82	0.79				
25. Flow length, L	ft		900	164				
26. $T_t = L / 3600 * V$	hr		0.306	0.058				= 0.363

27. Watershed or subarea Tc or Tt hr 0.373



Worksheet 3: Time of concentration (Tc) or travel time (Tt)

Project : **Elkton Road, MD Line to Casho Mill** By **DEN** **8/11/2017**

Location : **Swale 15 (7044+59- 7055+28 RT)** Checked

County : **New Castle County, DE**

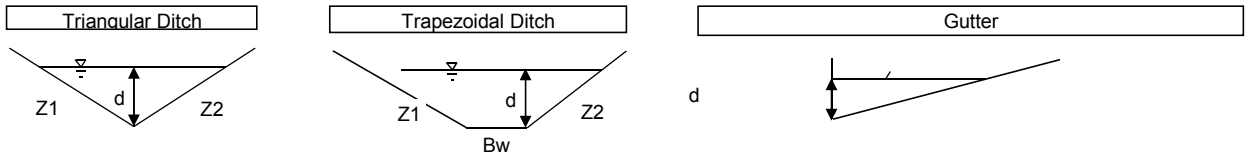
Circle one: Present [Developed] **ULTIMATE CONDITIONS**

NOTE : Space for as many as three segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments

Sheet flow (Applicable to Tc only)		Segment ID	12-AB					
1. Surface Description (table 3-1)			Range (natural)					
2. Manning's roughness coeff., n (table 3-1)			0.130					
3. Flow length, L (total L ≤ 100 ft)	ft		38					
4. Two-yr 24-hr rainfall, P_2	in		3.2					
5. Upstream elevation			122					
6. Downstream elevation			117.67					
7. Land slope, s	ft/ft		0.114					
8. $T_t = 0.007\ (nL)^{0.8} / [(P_2^{0.5})(s^{0.4})]$	hr		0.033					= 0.033

Channel Flow		Segment ID	12-BC	15-AB	15-BC	15-CD	15-DE	
16. Channel Geometry			Trapezoidal Ditch; Assume Depth = .33; Z1 = 4; Z2 = 4; Bw = 4	P-232	P-233	P-234	Trapezoidal Ditch; Assume Depth = .33; Z1 = 4; Z2 = 4; Bw = 4	
17. Cross-sectional flow area, A	ft²		1.7556				1.7556	
18. Wetted perimeter, P_W	ft²		6.7212				6.7212	
19. Hydraulic radius, R	ft		0.2612				0.2612	
20. Upstream elevation			117.67				111.89	
21. Downstream elevation			114.24				105.51	
22. Channel slope, S	ft/ft		0.0083				0.0060	
23. Manning's roughness coeff., n			0.045	0.013	0.013	0.013	0.045	
24. Velocity	ft/s		1.23	6.50	4.64	4.79	1.04	
25. Flow length, L	ft		412	60	122	66	1070	
26. $T_t = L / 3600 * V$	hr		0.093	0.003	0.007	0.004	0.284	= 0.391

27. Watershed or subarea Tc or Tt hr 0.424



Worksheet 3: Time of concentration (Tc) or travel time (Tt)

Project : **Elkton Road, MD Line to Casho M** By **DEN** Date **8/11/2017**

Location : **Swale 16 (6052+00 - 6053+22 LT)** Checked _____ Date _____

County : **New Castle County, DE**

Circle one: Present [Developed] **ULTIMATE CONDITIONS**

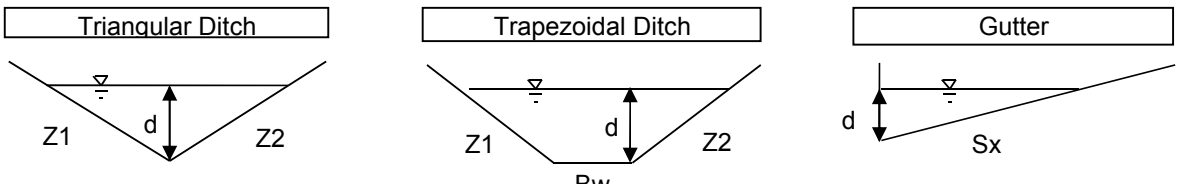
NOTE : Space for as many as three segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments

Sheet flow (Applicable to Tc only)		Segment ID	16-AB			
1. Surface Description (table 3-1)			Concrete			
2. Manning's roughness coeff., n (table 3-1)			0.011			
3. Flow length, L (total L ≤ 100 ft)	ft		73			
4. Two-yr 24-hr rainfall, P_2	in		3.2			
5. Upstream elevation			111.55			
6. Downstream elevation			107.67			
7. Land slope, s	ft/ft		0.053			
8. $T_t = 0.007\ (nL)^{0.8} / [(P_2^{0.5})(s^{0.4})]$	hr		0.011			= 0.011

Shallow concentrated flow		Segment ID				
9. Surface description (Cerrelli Chart)						
10. Flow length, L	ft					
11. Upstream elevation						
12. Downstream elevation						
13. Watercourse slope, s	ft/ft					
14. Average velocity, V	ft/s					
15. T_t = L / 3600*V	hr					= 0.000

Channel Flow		Segment ID	16-BC			
16. Channel Geometry			Trapezoidal Ditch; Assume Depth = .33; Z1 = 4; Z2 = 4; Bw = 4			
17. Cross-sectional flow area, A	ft^2		1.7556			
18. Wetted perimeter, P_W	ft^2		6.7212			
19. Hydraulic radius, R	ft		0.2612			
20. Upstream elevation			107.67			
21. Downstream elevation			106.8			
22. Channel slope, S	ft/ft		0.0071			
23. Manning's roughness coeff., n			0.045			
24. Velocity	ft/s		1.14			
25. Flow length, L	ft		122			
26. T_t = L / 3600*V	hr		0.030			= 0.030

27. Watershed or subarea Tc or Tt hr 0.040



JOHNSON, MIRMIRAN & THOMPSON
Engineering A Brighter Future
30 YEARS OF EXCELLENCE

Worksheet 3: Time of concentration (Tc) or travel time (Tt)

Project : **Elkton Road, MD Line to Casho Mill** By **DEN** **8/11/2017**

Location : **Swale 17 (6055+00 - 6060+40 RT)** Checked

County : **New Castle County, DE**

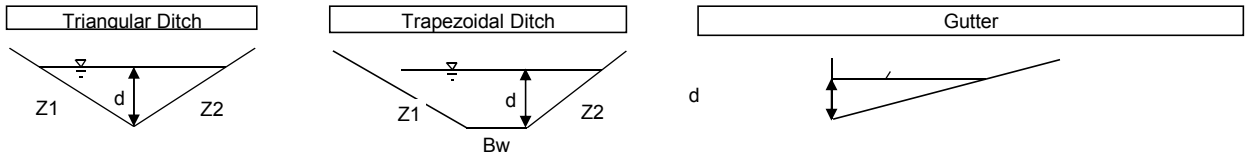
Circle one: Present [Developed] **ULTIMATE CONDITIONS**

NOTE : Space for as many as three segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments

Sheet flow (Applicable to Tc only)		Segment ID	17-AB					
1. Surface Description (table 3-1)			Concrete					
2. Manning's roughness coeff., n (table 3-1)			0.011					
3. Flow length, L (total L ≤ 100 ft)	ft		26					
4. Two-yr 24-hr rainfall, P_2	in		3.2					
5. Upstream elevation			109.78					
6. Downstream elevation			108.40					
7. Land slope, s	ft/ft		0.053					
8. $T_t = 0.007\ (nL)^{0.8} / [(P_2^{0.5})(s^{0.4})]$	hr		0.005					= 0.005

Channel Flow		Segment ID	17-BC					
16. Channel Geometry			Trapezoidal Ditch; Assume Depth = .33; Z1 = 14; Z2 = 8; Bw = 4					
17. Cross-sectional flow area, A	ft^2		2.5179					
18. Wetted perimeter, P_W	ft^2		11.2923					
19. Hydraulic radius, R	ft		0.2230					
20. Upstream elevation			108.4					
21. Downstream elevation			105.67					
22. Channel slope, S	ft/ft		0.0051					
23. Manning's roughness coeff., n			0.045					
24. Velocity	ft/s		0.87					
25. Flow length, L	ft		540					
26. $T_t = L / 3600 * V$	hr		0.173					= 0.173

27. Watershed or subarea Tc or Tt hr **0.178**



Worksheet 3: Time of concentration (Tc) or travel time (Tt)

Project : **Elkton Road, MD Line to Casho Mill** By **DEN** **8/11/2017**

Location : **Swale 18 (6060+44 - 6063+26 RT)** Checked

County : **New Castle County, DE**

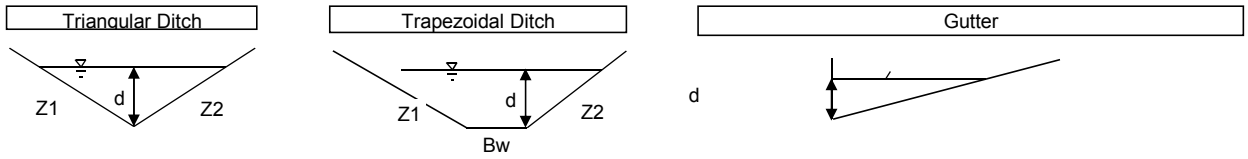
Circle one: Present [Developed] **ULTIMATE CONDITIONS**

NOTE : Space for as many as three segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments

Sheet flow (Applicable to Tc only)		Segment ID	18-AB					
1. Surface Description (table 3-1)			Concrete					
2. Manning's roughness coeff., n (table 3-1)			0.011					
3. Flow length, L (total L ≤ 100 ft)	ft		48					
4. Two-yr 24-hr rainfall, P_2	in		3.2					
5. Upstream elevation			107.16					
6. Downstream elevation			106.09					
7. Land slope, s	ft/ft		0.022					
8. $T_t = 0.007\ (nL)^{0.8} / [(P_2^{0.5})(s^{0.4})]$	hr		0.011					= 0.011

Channel Flow		Segment ID	18-BC					
16. Channel Geometry			Trapezoidal Ditch; Assume Depth = .33; Z1 = 14; Z2 = 8; Bw = 4					
17. Cross-sectional flow area, A	ft^2		2.5179					
18. Wetted perimeter, P_W	ft^2		11.2923					
19. Hydraulic radius, R	ft		0.2230					
20. Upstream elevation			106.09					
21. Downstream elevation			104.76					
22. Channel slope, S	ft/ft		0.0047					
23. Manning's roughness coeff., n			0.045					
24. Velocity	ft/s		0.83					
25. Flow length, L	ft		283					
26. $T_t = L / 3600 * V$	hr		0.094					= 0.094

27. Watershed or subarea Tc or Tt hr **0.105**



Worksheet 3: Time of concentration (Tc) or travel time (Tt)

Project : **Elkton Road, MD Line to Casho Mill** By **DEN** **8/11/2017**

Location : **Swale 19A (6056+46 - 6057+37 LT)** Checked

County : **New Castle County, DE**

Circle one: Present [Developed] **ULTIMATE CONDITIONS**

NOTE : Space for as many as three segments per flow type can be used for each worksheet. Include a map, schematic, or description of flow segments

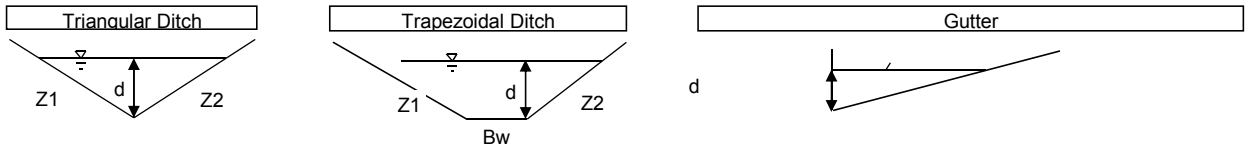
Sheet flow (Applicable to Tc only)		Segment ID	19A-AB					
1. Surface Description (table 3-1)			Concrete					
2. Manning's roughness coeff., n (table 3-1)			0.011					
3. Flow length, L (total L ≤ 100 ft)	ft		76					
4. Two-yr 24-hr rainfall, P_2	in		3.2					
5. Upstream elevation			109.59					
6. Downstream elevation			108.38					
7. Land slope, s	ft/ft		0.016					
8. $T_t = 0.007\ (nL)^{0.8} / [(P_2^{0.5})(s^{0.4})]$	hr		0.018					= 0.018

Shallow concentrated flow		Segment ID	19A-BC					
9. Surface description (Cerrelli Chart)			Wide Swale, Low Veg.					
10. Flow length, L	ft		45					
11. Upstream elevation			108.38					
12. Downstream elevation			105.5					
13. Watercourse slope, s	ft/ft		0.0640					
14. Average velocity, V	ft/s		1.95					
15. T_t = L / 3600*V	hr		0.006					= 0.006

Channel Flow		Segment ID	19A-CD					
16. Channel Geometry			Trapezoidal Ditch; Assume Depth = .33; Z1 = 4; Z2 = 4; Bw = 4					
17. Cross-sectional flow area, A	ft²		1.7556					
18. Wetted perimeter, P_W	ft²		6.7212					
19. Hydraulic radius, R	ft		0.2612					
20. Upstream elevation			105.5					
21. Downstream elevation			104.72					
22. Channel slope, S	ft/ft		0.0085					
23. Manning's roughness coeff., n			0.045					
24. Velocity	ft/s		1.25					
25. Flow length, L	ft		92					
26. T_t = L / 3600*V	hr		0.021					= 0.021

27. Watershed or subarea Tc or Tt hr 0.045

0.083



Worksheet 3: Time of concentration (Tc) or travel time (Tt)

Project : **Elkton Road, MD Line to Casho Mill** By **DEN** **8/11/2017**

Location : **Swale 19B (6057+84 - 6060+23 LT)** Checked

County : **New Castle County, DE**

Circle one: Present [Developed] **ULTIMATE CONDITIONS**

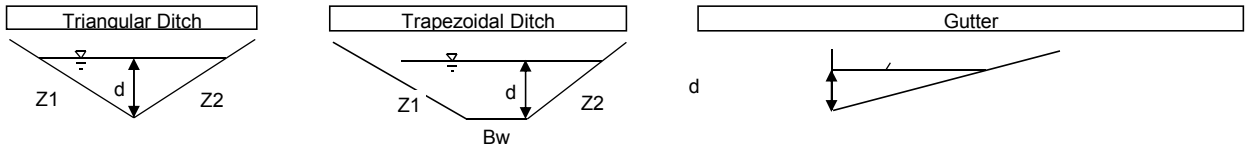
NOTE : Space for as many as three segments per flow type can be used for each worksheet. Include a map, schematic, or description of flow segments

Sheet flow (Applicable to Tc only)		Segment ID	19A-AB					
1. Surface Description (table 3-1)			Concrete					
2. Manning's roughness coeff., n (table 3-1)			0.011					
3. Flow length, L (total L ≤ 100 ft)	ft		76					
4. Two-yr 24-hr rainfall, P_2	in		3.2					
5. Upstream elevation			109.59					
6. Downstream elevation			108.38					
7. Land slope, s	ft/ft		0.016					
8. $T_t = 0.007\ (nL)^{0.8} / [(P_2^{0.5})(s^{0.4})]$	hr		0.018					= 0.018

Shallow concentrated flow		Segment ID	19A-BC					
9. Surface description (Cerrelli Chart)			Wide Swale, Low Veg.					
10. Flow length, L	ft		45					
11. Upstream elevation			108.38					
12. Downstream elevation			105.5					
13. Watercourse slope, s	ft/ft		0.0640					
14. Average velocity, V	ft/s		1.95					
15. T_t = L / 3600*V	hr		0.006					= 0.006

Channel Flow		Segment ID	19A-CD	19B-AB	19B-BC			
16. Channel Geometry			Trapezoidal Ditch; Assume Depth = .33; Z1 = 4; Z2 = 4; Bw = 4	P-331	Trapezoidal Ditch; Assume Depth = .33; Z1 = 4; Z2 = 4; Bw = 4			
17. Cross-sectional flow area, A	ft²		1.7556		1.7556			
18. Wetted perimeter, P_W	ft²		6.7212		6.7212			
19. Hydraulic radius, R	ft		0.2612		0.2612			
20. Upstream elevation			105.5		104.49			
21. Downstream elevation			104.72		103.29			
22. Channel slope, S	ft/ft		0.0085		0.0050			
23. Manning's roughness coeff., n			0.045	0.013	0.045			
24. Velocity	ft/s		1.25	2.98	0.96			
25. Flow length, L	ft		92	47	239			
26. T_t = L / 3600*V	hr		0.021	0.004	0.069			= 0.094

27. Watershed or subarea Tc or Tt hr 0.118



Worksheet 3: Time of concentration (Tc) or travel time (Tt)

Project : **Elkton Road, MD Line to Casho Mill** By **DEN** **8/11/2017**

Location : **Swale 19C (6061+74 - 6062+70 LT)** Checked

County : **New Castle County, DE**

Circle one: Present [Developed] **ULTIMATE CONDITIONS**

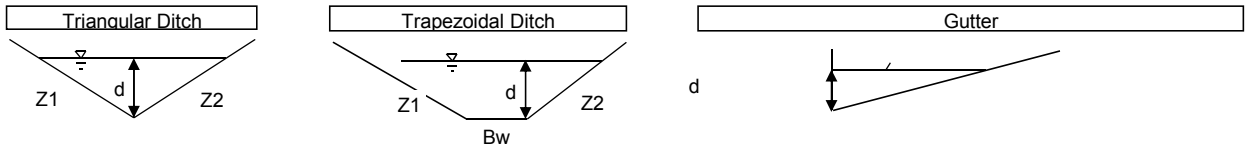
NOTE : Space for as many as three segments per flow type can be used for each worksheet. Include a map, schematic, or description of flow segments

Sheet flow (Applicable to Tc only)		Segment ID	19A-AB					
1. Surface Description (table 3-1)			Concrete					
2. Manning's roughness coeff., n (table 3-1)			0.011					
3. Flow length, L (total L ≤ 100 ft)	ft		76					
4. Two-yr 24-hr rainfall, P_2	in		3.2					
5. Upstream elevation			109.59					
6. Downstream elevation			108.38					
7. Land slope, s	ft/ft		0.016					
8. $T_t = 0.007\ (nL)^{0.8} / [(P_2^{0.5})(s^{0.4})]$	hr		0.018					= 0.018

Shallow concentrated flow		Segment ID	19A-BC					
9. Surface description (Cerrelli Chart)			Wide Swale, Low Veg.					
10. Flow length, L	ft		45					
11. Upstream elevation			108.38					
12. Downstream elevation			105.5					
13. Watercourse slope, s	ft/ft		0.0640					
14. Average velocity, V	ft/s		1.95					
15. T_t = L / 3600*V	hr		0.006					= 0.006

Channel Flow		Segment ID	19A-CD	19B-AB	19B-BC	19C-AB	19C-BC	
16. Channel Geometry			Trapezoidal Ditch; Assume Depth = .33; Z1 = 4; Z2 = 4; Bw = 4	P-331	Trapezoidal Ditch; Assume Depth = .33; Z1 = 4; Z2 = 4; Bw = 4	P-341	Trapezoidal Ditch; Assume Depth = .33; Z1 = 3; Z2 = 3; Bw = 4	
17. Cross-sectional flow area, A	ft^2		1.7556		1.7556		1.6467	
18. Wetted perimeter, P_W	ft^2		6.7212		6.7212		6.0871	
19. Hydraulic radius, R	ft		0.2612		0.2612		0.2705	
20. Upstream elevation			105.5		104.49		102.49	
21. Downstream elevation			104.72		103.29		100	
22. Channel slope, S	ft/ft		0.0085		0.0050		0.0252	
23. Manning's roughness coeff., n			0.045	0.013	0.045	0.013	0.045	
24. Velocity	ft/s		1.25	2.98	0.96	7.83	2.20	
25. Flow length, L	ft		92	47	239	152	99	
26. T_t = L / 3600*V	hr		0.021	0.004	0.069	0.005	0.013	= 0.112

27. Watershed or subarea Tc or Tt hr 0.136



Worksheet 3: Time of concentration (Tc) or travel time (Tt)

Project : **Elkton Road, MD Line to Casho Mill R** By **DEN** Date **8/11/2017**

Location : **Swale 20 (6069 +48 RT - 6067+04 RT)** Checked _____ Date _____

County : **New Castle County, DE**

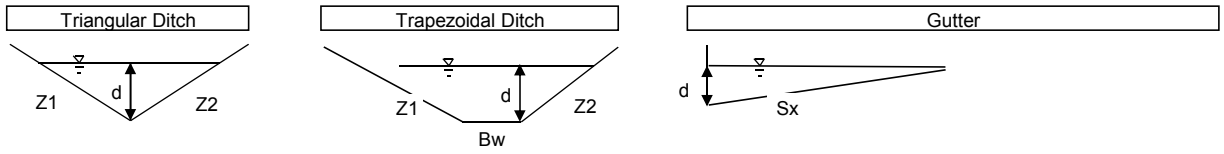
Circle one: Present [Developed] **ULTIMATE CONDITIONS**

NOTE : Space for as many as three segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments

Sheet flow (Applicable to Tc only)		Segment ID	20-AB				
1. Surface Description (table 3-1)			Concrete				
2. Manning's roughness coeff., n (table 3-1)			0.011				
3. Flow length, L (total L ≤ 100 ft)	ft		38				
4. Two-yr 24-hr rainfall, P_2	in		3.2				
5. Upstream elevation			105.28				
6. Downstream elevation			104.08				
7. Land slope, s	ft/ft		0.032				
8. $T_t = 0.007 (nL)^{0.8} / [(P_2^{0.5})(s^{0.4})]$	hr		0.008				= 0.008

Pipe Flow		Segment ID	20-BC				
16. Surface Description			Trapezoidal Ditch; Assume Depth = .33; Z1 = 14; Z2 = 8; Bw = 4				
17. Cross-sectional flow area, A	ft^2		2.5179				
18. Wetted perimeter, P_W	ft^2		11.2923				
19. Hydraulic radius, R	ft		0.2230				
20. Upstream elevation			104.08				
21. Downstream elevation			103.32				
22. Channel slope, S	ft/ft		0.0031				
17. Manning's roughness coeff., n			0.045				
18. Velocity	ft/s		0.68				
19. Flow length, L	ft		245				
20. $T_t = L / 3600*V$	hr		0.100				= 0.100

27. Watershed or subarea Tc or Tt ..... hr 0.108



Worksheet 3: Time of concentration (Tc) or travel time (Tt)

Project : **Elkton Road, MD Line to Casho Mill R** By **DEN** **8/11/2017**

Location : **Swale 21 (7061+44 - 7062+56 RT)** Checked

County : **New Castle County, DE**

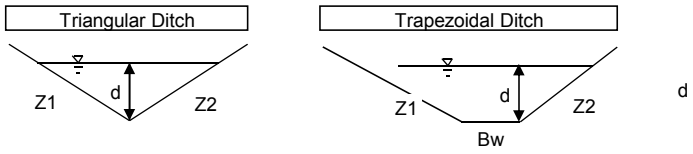
Circle one: Present [Developed] **ULTIMATE CONDITIONS**

NOTE : Space for as many as three segments per flow type can be used for each worksheet. Include a map, schematic, or description of flow segments

Sheet flow (Applicable to Tc only)		Segment ID	21-AB					
1. Surface Description (table 3-1)			Concrete					
2. Manning's roughness coeff., n (table 3-1)			0.011					
3. Flow length, L (total L ≤ 100 ft)	ft		52					
4. Two-yr 24-hr rainfall, P_2	in		3.2					
5. Upstream elevation			107.22					
6. Downstream elevation			103.97					
7. Land slope, s	ft/ft		0.063					
8. $T_t = 0.007\ (nL)^{0.8} / [(P_2^{0.5})(s^{0.4})]$	hr		0.008				=	0.008

Pipe Flow		Segment ID	21-BC					
16. Surface Description			Trapezoidal Ditch; Assume Depth = .33; Z1 = 4; Z2 = 4; Bw = 4					
17. Cross-sectional flow area, A	ft^2		1.7556					
18. Wetted perimeter, P_W	ft^2		6.7212					
19. Hydraulic radius, R	ft		0.2612					
20. Upstream elevation			103.98					
21. Downstream elevation			103.4					
22. Channel slope, S	ft/ft		0.0052					
17. Manning's roughness coeff., n			0.013					
18. Velocity	ft/s		3.37					
19. Flow length, L	ft		112					
20. $T_t = L / 3600*V$	hr		0.009				=	0.009

27. Watershed or subarea Tc or Tt ..... hr **0.017**



Worksheet 3: Time of concentration (Tc) or travel time (Tt)

Project : **Elkton Road, MD Line to Casho Mill** By **DEN** **8/11/2017**

Location : **Swale 22 (6069+48 - 6066+85 LT)** Checked

County : **New Castle County, DE**

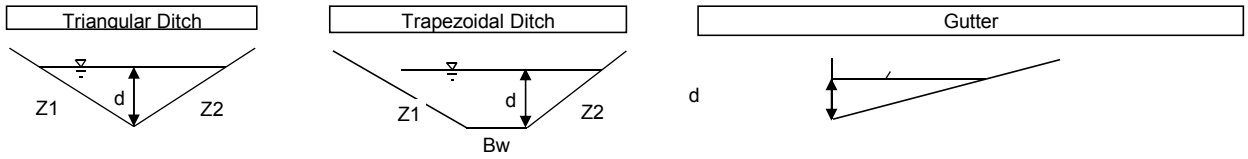
Circle one: Present [Developed] **ULTIMATE CONDITIONS**

NOTE : Space for as many as three segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments

Sheet flow (Applicable to Tc only)		Segment ID	22-AB					
1. Surface Description (table 3-1)			Concrete					
2. Manning's roughness coeff., n (table 3-1)			0.011					
3. Flow length, L (total L ≤ 100 ft)	ft		55					
4. Two-yr 24-hr rainfall, P_2	in		3.2					
5. Upstream elevation			105.28					
6. Downstream elevation			101.13					
7. Land slope, s	ft/ft		0.075					
8. $T_t = 0.007\ (nL)^{0.8} / [(P_2^{0.5})(s^{0.4})]$	hr		0.007					= 0.007

Channel Flow		Segment ID	22-BC					
16. Channel Geometry			Trapezoidal Ditch; Assume Depth = .33; Z1 = 4; Z2 = 4; Bw = 4					
17. Cross-sectional flow area, A	ft^2		1.7556					
18. Wetted perimeter, P_W	ft^2		6.7212					
19. Hydraulic radius, R	ft		0.2612					
20. Upstream elevation			101.13					
21. Downstream elevation			100.11					
22. Channel slope, S	ft/ft		0.0039					
23. Manning's roughness coeff., n			0.045					
24. Velocity	ft/s		0.84					
25. Flow length, L	ft		262					
26. $T_t = L / 3600 * V$	hr		0.086					= 0.086

27. Watershed or subarea Tc or Tt hr 0.094



Worksheet 3: Time of concentration (Tc) or travel time (Tt)

Project : **Elkton Road, MD Line to Casho Mill** By **DEN** **8/11/2017**

Location : **Swale 23 (6069+48 - 6072+61 LT)** Checked

County : **New Castle County, DE**

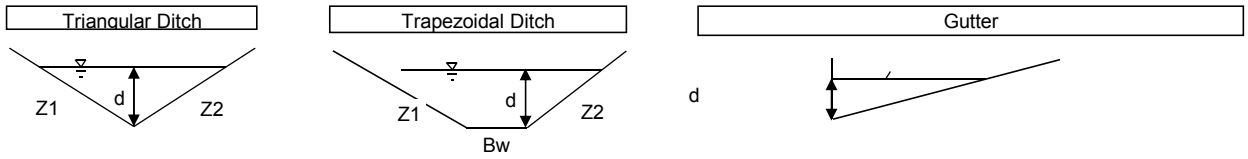
Circle one: Present [Developed] **ULTIMATE CONDITIONS**

NOTE : Space for as many as three segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments

Sheet flow (Applicable to Tc only)		Segment ID	23-AB					
1. Surface Description (table 3-1)			Concrete					
2. Manning's roughness coeff., n (table 3-1)			0.011					
3. Flow length, L (total L ≤ 100 ft)	ft		56					
4. Two-yr 24-hr rainfall, P_2	in		3.2					
5. Upstream elevation			105.29					
6. Downstream elevation			101.13					
7. Land slope, s	ft/ft		0.074					
8. $T_t = 0.007\ (nL)^{0.8} / [(P_2^{0.5})(s^{0.4})]$	hr		0.008					= 0.008

Channel Flow		Segment ID	23-BC					
16. Channel Geometry			Trapezoidal Ditch; Assume Depth = .33; Z1 = 4; Z2 = 4; Bw = 4					
17. Cross-sectional flow area, A	ft^2		1.7556					
18. Wetted perimeter, P_W	ft^2		6.7212					
19. Hydraulic radius, R	ft		0.2612					
20. Upstream elevation			101.13					
21. Downstream elevation			100.1					
22. Channel slope, S	ft/ft		0.0033					
23. Manning's roughness coeff., n			0.045					
24. Velocity	ft/s		0.77					
25. Flow length, L	ft		315					
26. $T_t = L / 3600 * V$	hr		0.113					= 0.113

27. Watershed or subarea Tc or Tt hr 0.121



Worksheet 3: Time of concentration (Tc) or travel time (Tt)

Project : **Elkton Road, MD Line to Casho Mill** By **DEN** **8/11/2017**

Location : **Swale 24 (6069+48 - 7072+44 RT)** Checked

County : **New Castle County, DE**

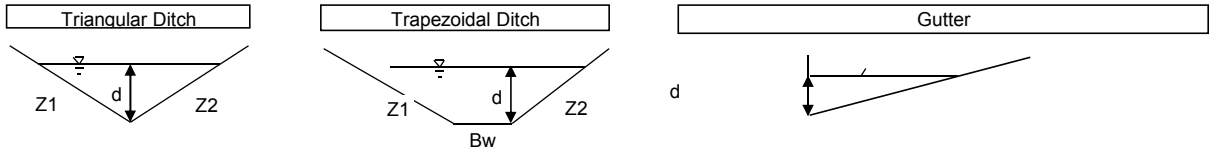
Circle one: Present [Developed] **ULTIMATE CONDITIONS**

NOTE : Space for as many as three segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments

Sheet flow (Applicable to Tc only)		Segment ID	24-AB					
1. Surface Description (table 3-1)			Concrete					
2. Manning's roughness coeff., n (table 3-1)			0.011					
3. Flow length, L (total L ≤ 100 ft)	ft		40					
4. Two-yr 24-hr rainfall, P_2	in		3.2					
5. Upstream elevation			105.29					
6. Downstream elevation			104.05					
7. Land slope, s	ft/ft		0.031					
8. $T_t = 0.007\ (nL)^{0.8} / [(P_2^{0.5})(s^{0.4})]$	hr		0.008				=	0.008

Channel Flow		Segment ID	24-BC					
16. Channel Geometry			Trapezoidal Ditch; Assume Depth = .33; Z1 = 15; Z2 = 8; Bw = 4					
17. Cross-sectional flow area, A	ft^2		2.57235					
18. Wetted perimeter, P_W	ft^2		11.6215					
19. Hydraulic radius, R	ft		0.2213					
20. Upstream elevation			104.05					
21. Downstream elevation			103					
22. Channel slope, S	ft/ft		0.0036					
23. Manning's roughness coeff., n			0.045					
24. Velocity	ft/s		0.72					
25. Flow length, L	ft		295					
26. $T_t = L / 3600*V$	hr		0.113				=	0.113

27. Watershed or subarea Tc or Tt hr **0.122**



Worksheet 3: Time of concentration (Tc) or travel time (Tt)

Project : **Elkton Road, MD Line to Casho Mill** By **DEN** **8/11/2017**

Location : **Swale 25 (6072+83 - 7076+40 RT)** Checked

County : **New Castle County, DE**

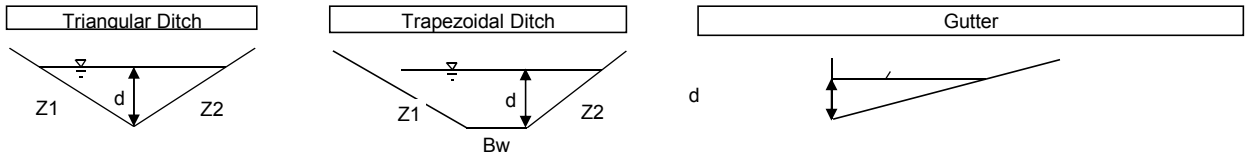
Circle one: Present [Developed] **ULTIMATE CONDITIONS**

NOTE : Space for as many as three segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments

Sheet flow (Applicable to Tc only)		Segment ID	25-AB					
1. Surface Description (table 3-1)			Concrete					
2. Manning's roughness coeff., n (table 3-1)			0.011					
3. Flow length, L (total L ≤ 100 ft)	ft		56					
4. Two-yr 24-hr rainfall, P_2	in		3.2					
5. Upstream elevation			104.09					
6. Downstream elevation			102.84					
7. Land slope, s	ft/ft		0.022					
8. $T_t = 0.007\ (nL)^{0.8} / [(P_2^{0.5})(s^{0.4})]$	hr		0.012					= 0.012

Channel Flow		Segment ID	25-BC					
16. Channel Geometry			Trapezoidal Ditch; Assume Depth = .33; Z1 = 14; Z2 = 8; Bw = 4					
17. Cross-sectional flow area, A	ft^2		2.5179					
18. Wetted perimeter, P_W	ft^2		11.2923					
19. Hydraulic radius, R	ft		0.2230					
20. Upstream elevation			102.84					
21. Downstream elevation			101.18					
22. Channel slope, S	ft/ft		0.0046					
23. Manning's roughness coeff., n			0.045					
24. Velocity	ft/s		0.83					
25. Flow length, L	ft		358					
26. $T_t = L / 3600 * V$	hr		0.120					= 0.120

27. Watershed or subarea Tc or Tt hr 0.132



Appendix D.2

Backup Swale Calculations
(Hydraulic Toolbox 4.2)

Hydraulic Analysis Report

Project Data

Project Title: Elkton Road, MD Line to Casho Mill Road

Designer: JMT

Project Date: Friday, August 11, 2017

Project Units: U.S. Customary Units

Notes:

Channel Analysis: Swale 1

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 8.0000 ft/ft

Side Slope 2 (Z2): 8.0000 ft/ft

Channel Width: 4.0000 ft

Longitudinal Slope: 0.0230 ft/ft

Manning's n: 0.0450

Flow: 2.8300 cfs

Result Parameters

Depth: 0.2694 ft

Area of Flow: 1.6578 ft^2

Wetted Perimeter: 8.3432 ft

Hydraulic Radius: 0.1987 ft

Average Velocity: 1.7070 ft/s

Top Width: 8.3097 ft

Froude Number: 0.6735

Critical Depth: 0.2147 ft

Critical Velocity: 2.3060 ft/s

Critical Slope: 0.0541 ft/ft

Critical Top Width: 7.43 ft

Calculated Max Shear Stress: 0.3866 lb/ft^2

Calculated Avg Shear Stress: 0.2852 lb/ft^2

Channel Analysis: Swale 2

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 4.0000 ft/ft

Side Slope 2 (Z2): 4.0000 ft/ft

Channel Width: 4.0000 ft

Longitudinal Slope: 0.0120 ft/ft

Manning's n: 0.0450

Flow: 1.5600 cfs

Result Parameters

Depth: 0.2482 ft

Area of Flow: 1.2394 ft^2

Wetted Perimeter: 6.0469 ft

Hydraulic Radius: 0.2050 ft

Average Velocity: 1.2587 ft/s

Top Width: 5.9858 ft

Froude Number: 0.4875

Critical Depth: 0.1587 ft

Critical Velocity: 2.1209 ft/s

Critical Slope: 0.0575 ft/ft

Critical Top Width: 5.27 ft

Calculated Max Shear Stress: 0.1859 lb/ft^2

Calculated Avg Shear Stress: 0.1535 lb/ft^2

Channel Analysis: Swale 3A

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 8.0000 ft/ft

Side Slope 2 (Z2): 8.0000 ft/ft

Channel Width: 4.0000 ft

Longitudinal Slope: 0.0280 ft/ft

Manning's n: 0.0450

Flow: 4.3800 cfs

Result Parameters

Depth: 0.3217 ft

Area of Flow: 2.1146 ft^2

Wetted Perimeter: 9.1871 ft

Hydraulic Radius: 0.2302 ft

Average Velocity: 2.0713 ft/s

Top Width: 9.1470 ft

Froude Number: 0.7592

Critical Depth: 0.2757 ft

Critical Velocity: 2.5605 ft/s

Critical Slope: 0.0505 ft/ft

Critical Top Width: 8.41 ft

Calculated Max Shear Stress: 0.5621 lb/ft^2

Calculated Avg Shear Stress: 0.4022 lb/ft^2

Channel Analysis: Swale 3B

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 8.0000 ft/ft

Side Slope 2 (Z2): 8.0000 ft/ft

Channel Width: 4.0000 ft

Longitudinal Slope: 0.0140 ft/ft

Manning's n: 0.0450

Flow: 0.2700 cfs

Result Parameters

Depth: 0.0845 ft

Area of Flow: 0.3953 ft^2

Wetted Perimeter: 5.3632 ft

Hydraulic Radius: 0.0737 ft

Average Velocity: 0.6830 ft/s

Top Width: 5.3526 ft

Froude Number: 0.4429

Critical Depth: 0.0503 ft

Critical Velocity: 1.2182 ft/s

Critical Slope: 0.0824 ft/ft

Critical Top Width: 4.81 ft

Calculated Max Shear Stress: 0.0739 lb/ft^2

Calculated Avg Shear Stress: 0.0644 lb/ft^2

Channel Analysis: Swale 4

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Channel Width: 4.0000 ft

Longitudinal Slope: 0.0440 ft/ft

Manning's n: 0.0450

Flow: 8.8400 cfs

Result Parameters

Depth: 0.4820 ft

Area of Flow: 2.3928 ft^2

Wetted Perimeter: 6.1557 ft

Hydraulic Radius: 0.3887 ft

Average Velocity: 3.6945 ft/s

Top Width: 5.9281 ft

Froude Number: 1.0248

Critical Depth: 0.4892 ft

Critical Velocity: 3.6295 ft/s

Critical Slope: 0.0419 ft/ft

Critical Top Width: 5.96 ft

Calculated Max Shear Stress: 1.3234 lb/ft^2

Calculated Avg Shear Stress: 1.0672 lb/ft^2

Channel Analysis: Swale 5A

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 4.0000 ft/ft

Side Slope 2 (Z2): 4.0000 ft/ft

Channel Width: 4.0000 ft

Longitudinal Slope: 0.0120 ft/ft

Manning's n: 0.0450

Flow: 3.7300 cfs

Result Parameters

Depth: 0.4027 ft

Area of Flow: 2.2595 ft^2

Wetted Perimeter: 7.3208 ft

Hydraulic Radius: 0.3086 ft

Average Velocity: 1.6508 ft/s

Top Width: 7.2216 ft

Froude Number: 0.5201

Critical Depth: 0.2725 ft

Critical Velocity: 2.6890 ft/s

Critical Slope: 0.0493 ft/ft

Critical Top Width: 6.18 ft

Calculated Max Shear Stress: 0.3015 lb/ft^2

Calculated Avg Shear Stress: 0.2311 lb/ft^2

Channel Analysis: Swale 5B

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 4.0000 ft/ft

Side Slope 2 (Z2): 4.0000 ft/ft

Channel Width: 4.0000 ft

Longitudinal Slope: 0.0090 ft/ft

Manning's n: 0.0450

Flow: 5.8200 cfs

Result Parameters

Depth: 0.5512 ft

Area of Flow: 3.4197 ft^2

Wetted Perimeter: 8.5450 ft

Hydraulic Radius: 0.4002 ft

Average Velocity: 1.7019 ft/s

Top Width: 8.4093 ft

Froude Number: 0.4703

Critical Depth: 0.3561 ft

Critical Velocity: 3.0128 ft/s

Critical Slope: 0.0458 ft/ft

Critical Top Width: 6.85 ft

Calculated Max Shear Stress: 0.3095 lb/ft^2

Calculated Avg Shear Stress: 0.2248 lb/ft^2

Channel Analysis: Swale 6

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Channel Width: 4.0000 ft

Longitudinal Slope: 0.0050 ft/ft

Manning's n: 0.0450

Flow: 4.5100 cfs

Result Parameters

Depth: 0.6097 ft

Area of Flow: 3.1822 ft^2

Wetted Perimeter: 6.7266 ft

Hydraulic Radius: 0.4731 ft

Average Velocity: 1.4172 ft/s

Top Width: 6.4388 ft

Froude Number: 0.3553

Critical Depth: 0.3221 ft

Critical Velocity: 3.0151 ft/s

Critical Slope: 0.0466 ft/ft

Critical Top Width: 5.29 ft

Calculated Max Shear Stress: 0.1902 lb/ft^2

Calculated Avg Shear Stress: 0.1476 lb/ft^2

Channel Analysis: Swale 7

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 8.0000 ft/ft

Side Slope 2 (Z2): 8.0000 ft/ft

Channel Width: 4.0000 ft

Longitudinal Slope: 0.0110 ft/ft

Manning's n: 0.0450

Flow: 1.3500 cfs

Result Parameters

Depth: 0.2210 ft

Area of Flow: 1.2751 ft^2

Wetted Perimeter: 7.5643 ft

Hydraulic Radius: 0.1686 ft

Average Velocity: 1.0587 ft/s

Top Width: 7.5368 ft

Froude Number: 0.4536

Critical Depth: 0.1382 ft

Critical Velocity: 1.9136 ft/s

Critical Slope: 0.0613 ft/ft

Critical Top Width: 6.21 ft

Calculated Max Shear Stress: 0.1517 lb/ft^2

Calculated Avg Shear Stress: 0.1157 lb/ft^2

Channel Analysis: Swale 8

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 4.0000 ft/ft

Side Slope 2 (Z2): 4.0000 ft/ft

Channel Width: 4.0000 ft

Longitudinal Slope: 0.0130 ft/ft

Manning's n: 0.0450

Flow: 4.9400 cfs

Result Parameters

Depth: 0.4587 ft

Area of Flow: 2.6763 ft^2

Wetted Perimeter: 7.7824 ft

Hydraulic Radius: 0.3439 ft

Average Velocity: 1.8459 ft/s

Top Width: 7.6694 ft

Froude Number: 0.5507

Critical Depth: 0.3228 ft

Critical Velocity: 2.8926 ft/s

Critical Slope: 0.0471 ft/ft

Critical Top Width: 6.58 ft

Calculated Max Shear Stress: 0.3721 lb/ft^2

Calculated Avg Shear Stress: 0.2790 lb/ft^2

Channel Analysis: Swale 9A

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 13.0000 ft/ft

Side Slope 2 (Z2): 8.0000 ft/ft

Longitudinal Slope: 0.0050 ft/ft

Manning's n: 0.0450

Flow: 0.6200 cfs

Result Parameters

Depth: 0.2998 ft

Area of Flow: 0.9439 ft^2

Wetted Perimeter: 6.3265 ft

Hydraulic Radius: 0.1492 ft

Average Velocity: 0.6568 ft/s

Top Width: 6.2963 ft

Froude Number: 0.2990

Critical Depth: 0.1871 ft

Critical Velocity: 1.6859 ft/s

Critical Slope: 0.0617 ft/ft

Critical Top Width: 4.17 ft

Calculated Max Shear Stress: 0.0935 lb/ft^2

Calculated Avg Shear Stress: 0.0465 lb/ft^2

Channel Analysis: Swale 9B

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 14.0000 ft/ft

Side Slope 2 (Z2): 8.0000 ft/ft

Channel Width: 4.0000 ft

Longitudinal Slope: 0.0070 ft/ft

Manning's n: 0.0450

Flow: 1.6100 cfs

Result Parameters

Depth: 0.2618 ft

Area of Flow: 1.8009 ft^2

Wetted Perimeter: 9.7847 ft

Hydraulic Radius: 0.1841 ft

Average Velocity: 0.8940 ft/s

Top Width: 9.7590 ft

Froude Number: 0.3668

Critical Depth: 0.1484 ft

Critical Velocity: 1.9259 ft/s

Critical Slope: 0.0609 ft/ft

Critical Top Width: 7.27 ft

Calculated Max Shear Stress: 0.1143 lb/ft^2

Calculated Avg Shear Stress: 0.0804 lb/ft^2

Channel Analysis: Swale 9C

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 18.0000 ft/ft

Side Slope 2 (Z2): 8.0000 ft/ft

Channel Width: 4.0000 ft

Longitudinal Slope: 0.0150 ft/ft

Manning's n: 0.0450

Flow: 1.1100 cfs

Result Parameters

Depth: 0.1733 ft

Area of Flow: 1.0833 ft^2

Wetted Perimeter: 8.5204 ft

Hydraulic Radius: 0.1271 ft

Average Velocity: 1.0246 ft/s

Top Width: 8.5048 ft

Froude Number: 0.5059

Critical Depth: 0.1170 ft

Critical Velocity: 1.7184 ft/s

Critical Slope: 0.0656 ft/ft

Critical Top Width: 7.04 ft

Calculated Max Shear Stress: 0.1622 lb/ft^2

Calculated Avg Shear Stress: 0.1190 lb/ft^2

Channel Analysis: Swale 9D

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 16.0000 ft/ft

Side Slope 2 (Z2): 8.0000 ft/ft

Channel Width: 4.0000 ft

Longitudinal Slope: 0.0140 ft/ft

Manning's n: 0.0450

Flow: 2.0400 cfs

Result Parameters

Depth: 0.2444 ft

Area of Flow: 1.6939 ft^2

Wetted Perimeter: 9.8874 ft

Hydraulic Radius: 0.1713 ft

Average Velocity: 1.2043 ft/s

Top Width: 9.8646 ft

Froude Number: 0.5121

Critical Depth: 0.1682 ft

Critical Velocity: 2.0153 ft/s

Critical Slope: 0.0591 ft/ft

Critical Top Width: 8.04 ft

Calculated Max Shear Stress: 0.2135 lb/ft^2

Calculated Avg Shear Stress: 0.1497 lb/ft^2

Channel Analysis: Swale 10

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 4.0000 ft/ft

Side Slope 2 (Z2): 4.0000 ft/ft

Channel Width: 4.0000 ft

Longitudinal Slope: 0.0050 ft/ft

Manning's n: 0.0450

Flow: 1.9500 cfs

Result Parameters

Depth: 0.3589 ft

Area of Flow: 1.9508 ft^2

Wetted Perimeter: 6.9596 ft

Hydraulic Radius: 0.2803 ft

Average Velocity: 0.9996 ft/s

Top Width: 6.8712 ft

Froude Number: 0.3306

Critical Depth: 0.1826 ft

Critical Velocity: 2.2576 ft/s

Critical Slope: 0.0552 ft/ft

Critical Top Width: 5.46 ft

Calculated Max Shear Stress: 0.1120 lb/ft^2

Calculated Avg Shear Stress: 0.0875 lb/ft^2

Channel Analysis: Swale 11A

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 13.0000 ft/ft

Side Slope 2 (Z2): 8.0000 ft/ft

Longitudinal Slope: 0.0050 ft/ft

Manning's n: 0.0450

Flow: 0.9500 cfs

Result Parameters

Depth: 0.3519 ft

Area of Flow: 1.2999 ft^2

Wetted Perimeter: 7.4244 ft

Hydraulic Radius: 0.1751 ft

Average Velocity: 0.7308 ft/s

Top Width: 7.3890 ft

Froude Number: 0.3070

Critical Depth: 0.2220 ft

Critical Velocity: 1.8361 ft/s

Critical Slope: 0.0583 ft/ft

Critical Top Width: 4.94 ft

Calculated Max Shear Stress: 0.1098 lb/ft^2

Calculated Avg Shear Stress: 0.0546 lb/ft^2

Channel Analysis: Swale 11B

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 13.0000 ft/ft

Side Slope 2 (Z2): 8.0000 ft/ft

Longitudinal Slope: 0.0083 ft/ft

Manning's n: 0.0450

Flow: 0.8900 cfs

Result Parameters

Depth: 0.3122 ft

Area of Flow: 1.0236 ft^2

Wetted Perimeter: 6.5882 ft

Hydraulic Radius: 0.1554 ft

Average Velocity: 0.8695 ft/s

Top Width: 6.5568 ft

Froude Number: 0.3878

Critical Depth: 0.2163 ft

Critical Velocity: 1.8123 ft/s

Critical Slope: 0.0588 ft/ft

Critical Top Width: 4.81 ft

Calculated Max Shear Stress: 0.1617 lb/ft^2

Calculated Avg Shear Stress: 0.0805 lb/ft^2

Channel Analysis: Swale 12

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 4.0000 ft/ft

Side Slope 2 (Z2): 4.0000 ft/ft

Channel Width: 4.0000 ft

Longitudinal Slope: 0.0080 ft/ft

Manning's n: 0.0450

Flow: 2.9800 cfs

Result Parameters

Depth: 0.3978 ft

Area of Flow: 2.2244 ft^2

Wetted Perimeter: 7.2807 ft

Hydraulic Radius: 0.3055 ft

Average Velocity: 1.3397 ft/s

Top Width: 7.1827 ft

Froude Number: 0.4242

Critical Depth: 0.2376 ft

Critical Velocity: 2.5340 ft/s

Critical Slope: 0.0512 ft/ft

Critical Top Width: 5.90 ft

Calculated Max Shear Stress: 0.1986 lb/ft^2

Calculated Avg Shear Stress: 0.1525 lb/ft^2

Channel Analysis: Swale 13

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 4.0000 ft/ft

Side Slope 2 (Z2): 4.0000 ft/ft

Channel Width: 4.0000 ft

Longitudinal Slope: 0.0080 ft/ft

Manning's n: 0.0450

Flow: 6.6000 cfs

Result Parameters

Depth: 0.6072 ft

Area of Flow: 3.9040 ft^2

Wetted Perimeter: 9.0075 ft

Hydraulic Radius: 0.4334 ft

Average Velocity: 1.6906 ft/s

Top Width: 8.8580 ft

Froude Number: 0.4488

Critical Depth: 0.3837 ft

Critical Velocity: 3.1073 ft/s

Critical Slope: 0.0448 ft/ft

Critical Top Width: 7.07 ft

Calculated Max Shear Stress: 0.3031 lb/ft^2

Calculated Avg Shear Stress: 0.2164 lb/ft^2

Channel Analysis: Swale 14A

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 13.0000 ft/ft

Side Slope 2 (Z2): 8.0000 ft/ft

Longitudinal Slope: 0.0070 ft/ft

Manning's n: 0.0450

Flow: 2.5300 cfs

Result Parameters

Depth: 0.4770 ft

Area of Flow: 2.3888 ft^2

Wetted Perimeter: 10.0644 ft

Hydraulic Radius: 0.2373 ft

Average Velocity: 1.0591 ft/s

Top Width: 10.0164 ft

Froude Number: 0.3822

Critical Depth: 0.3285 ft

Critical Velocity: 2.2335 ft/s

Critical Slope: 0.0512 ft/ft

Critical Top Width: 7.31 ft

Calculated Max Shear Stress: 0.2083 lb/ft^2

Calculated Avg Shear Stress: 0.1037 lb/ft^2

Channel Analysis: Swale 14B

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 14.0000 ft/ft

Side Slope 2 (Z2): 8.0000 ft/ft

Channel Width: 4.0000 ft

Longitudinal Slope: 0.0040 ft/ft

Manning's n: 0.0450

Flow: 2.6400 cfs

Result Parameters

Depth: 0.3838 ft

Area of Flow: 3.1554 ft^2

Wetted Perimeter: 12.4810 ft

Hydraulic Radius: 0.2528 ft

Average Velocity: 0.8366 ft/s

Top Width: 12.4435 ft

Froude Number: 0.2928

Critical Depth: 0.1974 ft

Critical Velocity: 2.1676 ft/s

Critical Slope: 0.0562 ft/ft

Critical Top Width: 8.34 ft

Calculated Max Shear Stress: 0.0958 lb/ft^2

Calculated Avg Shear Stress: 0.0631 lb/ft^2

Channel Analysis: Swale 15

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 4.0000 ft/ft

Side Slope 2 (Z2): 4.0000 ft/ft

Channel Width: 4.0000 ft

Longitudinal Slope: 0.0060 ft/ft

Manning's n: 0.0450

Flow: 8.2700 cfs

Result Parameters

Depth: 0.7340 ft

Area of Flow: 5.0910 ft^2

Wetted Perimeter: 10.0527 ft

Hydraulic Radius: 0.5064 ft

Average Velocity: 1.6244 ft/s

Top Width: 9.8720 ft

Froude Number: 0.3986

Critical Depth: 0.4377 ft

Critical Velocity: 3.2857 ft/s

Critical Slope: 0.0433 ft/ft

Critical Top Width: 7.50 ft

Calculated Max Shear Stress: 0.2748 lb/ft^2

Calculated Avg Shear Stress: 0.1896 lb/ft^2

Channel Analysis: Swale 16

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 4.0000 ft/ft

Side Slope 2 (Z2): 4.0000 ft/ft

Channel Width: 4.0000 ft

Longitudinal Slope: 0.0070 ft/ft

Manning's n: 0.0450

Flow: 1.2900 cfs

Result Parameters

Depth: 0.2595 ft

Area of Flow: 1.3074 ft^2

Wetted Perimeter: 6.1400 ft

Hydraulic Radius: 0.2129 ft

Average Velocity: 0.9867 ft/s

Top Width: 6.0761 ft

Froude Number: 0.3748

Critical Depth: 0.1407 ft

Critical Velocity: 2.0093 ft/s

Critical Slope: 0.0596 ft/ft

Critical Top Width: 5.13 ft

Calculated Max Shear Stress: 0.1134 lb/ft^2

Calculated Avg Shear Stress: 0.0930 lb/ft^2

Channel Analysis: Swale 17

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 14.0000 ft/ft

Side Slope 2 (Z2): 8.0000 ft/ft

Channel Width: 4.0000 ft

Longitudinal Slope: 0.0050 ft/ft

Manning's n: 0.0450

Flow: 1.7300 cfs

Result Parameters

Depth: 0.2957 ft

Area of Flow: 2.1443 ft^2

Wetted Perimeter: 10.5337 ft

Hydraulic Radius: 0.2036 ft

Average Velocity: 0.8068 ft/s

Top Width: 10.5047 ft

Froude Number: 0.3147

Critical Depth: 0.1548 ft

Critical Velocity: 1.9600 ft/s

Critical Slope: 0.0602 ft/ft

Critical Top Width: 7.41 ft

Calculated Max Shear Stress: 0.0922 lb/ft^2

Calculated Avg Shear Stress: 0.0635 lb/ft^2

Channel Analysis: Swale 18

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 14.0000 ft/ft

Side Slope 2 (Z2): 8.0000 ft/ft

Channel Width: 4.0000 ft

Longitudinal Slope: 0.0050 ft/ft

Manning's n: 0.0450

Flow: 1.7300 cfs

Result Parameters

Depth: 0.2957 ft

Area of Flow: 2.1443 ft^2

Wetted Perimeter: 10.5337 ft

Hydraulic Radius: 0.2036 ft

Average Velocity: 0.8068 ft/s

Top Width: 10.5047 ft

Froude Number: 0.3147

Critical Depth: 0.1548 ft

Critical Velocity: 1.9600 ft/s

Critical Slope: 0.0602 ft/ft

Critical Top Width: 7.41 ft

Calculated Max Shear Stress: 0.0922 lb/ft^2

Calculated Avg Shear Stress: 0.0635 lb/ft^2

Channel Analysis: Swale 19A

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 4.0000 ft/ft

Side Slope 2 (Z2): 4.0000 ft/ft

Channel Width: 4.0000 ft

Longitudinal Slope: 0.0090 ft/ft

Manning's n: 0.0450

Flow: 1.2600 cfs

Result Parameters

Depth: 0.2388 ft

Area of Flow: 1.1834 ft^2

Wetted Perimeter: 5.9694 ft

Hydraulic Radius: 0.1982 ft

Average Velocity: 1.0647 ft/s

Top Width: 5.9106 ft

Froude Number: 0.4193

Critical Depth: 0.1386 ft

Critical Velocity: 1.9957 ft/s

Critical Slope: 0.0599 ft/ft

Critical Top Width: 5.11 ft

Calculated Max Shear Stress: 0.1341 lb/ft^2

Calculated Avg Shear Stress: 0.1113 lb/ft^2

Channel Analysis: Swale 19B

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 4.0000 ft/ft

Side Slope 2 (Z2): 4.0000 ft/ft

Channel Width: 4.0000 ft

Longitudinal Slope: 0.0050 ft/ft

Manning's n: 0.0450

Flow: 2.8800 cfs

Result Parameters

Depth: 0.4435 ft

Area of Flow: 2.5605 ft^2

Wetted Perimeter: 7.6569 ft

Hydraulic Radius: 0.3344 ft

Average Velocity: 1.1248 ft/s

Top Width: 7.5478 ft

Froude Number: 0.3403

Critical Depth: 0.2326 ft

Critical Velocity: 2.5116 ft/s

Critical Slope: 0.0516 ft/ft

Critical Top Width: 5.86 ft

Calculated Max Shear Stress: 0.1384 lb/ft^2

Calculated Avg Shear Stress: 0.1043 lb/ft^2

Channel Analysis: Swale 19C

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 3.0000 ft/ft

Side Slope 2 (Z2): 3.0000 ft/ft

Longitudinal Slope: 0.0250 ft/ft

Manning's n: 0.0450

Flow: 3.7600 cfs

Result Parameters

Depth: 0.7056 ft

Area of Flow: 1.4938 ft^2

Wetted Perimeter: 4.4629 ft

Hydraulic Radius: 0.3347 ft

Average Velocity: 2.5171 ft/s

Top Width: 4.2339 ft

Froude Number: 0.7468

Critical Depth: 0.6279 ft

Critical Velocity: 3.1794 ft/s

Critical Slope: 0.0466 ft/ft

Critical Top Width: 3.77 ft

Calculated Max Shear Stress: 1.1008 lb/ft^2

Calculated Avg Shear Stress: 0.5222 lb/ft^2

Channel Analysis: Swale 20

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 14.0000 ft/ft

Side Slope 2 (Z2): 8.0000 ft/ft

Channel Width: 4.0000 ft

Longitudinal Slope: 0.0030 ft/ft

Manning's n: 0.0450

Flow: 1.4600 cfs

Result Parameters

Depth: 0.3084 ft

Area of Flow: 2.2796 ft^2

Wetted Perimeter: 10.8145 ft

Hydraulic Radius: 0.2108 ft

Average Velocity: 0.6405 ft/s

Top Width: 10.7843 ft

Froude Number: 0.2455

Critical Depth: 0.1402 ft

Critical Velocity: 1.8798 ft/s

Critical Slope: 0.0619 ft/ft

Critical Top Width: 7.08 ft

Calculated Max Shear Stress: 0.0577 lb/ft^2

Calculated Avg Shear Stress: 0.0395 lb/ft^2

Channel Analysis: Swale 21

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 4.0000 ft/ft

Side Slope 2 (Z2): 4.0000 ft/ft

Channel Width: 4.0000 ft

Longitudinal Slope: 0.0050 ft/ft

Manning's n: 0.0450

Flow: 0.7300 cfs

Result Parameters

Depth: 0.2068 ft

Area of Flow: 0.9985 ft^2

Wetted Perimeter: 5.7057 ft

Hydraulic Radius: 0.1750 ft

Average Velocity: 0.7311 ft/s

Top Width: 5.6548 ft

Froude Number: 0.3066

Critical Depth: 0.0977 ft

Critical Velocity: 1.7010 ft/s

Critical Slope: 0.0665 ft/ft

Critical Top Width: 4.78 ft

Calculated Max Shear Stress: 0.0645 lb/ft^2

Calculated Avg Shear Stress: 0.0546 lb/ft^2

Channel Analysis: Swale 22

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 4.0000 ft/ft

Side Slope 2 (Z2): 4.0000 ft/ft

Channel Width: 4.0000 ft

Longitudinal Slope: 0.0040 ft/ft

Manning's n: 0.0450

Flow: 1.8300 cfs

Result Parameters

Depth: 0.3686 ft

Area of Flow: 2.0181 ft^2

Wetted Perimeter: 7.0398 ft

Hydraulic Radius: 0.2867 ft

Average Velocity: 0.9068 ft/s

Top Width: 6.9491 ft

Froude Number: 0.2965

Critical Depth: 0.1755 ft

Critical Velocity: 2.2180 ft/s

Critical Slope: 0.0559 ft/ft

Critical Top Width: 5.40 ft

Calculated Max Shear Stress: 0.0920 lb/ft^2

Calculated Avg Shear Stress: 0.0716 lb/ft^2

Channel Analysis: Swale 23

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 4.0000 ft/ft

Side Slope 2 (Z2): 4.0000 ft/ft

Channel Width: 4.0000 ft

Longitudinal Slope: 0.0030 ft/ft

Manning's n: 0.0450

Flow: 1.6600 cfs

Result Parameters

Depth: 0.3778 ft

Area of Flow: 2.0818 ft^2

Wetted Perimeter: 7.1151 ft

Hydraulic Radius: 0.2926 ft

Average Velocity: 0.7974 ft/s

Top Width: 7.0221 ft

Froude Number: 0.2581

Critical Depth: 0.1651 ft

Critical Velocity: 2.1582 ft/s

Critical Slope: 0.0569 ft/ft

Critical Top Width: 5.32 ft

Calculated Max Shear Stress: 0.0707 lb/ft^2

Calculated Avg Shear Stress: 0.0548 lb/ft^2

Channel Analysis: Swale 24

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 15.0000 ft/ft

Side Slope 2 (Z2): 8.0000 ft/ft

Channel Width: 4.0000 ft

Longitudinal Slope: 0.0040 ft/ft

Manning's n: 0.0450

Flow: 1.7100 cfs

Result Parameters

Depth: 0.3083 ft

Area of Flow: 2.3262 ft^2

Wetted Perimeter: 11.1202 ft

Hydraulic Radius: 0.2092 ft

Average Velocity: 0.7351 ft/s

Top Width: 11.0908 ft

Froude Number: 0.2829

Critical Depth: 0.1529 ft

Critical Velocity: 1.9426 ft/s

Critical Slope: 0.0606 ft/ft

Critical Top Width: 7.52 ft

Calculated Max Shear Stress: 0.0770 lb/ft^2

Calculated Avg Shear Stress: 0.0522 lb/ft^2

Channel Analysis: Swale 25

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 14.0000 ft/ft

Side Slope 2 (Z2): 8.0000 ft/ft

Channel Width: 4.0000 ft

Longitudinal Slope: 0.0050 ft/ft

Manning's n: 0.0450

Flow: 1.5400 cfs

Result Parameters

Depth: 0.2787 ft

Area of Flow: 1.9694 ft^2

Wetted Perimeter: 10.1592 ft

Hydraulic Radius: 0.1939 ft

Average Velocity: 0.7820 ft/s

Top Width: 10.1319 ft

Froude Number: 0.3126

Critical Depth: 0.1446 ft

Critical Velocity: 1.9050 ft/s

Critical Slope: 0.0614 ft/ft

Critical Top Width: 7.18 ft

Calculated Max Shear Stress: 0.0870 lb/ft^2

Calculated Avg Shear Stress: 0.0605 lb/ft^2

Channel Analysis: Swale 26

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 4.0000 ft/ft

Side Slope 2 (Z2): 4.0000 ft/ft

Longitudinal Slope: 0.0020 ft/ft

Manning's n: 0.0450

Flow: 0.0100 cfs

Result Parameters

Depth: 0.1095 ft

Area of Flow: 0.0479 ft^2

Wetted Perimeter: 0.9027 ft

Hydraulic Radius: 0.0531 ft

Average Velocity: 0.2086 ft/s

Top Width: 0.8757 ft

Froude Number: 0.1572

Critical Depth: 0.0522 ft

Critical Velocity: 0.9169 ft/s

Critical Slope: 0.1036 ft/ft

Critical Top Width: 0.42 ft

Calculated Max Shear Stress: 0.0137 lb/ft^2

Calculated Avg Shear Stress: 0.0066 lb/ft^2

Channel Analysis: Swale 27

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 4.0000 ft/ft

Side Slope 2 (Z2): 4.0000 ft/ft

Longitudinal Slope: 0.0020 ft/ft

Manning's n: 0.0450

Flow: 0.0100 cfs

Result Parameters

Depth: 0.1095 ft

Area of Flow: 0.0479 ft^2

Wetted Perimeter: 0.9027 ft

Hydraulic Radius: 0.0531 ft

Average Velocity: 0.2086 ft/s

Top Width: 0.8757 ft

Froude Number: 0.1572

Critical Depth: 0.0522 ft

Critical Velocity: 0.9169 ft/s

Critical Slope: 0.1036 ft/ft

Critical Top Width: 0.42 ft

Calculated Max Shear Stress: 0.0137 lb/ft^2

Calculated Avg Shear Stress: 0.0066 lb/ft^2

Appendix E

Pipe Sizing Calculations

Pipe Sizing Calculations

Figure 6B-13 modified, Chapter 6 DelDOT Road Design Manual

STORM DRAIN COMPUTATION SHEET — **Project No.** T201504401 **Sheet No.** 1 **of** 6 — **Computed By:** DEN **Chk. By:** JJK

Pipe Unit			Design Frequency (yr)	Area ΔA (ac)	Runoff Coefficient C	C x ΔA	CA	Time of Concentration Tc (min)	Rainfall Intensity I (in/hr)	ΔQ = ΔCIΔA (ft3/s)	Diameter D (in)	Length L (ft)	Friction Slope Sf (ft/ft)	Slope S (ft/ft)	Velocity V (ft/s)	Full Flow Velocity V (ft/s)	Travel Time Tt (min)	Invert Elevations		Crown Drop	Notes
No.	From	To																Upper	Lower		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
P-101	DI-100	DI-101	10	0.193	0.95	0.183	0.183	5.00	6.42	1.18	15	197.0	0.025	0.025	5.22	8.32	0.60	130.12	125.20		
P-102	DI-101	DI-102	10	0.245	0.73	0.179	0.362	5.60	6.19	2.24	15	257.1	0.030	0.030	6.92	9.12	0.60	125.00	117.29	0.20	
P-103	DI-102	DI-103	10	0.291	0.81	0.236	0.598	6.20	6.01	3.59	15	74.4	0.024	0.030	7.9	9.12	0.18	117.09	114.88	0.20	
P-110	DI-108	DI-103	10	0.061	0.95	0.058	0.058	5.00	6.42	0.37	15	53.6	0.003	0.010	2.72	5.26	0.30	115.42	114.88		
P-104	DI-103	DI-104	10	0.110	0.95	0.105	0.760	6.38	5.95	4.53	15	169.4	0.027	0.029	8.37	8.96	0.36	114.68	109.71	0.20	
P-105	DI-104	DI-105	10	0.260	0.95	0.247	1.007	6.74	5.85	5.90	15	275	0.022	0.022	7.98	7.81	0.60	109.51	103.48	0.20	
P-106	DI-105	FES-106	10	0.223	0.95	0.212	1.219	7.34	5.70	6.94	15	64.6	0.034	0.034	9.77	9.71	0.12	103.48	101.29	0.00	
P-107	DI-106	FES-107	10	1.074	0.46	0.494	0.494	5.00	6.42	3.17	18	203.7	0.004	0.007	4.65	4.97	0.72	117.00	115.50		
P-111	DI-110	FES-112	10	0.252	0.47	0.118	0.118	5.00	6.42	0.76	18	164.3	0.000	0.007	3.00	4.97	0.90	105.10	104.00		
P-115	FES-115	FES-116	10	0.815	0.64	0.522	0.522	5.00	6.42	3.35	18	122.3	0.004	0.009	5.08	5.64	0.42	102.50	101.41		
P-117	FES-117	DI-122	10	0.143	0.10	0.014	0.014	5.00	6.42	0.09	15	27.0	0.048	0.078	3.84	14.70	0.12	108.54	106.44		
P-118	FES-118	DI-121	10	0.302	0.15	0.047	0.047	5.00	6.42	0.30	15	30.9	0.000	0.018	3.33	7.06	0.18	108.80	108.23		
P-119	FES-119	DI-120	10	0.930	0.26	0.243	0.243	5.00	6.42	1.56	15	40.5	0.001	0.005	3.42	3.72	0.18	109.85	109.64		
P-120	OS-119	DI-120	10	0.970	0.47	0.454	0.454	5.00	6.42	2.91	15	122.0	0.005	0.011	3.95	5.52	0.54	110.50	109.89		
P-121	DI-120	DI-121	10	0.115	0.79	0.091	0.545	5.54	6.21	3.39	18	228.5	0.006	0.006	4.8	4.60	0.78	109.58	108.23	0.31	
P-122	DI-121	DI-122	10	0.306	0.79	0.242	0.787	6.32	5.97	4.70	18	104.0	0.019	0.02	8.09	8.41	0.24	108.23	106.11	0.00	
P-123	DI-122	DI-123	10	0.140	0.79	0.111	0.897	6.56	5.90	5.30	21	72	0.002	0.005	4.93	4.66	0.24	106.11	105.75	0.33	
P-125	DI-124	DI-125	10	0.324	0.52	0.168	0.168	5.00	6.42	1.08	15	168.3	0.008	0.008	3.61	4.71	0.78	112.87	111.53		
P-126	DI-125	DI-123	10	0.204	0.78	0.159	0.328	5.78	6.14	2.01	15	299.0	0.016	0.018	5.78	7.06	0.84	111.33	105.95	0.20	

Figure 6B-13 modified, Chapter 6 DelDOT Road Design Manual

STORM DRAIN COMPUTATION SHEET

Project No. T201504401 **Sheet No.** 2 **of** 6
Computed By: DEN **Chk. By:** JJK

Pipe Unit			Design Frequency (yr)	Area ΔA (ac)	Runoff Coefficient C	C x ΔA	CA	Time of Concentration Tc (min)	Rainfall Intensity I (in/hr)	ΔQ = ΔCIΔA (ft3/s)	Diameter D (in)	Length L (ft)	Friction Slope Sf (ft/ft)	Slope S (ft/ft)	Velocity V (ft/s)	Full Flow Velocity V (ft/s)	Travel Time Tt (min)	Invert Elevations		Crown Drop	Notes
No.	From	To																Upper	Lower		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
P-127	FES-127	DI-127	10	1.184	0.661	0.783	0.783	5.00	6.42	5.02	18	73.5	0.025	0.026	8.4	9.58	0.12	108.00	106.07		
P-124	DI-123	DI-127	10	0.390	0.73	0.285	1.183	6.80	5.84	6.90	24	67	0.002	0.005	5.42	5.09	0.18	105.75	105.42	0.00	
P-128	DI-127	MH-128	10	0.010	0.10	0.001	1.184	6.98	5.79	6.85	24	71.8	0.004	0.005	5.8	5.09	0.18	105.42	105.06	0.00	
P-129	MH-128	FES-129	10	0.000	0.00	0.000	1.184	7.16	5.74	6.80	24	31.2	0.004	0.006	6.32	5.58	0.06	104.94	104.75	0.12	
P-132	DI-131	DI-132	10	0.245	0.63	0.154	0.154	5.00	6.42	0.99	15	144	0.012	0.012	3.86	5.77	0.60	115.65	113.92		
P-133	DI-132	DI-133	10	0.222	0.63	0.140	0.294	5.60	6.19	1.82	15	48.4	0.010	0.012	4.68	5.77	0.18	113.72	113.15	0.20	
P-134	DI-133	DI-134	10	0.137	0.84	0.115	0.409	5.78	6.14	2.51	15	31.4	0.014	0.015	5.52	6.45	0.12	113.15	112.69	0.00	
P-135	DI-134	DI-135	10	0.058	0.95	0.055	0.464	5.90	6.10	2.83	18	49.6	0.001	0.009	4.69	5.64	0.18	112.49	112.05	0.20	
P-136	DI-135	DI-136	10	0.071	0.95	0.067	0.532	6.08	6.04	3.21	18	27.5	0.001	0.003	3.22	3.26	0.12	112.05	111.97	0.00	
P-137	DI-136	DI-137	10	0.036	0.95	0.034	0.566	6.20	6.01	3.40	18	26.6	0.001	0.003	3.47	3.26	0.12	111.97	111.88	0.00	
P-138	DI-137	FES-138	10	0.151	0.95	0.143	0.709	6.32	5.97	4.24	18	63.2	0.001	0.004	3.73	3.76	0.30	111.88	111.65	0.00	
P-139	DI-138	FES-139	10	0.253	0.95	0.240	0.240	5.00	6.42	1.54	18	10.9	0.000	0.006	3.19	4.60	0.06	110.26	110.20		
P-140	HW-140	DI-140	10	1.840	0.62	1.144	1.144	5.00	6.42	7.34	19 x 30	13.2	0.001	0.005	4.99	5.09	0.06	108.94	108.87		
P-141	DI-140	DI-141	10	0.146	0.95	0.139	1.283	5.06	6.38	8.19	19 x 30	42.9	0.001	0.004	4.55	4.55	0.18	108.87	108.71	0.00	
P-142	DI-141	FES-142	10	0.104	0.95	0.099	1.382	5.24	6.32	8.73	19 x 30	22.5	0.001	0.004	4.56	4.55	0.06	108.71	108.63	0.00	
P-143	FES-143	FES-144	10	2.5	0.71	1.775	1.775	5.00	6.42	11.39	24	38	0.002	0.003	4.41	3.94	0.12	108.44	108.33		
P-145	FES-145	FES-146	10	1.400	0.726	1.016	1.016	5.00	6.42	6.52	21	41.0	0.001	0.008	5.54	5.89	0.12	109.98	109.65		
P-151	DI-150	DI-151	10	0.27	0.95	0.257	0.257	5.00	6.42	1.65	15	71.0	0.029	0.032	5.79	9.42	0.18	104.30	102.00		
P-152	DI-151	DI-152	10	0.118	0.91	0.107	0.364	5.18	6.34	2.31	15	64.0	0.015	0.015	5.26	6.45	0.18	101.80	100.84	0.20	
P-153	DI-152	DI-153	10	0.074	0.92	0.068	0.432	5.36	6.28	2.71	15	34.6	0.002	0.010	4.93	5.26	0.12	100.64	100.29	0.20	
P-160	DI-160	DI-161	10	0.480	0.80	0.384	0.384	5.00	6.42	2.46	15	68.4	0.026	0.030	6.14	9.12	0.18	103.81	101.76		
P-161	DI-161	MH-162	10	0.097	0.74	0.072	0.456	5.18	6.34	2.89	18	60.6	0.003	0.020	6.12	8.41	0.18	101.56	100.34	0.20	

Figure 6B-13 modified, Chapter 6 DelDOT Road Design Manual

STORM DRAIN COMPUTATION SHEET

Project No. T201504401 **Sheet No.** 3 **of** 6
Computed By: DEN **Chk. By:** JJK

Pipe Unit			Design Frequency (yr)	Area ΔA (ac)	Runoff Coefficient C	C x ΔA	CA	Time of Concentration Tc (min)	Rainfall Intensity I (in/hr)	ΔQ = ΔCIΔA (ft3/s)	Diameter D (in)	Length L (ft)	Friction Slope Sf (ft/ft)	Slope S (ft/ft)	Velocity V (ft/s)	Full Flow Velocity V (ft/s)	Travel Time Tt (min)	Invert Elevations		Crown Drop	Notes
No.	From	To																Upper	Lower		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
P-162	DI-162	MH-162	10	0.103	0.65	0.067	0.067	5.00	6.42	0.43	18	10.8	0.000	0.006	2.42	4.60	0.06	100.40	100.34		
P-163	FES-164	DI-163	10	0.706	0.50	0.355	0.355	5.00	6.42	2.28	18	64.4	0.000	0.005	1.3	4.20	0.84	100.11	99.78		
P-164	DI-163	DI-164	10	0.151	0.61	0.092	0.447	5.84	6.12	2.74	18	51.9	0.001	0.005	1.77	4.20	0.48	99.78	99.52	0.00	
P-167	MH-162	DI-164	10	0.000	0.00	0.000	0.456	5.36	6.28	2.86	18	29.6	0.001	0.014	1.69	7.03	0.30	100.14	99.72	0.20	
P-165	DI-164	DI-166	10	0.105	0.95	0.100	0.547	6.32	5.97	3.27	18	32.4	0.004	0.005	3.63	4.20	0.12	99.52	99.36	0.00	
P-168	DI-166	DI-165	10	0.010	0.95	0.010	0.556	6.44	5.94	3.30	18	40.5	0.004	0.005	3.64	4.20	0.18	99.36	99.14	0.00	
P-166	DI-165	DI-153	10	0.182	0.95	0.173	0.729	6.62	5.89	4.29	18	47.9	0.005	0.005	4	4.20	0.18	99.14	98.90	0.00	
P-154	DI-153	DI-154	10	0.116	0.81	0.094	0.823	6.80	5.84	4.81	21	42.7	0.004	0.005	4.25	4.66	0.18	98.90	98.68	0.00	
P-155	DI-154	DI-155	10	0.117	0.87	0.102	0.925	6.98	5.79	5.35	21	85.9	0.005	0.005	4.44	4.66	0.30	98.48	98.05	0.20	
P-156	EXISTING	DI-155	10	1.500	0.10	0.150	0.150	5.00	6.42	0.96	54	13	0.009	0.004	12.01	7.82	0.00	92.79	92.74		
P-256	DI-255	DI-256	10	0.650	0.47	0.306	0.306	5.00	6.42	1.96	15	280.6	0.017	0.033	7.12	9.56	0.66	102.00	92.62		
P-171	DI-170	DI-171	10	0.075	0.95	0.071	0.071	5.00	6.42	0.46	18	25.7	0.005	0.005	2.28	4.20	0.18	98.52	98.39		
P-172	DI-171	EX 42" PIPE	10	0.014	0.95	0.013	0.085	5.18	6.34	0.54	18	66.3	0.000	0.010	3.06	5.94	0.36	95.33	94.67	3.06	
P-181	DI-180	DI-181	10	0.145	0.95	0.138	0.138	5.00	6.42	0.88	18	18.5	0.004	0.025	4.99	9.40	0.06	97.97	97.51		
P-182	DI-181	FES-182	10	0.050	0.95	0.048	0.185	5.06	6.38	1.18	18	58.0	0.000	0.008	3.61	5.32	0.24	97.31	96.86	0.20	
P-200	DI-200	DI-202	10	1.020	0.49	0.500	0.500	5.00	6.42	3.21	18	190.0	0.024	0.024	7.18	9.21	0.42	119.50	114.95		
P-201	DI-201	DI-202	10	0.079	0.95	0.075	0.075	5.00	6.42	0.48	15	43.6	0.009	0.019	3.60	7.26	0.18	115.78	114.95		
P-202	DI-202	DI-203	10	0.084	0.95	0.080	0.580	5.42	6.25	3.63	18	65.4	0.023	0.023	7.47	9.01	0.12	114.85	113.35	0.10	
P-203	DI-203	DI-204	10	0.190	0.95	0.181	0.760	5.54	6.21	4.72	18	232.7	0.025	0.027	8.41	9.77	0.48	113.15	106.84	0.20	
P-204	DI-204	FES-205	10	0.216	0.84	0.181	0.942	6.02	6.06	5.71	21	122.0	0.010	0.015	7.07	8.07	0.30	106.64	104.77	0.20	

Figure 6B-13 modified, Chapter 6 DelDOT Road Design Manual

STORM DRAIN COMPUTATION SHEET

Project No. T201504401 **Sheet No.** 4 **of** 6
Computed By: DEN **Chk. By:** JJK

Pipe Unit																		Invert Elevations			
No.	From	To	Design Frequency (yr)	Area ΔA (ac)	Runoff Coefficient C	C x ΔA	CA	Time of Concentration Tc (min)	Rainfall Intensity I (in/hr)	ΔQ = ΔCIΔA (ft3/s)	Diameter D (in)	Length L (ft)	Friction Slope Sf (ft/ft)	Slope S (ft/ft)	Velocity V (ft/s)	Full Flow Velocity V (ft/s)	Travel Time Tt (min)	Upper	Lower	Crown Drop	Notes
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
P-211	DI-210	DI-214	10	0.04	0.10	0.004	0.004	5.00	6.42	0.03	8" HDPE	18.8	0.000	0.005	1.35	2.45	0.24	103.12	103.02		
P-214	DI-213	DI-214	10	0.105	0.95	0.100	0.100	5.00	6.42	0.64	15	28.1	0.002	0.007	2.92	4.40	0.18	103.33	103.12		
P-215	DI-214	DI-217	10	0.103	0.95	0.098	0.198	5.18	6.34	1.25	18	93.4	0.001	0.01	4.81	5.94	0.3	103.02	102.06	0.10	
P-216	DI-215	DI-216	10	0.230	0.95	0.219	0.219	5.00	6.40	1.40	15	96.1	0.000	0.008	3.61	4.71	0.42	102.88	102.12		
P-217	DI-216	DI-217	10	0.113	0.95	0.107	0.326	5.42	6.25	2.04	18	27.1	0.000	0.008	1.07	5.32	0.42	101.92	101.71	0.20	
P-218	DI-217	DI-218	10	0.040	0.95	0.038	0.236	5.48	6.23	1.47	24	28.4	0.000	0.004	1.58	4.55	0.30	101.51	101.4		
P-219	DI-218	OS-219	10	0.290	0.95	0.276	0.511	5.78	6.14	3.14	24	16.6	0.001	0.005	1.96	5.09	0.12	101.40	101.31	0.00	
P-220	OS-219	FES-220	10	6.330	0.65	4.115	4.626	32.70	2.94	13.61	24	24	0.005	0.005	5.8	5.09	0.06	101.31	101.19	0.00	
P-221	DI-220	DI-221	10	0.113	0.95	0.107	0.107	5.00	6.42	0.69	14 x 23	104.7	0.000	0.005	2.33	4.20	0.78	115.46	114.95		
P-222	DI-221	FES-222	10	0.095	0.95	0.090	0.198	5.78	6.14	1.21	14 x 23	67.0	0.000	0.004	2.67	3.76	0.42	114.95	114.66	0.00	
P-230	DI-230	DI-231	10	0.230	0.79	0.182	0.182	5.00	6.40	1.16	15	202.4	0.007	0.008	3.70	4.71	0.90	115.09	113.47		
P-231	DI-231	DI-232	10	0.259	0.78	0.202	0.202	5.90	6.10	1.23	18	87.7	0.003	0.005	3.75	4.20	0.36	113.47	113.03	0.00	
P-232	FES-231	DI-232	10	0.860	0.49	0.421	0.421	5.00	6.40	2.70	15	60.5	0.019	0.020	6.50	7.44	0.18	114.24	113.03		
P-233	DI-232	DI-233	10	0.199	0.80	0.159	0.159	6.26	5.99	0.95	18	121.9	0.005	0.005	4.64	4.20	0.42	112.83	112.22		
P-234	DI-233	FES-234	10	0.153	0.95	0.145	0.305	6.68	5.87	1.79	14 x 23	65.5	0.004	0.005	4.81	4.20	0.24	112.22	111.89	0.00	
P-241	DI-240	FES-241	10	0.167	0.95	0.159	0.159	5.00	6.42	1.02	15	77.0	0.000	0.007	3.06	4.40	0.01	100.32	99.76		
P-242	DI-241	DI-242	10	0.061	0.95	0.058	0.058	5.00	6.42	0.37	15	70.7	0.009	0.010	2.70	5.26	0.42	104.13	103.43		
P-243	DI-242	DI-243	10	0.096	0.95	0.091	0.149	5.42	6.25	0.93	18	80.6	0.005	0.005	2.68	4.20	0.48	103.43	103.03	0.00	
P-244	DI-243	DI-244	10	0.063	0.95	0.060	0.209	5.90	6.10	1.27	18	253.8	0.008	0.008	3.49	5.32	1.20	102.83	100.80	0.20	
P-245	DI-244	DI-245	10	0.370	0.84	0.309	0.518	7.10	5.76	2.98	18	113.2	0.005	0.005	3.92	4.20	0.48	100.6	100.03	0.20	
P-246	DI-245	FES-246	10	0.204	0.48	0.097	0.615	7.58	5.64	3.47	18	84.3	0.003	0.010	5.26	5.94	0.24	99.83	98.99	0.20	

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Figure 6B-13 modified, Chapter 6 DelDOT Road Design Manual

STORM DRAIN COMPUTATION SHEET — **Project No.** T201504401 **Sheet No.** 5 **of** 6 — **Computed By:** DEN **Chk. By:** JJK

Pipe Unit			Design Frequency (yr)	Area ΔA (ac)	Runoff Coefficient C	C x ΔA	CA	Time of Concentration Tc (min)	Rainfall Intensity I (in/hr)	ΔQ = ΔCIΔA (ft3/s)	Diameter D (in)	Length L (ft)	Friction Slope Sf (ft/ft)	Slope S (ft/ft)	Velocity V (ft/s)	Full Flow Velocity V (ft/s)	Travel Time Tt (min)	Invert Elevations		Crown Drop	Notes
No.	From	To																Upper	Lower		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
P-270	DI-263	DI-272	10	0.458	0.65	0.298	0.298	5.00	6.42	1.91	18	43.0	0.005	0.006	3.56	4.60	0.18	100.51	100.29		
P-271	DI-270	DI-271	10	0.100	0.95	0.095	0.095	5.00	6.42	0.61	15	132	0.004	0.005	2.51	3.72	0.9	100.95	100.29		
P-272	DI-271	DI-272	10	0.122	0.95	0.116	0.211	5.90	6.10	1.29	18	50	0.005	0.005	4.00	4.20	0.18	100.09	99.84	0.20	
P-273	DI-272	DI-273	10	0.059	0.95	0.056	0.354	6.08	6.04	2.14	18	43.5	0.009	0.010	5.35	5.94	0.12	99.64	99.20	0.65	
P-274	DI-273	DI-274	10	0.065	0.85	0.055	0.409	6.20	6.01	2.46	18	42.1	0.010	0.010	5.48	5.94	0.12	99.00	98.58	0.20	
P-275	DI-274	DI-275	10	0.194	0.95	0.184	0.593	6.32	5.97	3.54	18	50.8	0.005	0.005	4.50	4.20	0.18	98.38	98.12	0.20	
P-276	DI-279	DI-275	10	0.220	0.95	0.209	0.209	5.00	6.42	1.34	15	37.0	0.001	0.010	3.94	5.26	0.18	98.49	98.12		
P-277	DI-276	DI-277	10	0.192	0.95	0.182	0.182	5.00	6.42	1.17	15	45.3	0.005	0.010	3.75	5.26	0.18	98.69	98.24		
P-278	DI-277	DI-278	10	0.080	0.95	0.076	0.258	5.18	6.34	1.64	15	50.8	0.001	0.012	4.63	5.77	0.18	98.04	97.43	0.20	
P-280	DI-275	DI-278	10	0.190	0.95	0.181	0.774	6.50	5.92	4.58	24	98.3	0.003	0.006	5.32	5.58	0.30	98.02	97.43	0.10	
P-315	DI-315	DI-278	10	0.125	0.95	0.119	0.119	5.00	6.42	0.76	15	36.0	0.000	0.010	3.44	5.26	0.18	97.79	97.43		
P-279	DI-278	FES-279	10	0.110	0.95	0.105	0.105	6.80	5.84	0.61	24	32.5	0.002	0.010	7.04	7.20	0.06	97.23	96.90	0.20	
P-281	DI-280	DI-281	10	0.38	0.84	0.319	0.319	6.54	5.91	1.89	18	264.0	0.013	0.013	4.59	6.78	0.96	99.80	96.30		
P-284	DI-283	DI-284	10	0.075	0.95	0.071	0.071	5.00	6.42	0.46	15	156.2	0.005	0.005	2.32	3.72	1.14	97.84	97.06		
P-285	DI-284	DI-281	10	0.461	0.55	0.254	0.325	6.14	6.02	1.96	18	42.8	0.012	0.013	4.9	6.78	0.12	96.86	96.30	0.20	
P-286	DI-281	FES-286	10	0.241	0.84	0.202	0.522	7.5	5.66	2.95	21	36.9	0.01	0.030	8.31	11.41	0.06	96.10	95.00	0.20	
P-291	DI-290	DI-291	10	0.162	0.85	0.138	0.138	5.00	6.42	0.88	15	180.5	0.004	0.005	2.76	3.72	1.08	98.74	97.83		
P-292	DI-291	DI-292	10	0.275	0.89	0.245	0.382	6.08	6.04	2.31	15	83.8	0.004	0.005	3.63	3.72	0.36	97.83	97.40	0.00	
P-293	DI-292	DI-293	10	0.121	0.88	0.106	0.489	6.44	5.94	2.90	18	172.8	0.003	0.005	3.89	4.20	0.72	97.40	96.55	0.00	
P-294	DI-293	FES-294	10	0.181	0.95	0.172	0.661	7.16	5.74	3.79	21	24.0	0.001	0.010	5.36	6.59	0.06	96.24	96.00	0.31	

Figure 6B-13 modified, Chapter 6 DelDOT Road Design Manual

STORM DRAIN COMPUTATION SHEET — **Project No.** T201504401 **Sheet No.** 6 **of** 6 — **Computed By:** DEN **Chk. By:** JJK

Pipe Unit																		Invert Elevations			
No.	From	To	Design Frequency (yr)	Area ΔA (ac)	Runoff Coefficient C	C x ΔA	CA	Time of Concentration Tc (min)	Rainfall Intensity I (in/hr)	ΔQ = ΔCIΔA (ft3/s)	Diameter D (in)	Length L (ft)	Friction Slope Sf (ft/ft)	Slope S (ft/ft)	Velocity V (ft/s)	Full Flow Velocity V (ft/s)	Travel Time Tt (min)	Upper	Lower	Crown Drop	Notes
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
P-321	OS-320	DI-321	10	2.181	0.72	1.562	1.562	5.00	6.42	10.02	24	225	0.005	0.005	5.37	5.09	0.72	105.00	103.88		
P-322	DI-321	FES-322	10	0.314	0.65	0.204	1.766	5.72	6.16	10.87	24	98	0.004	0.009	6.88	6.83	0.24	103.88	103.00	0.00	
P-325	DI-325	FES-326	10	7.550	0.69	5.210	5.210	18.00	4.04	21.06	42	65.7	0.000	0.005	6.49	7.39	0.18	99.53	99.2		
P-331	FES-330	FES-331	10	0.321	0.52	0.168	0.168	5.00	6.42	1.08	18	47.2	0.000	0.005	2.98	4.20	0.24	104.72	104.49		
P-341	FES-340	FES-341	10	0.955	0.50	0.478	0.478	5.00	6.42	3.07	15	151.0	0.003	0.005	4.05	3.72	0.6	103.29	102.51		
P-401	DI-400	DI-401	10	0.089	0.95	0.085	0.085	5.00	6.42	0.54	18	48.5	0.011	0.012	3.25	6.51	0.24	103.35	102.77		
P-402	DI-401	DI-402	10	0.105	0.95	0.100	0.184	5.24	6.32	1.16	18	118.6	0.007	0.007	3.36	4.97	0.6	102.57	101.74	0.20	
P-403	DI-402	DI-403	10	0.119	0.95	0.113	0.297	5.84	6.12	1.82	18	83.9	0.007	0.007	3.82	4.97	0.36	101.64	101.05	0.10	
P-404	DI-403	DI-404	10	0.082	0.95	0.078	0.375	6.20	6.01	2.25	18	87.3	0.003	0.005	3.64	4.20	0.42	100.85	100.41	0.20	
P-405	DI-404	DI-405	10	0.089	0.95	0.085	0.460	6.62	5.89	2.71	18	38.0	0.001	0.006	4.11	4.60	0.18	100.21	99.98	0.20	
P-406	DI-405	FES-406	10	0.082	0.70	0.057	0.517	6.8	5.84	3.02	18	50.0	0.001	0.005	3.96	4.20	0.24	99.98	99.72	0.00	
P-500	Ex Pipe	DI-500	10	0.21	0.95	0.200	0.200	5.00	6.415	1.28	15	6	0.005	0.005	2.27	3.68	0.06	105.44	105.41		
P-501	DI-500	FES-501	10	0.21	0.95	0.200	0.200	5.00	6.42	1.28	15	21.9	0.000	0.007	3.35	4.40	0.12	104.11	103.96	1.3	

Notes:

1. **Inverts highlighted in blue indicate to match/hold existing pipe size/invert/slope/length**
2. **Time of concentration were based on the 5 minute time to inlet (Appendix C - spread computations) plus the travel time in the upstream conduit as necessary. Backup Tc computations are provided for storm sewer design where the initial start time is above the 5 minute minimum and can be found in Appendix E.1.**

Appendix E.1

Time of Concentration Calculations

Worksheet 3: Time of concentration (Tc) or travel time (Tt)

Project : **Elkton Road** By **DEN** Date **8/11/2017**

Location : **DI-102** Checked _____ Date _____

County : **New Castle County, DE**

Circle one: Present [Developed] **ULTIMATE CONDITIONS**

NOTE : Space for as many as three segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments

Sheet flow (Applicable to Tc only)		Segment ID	AB			
1. Surface Description (table 3-1)			Concrete			
2. Manning's roughness coeff., n (table 3-1)			0.011			
3. Flow length, L (total L ≤ 100 ft)	ft		47			
4. Two-yr 24-hr rainfall, P_2	in		3.2			
5. Upstream elevation			129.48			
6. Downstream elevation			127.62			
7. Land slope, s	ft/ft		0.040			
8. $T_t = 0.007 (nL)^{0.8} / [(P_2^{0.5})(s^{0.4})]$	hr		0.008			= 0.008

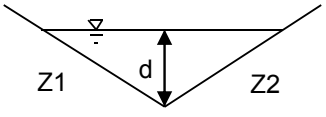
Shallow concentrated flow		Segment ID	BC			
9. Surface description (Cerrelli Chart)			Paved Areas			
10. Flow length, L	ft		150			
11. Upstream elevation			127.62			
12. Downstream elevation			123.14			
13. Watercourse slope, s	ft/ft		0.0299			
14. Average velocity, V	ft/s		3.51			
15. $T_t = L / 3600*V$	hr		0.012			= 0.012

Channel Flow		Segment ID	CD			
16. Channel Geometry			Gutter; Assume Depth = .167; Sx = .04			
17. Cross-sectional flow area, A	ft²		0.3486125			
18. Wetted perimeter, P_W	ft²		4.3453			
19. Hydraulic radius, R	ft		0.0802			
20. Upstream elevation			123.14			
21. Downstream elevation			120.53			
22. Channel slope, S	ft/ft		0.0284			
23. Manning's roughness coeff., n			0.013			
24. Velocity	ft/s		3.59			
25. Flow length, L	ft		92			
26. $T_t = L / 3600*V$	hr		0.007			= 0.007

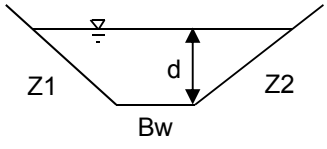
27. Watershed or subarea Tc or Tt ..... hr 0.027

0.083

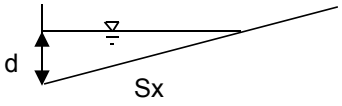
Triangular Ditch



Trapezoidal Ditch



Gutter



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Worksheet 3: Time of concentration (Tc) or travel time (Tt)

Project : **Elkton Road, MD Line to Casho M** By **DEN** Date **8/11/2017**

Location : **DI-200** Checked _____ Date _____

County : **New Castle County, DE**

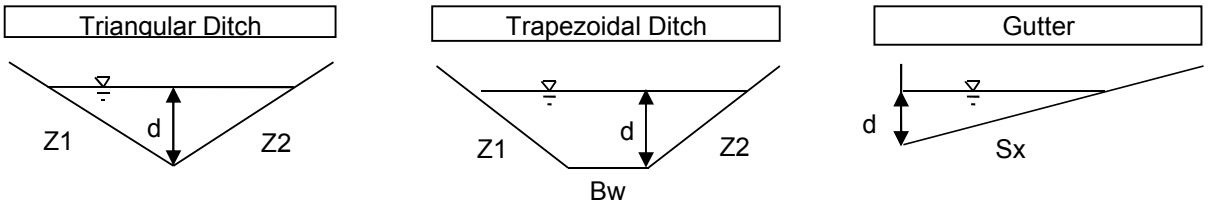
Circle one: Present [Developed] **ULTIMATE CONDITIONS**

NOTE : Space for as many as three segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments

Sheet flow (Applicable to Tc only)	Segment ID	AB			
1. Surface Description (table 3-1)		Concrete			
2. Manning's roughness coeff., n (table 3-1)		0.011			
3. Flow length, L (total L ≤ 100 ft)	ft	94			
4. Two-yr 24-hr rainfall, P_2	in	3.2			
5. Upstream elevation		136.12			
6. Downstream elevation		134.16			
7. Land slope, s	ft/ft	0.021			
8. $T_t = 0.007\ (nL)^{0.8} / [(P_2^{0.5})(s^{0.4})]$	hr	0.019			= 0.019

Channel Flow	Segment ID	BC	CD		
16. Channel Geometry		Trapezoidal Ditch; Assume Depth = .33; Z1 = 4; Z2 = 4; Bw = 4	Trapezoidal Ditch; Assume Depth = .33; Z1 = 4; Z2 = 4; Bw = 4		
17. Cross-sectional flow area, A	ft²	1.7556	1.7556		
18. Wetted perimeter, P_W	ft²	6.721249713	6.721249713		
19. Hydraulic radius, R	ft	0.2612	0.2612		
20. Upstream elevation		134.16	131.73		
21. Downstream elevation		131.73	123.5		
22. Channel slope, S	ft/ft	0.0122	0.0274		
23. Manning's roughness coeff., n		0.045	0.045		
24. Velocity	ft/s	1.49	2.24		
25. Flow length, L	ft	200	300		
26. $T_t = L / 3600*V$	hr	0.037	0.037		= 0.074

27. Watershed or subarea Tc or Tt ..... hr 0.093
0.083



Worksheet 3: Time of concentration (Tc) or travel time (Tt)

Project : **Elkton Road, Casho Mill Road** By **DEN** Date **8/11/2017**

Location : **DI-280** Checked _____ Date _____

County : **New Castle County, DE**

Circle one: Present [Developed] **ULTIMATE CONDITIONS**

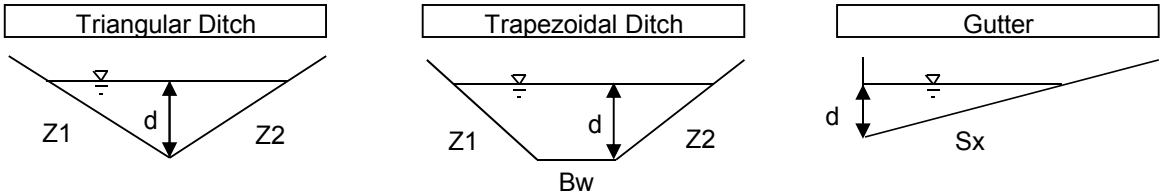
NOTE : Space for as many as three segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments

Sheet flow (Applicable to Tc only)		Segment ID	AB			
1. Surface Description (table 3-1)			Concrete			
2. Manning's roughness coeff., n (table 3-1)			0.011			
3. Flow length, L (total L ≤ 100 ft)	ft		40			
4. Two-yr 24-hr rainfall, P_2	in		3.2			
5. Upstream elevation			105.31			
6. Downstream elevation			104.45			
7. Land slope, s	ft/ft		0.022			
8. $T_t = 0.007 (nL)^{0.8} / [(P_2^{0.5})(s^{0.4})]$	hr		0.009			= 0.009

Shallow concentrated flow		Segment ID	BC			
9. Surface description (Cerrelli Chart)			Paved Areas			
10. Flow length, L	ft		150			
11. Upstream elevation			104.45			
12. Downstream elevation			103.86			
13. Watercourse slope, s	ft/ft		0.0039			
14. Average velocity, V	ft/s		1.27			
15. $T_t = L / 3600*V$	hr		0.033			= 0.033

Channel Flow		Segment ID	CD			
16. Channel Geometry			Gutter; Assume Depth = .10; Sx = .07			
17. Cross-sectional flow area, A	ft²		0.071428571			
18. Wetted perimeter, P_W	ft²		1.5321			
19. Hydraulic radius, R	ft		0.0466			
20. Upstream elevation			103.86			
21. Downstream elevation			102.56			
22. Channel slope, S	ft/ft		0.0051			
23. Manning's roughness coeff., n			0.013			
24. Velocity	ft/s		1.06			
25. Flow length, L	ft		255			
26. $T_t = L / 3600*V$	hr		0.067			= 0.067

27. Watershed or subarea Tc or Tt ..... hr **0.109**



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Worksheet 3: Time of concentration (Tc) or travel time (Tt)

Project : **Elkton Road, MD Line to Casho Mill** By **DEN** **8/11/2017**

Location : **DI-284** Checked

County : **New Castle County, DE**

Circle one: Present [Developed]

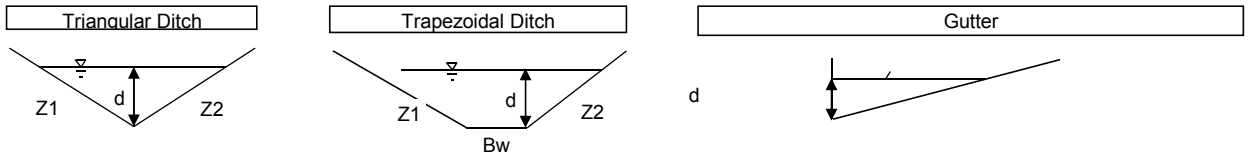
ULTIMATE CONDITIONS

NOTE : Space for as many as three segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments

Sheet flow (Applicable to Tc only)		Segment ID	AB						
1. Surface Description (table 3-1)			Concrete						
2. Manning's roughness coeff., n (table 3-1)			0.011						
3. Flow length, L (total L ≤ 100 ft)	ft		56						
4. Two-yr 24-hr rainfall, P_2	in		3.2						
5. Upstream elevation			104.09						
6. Downstream elevation			102.88						
7. Land slope, s	ft/ft		0.022						
8. $T_t = 0.007\ (nL)^{0.8} / [(P_2^{0.5})(s^{0.4})]$	hr		0.012					=	0.012

Channel Flow		Segment ID	BC						
16. Channel Geometry			Trapezoidal Ditch; Assume Depth = .33; Z1 = 14; Z2 = 8; Bw = 4						
17. Cross-sectional flow area, A	ft^2		2.5179						
18. Wetted perimeter, P_W	ft^2		11.2923						
19. Hydraulic radius, R	ft		0.2230						
20. Upstream elevation			102.88						
21. Downstream elevation			101.18						
22. Channel slope, S	ft/ft		0.0047						
23. Manning's roughness coeff., n			0.045						
24. Velocity	ft/s		0.84						
25. Flow length, L	ft		358						
26. $T_t = L / 3600*V$	hr		0.119					=	0.119

27. Watershed or subarea Tc or Tt hr 0.131



Worksheet 3: Time of concentration (Tc) or travel time (Tt)

Project : **Elkton Road, MD Line to Casho Mill** By **DEN** **8/11/2017**

Location : **DI-325** Checked

County : **New Castle County, DE**

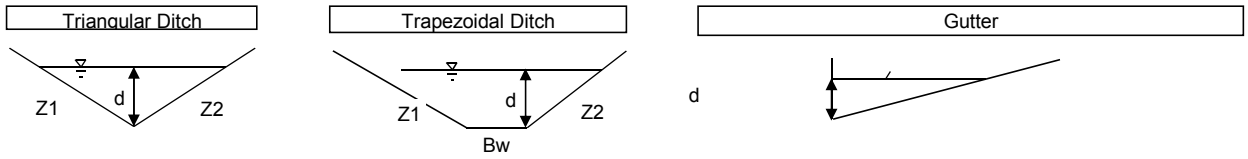
Circle one: Present [Developed] **ULTIMATE CONDITIONS**

NOTE : Space for as many as three segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments

Sheet flow (Applicable to Tc only)		Segment ID	AB						
1. Surface Description (table 3-1)			Concrete						
2. Manning's roughness coeff., n (table 3-1)			0.011						
3. Flow length, L (total L ≤ 100 ft)	ft		65						
4. Two-yr 24-hr rainfall, P_2	in		3.2						
5. Upstream elevation			115.86						
6. Downstream elevation			111.89						
7. Land slope, s	ft/ft		0.061						
8. $T_t = 0.007\ (nL)^{0.8} / [(P_2^{0.5})(s^{0.4})]$	hr		0.009					=	0.009

Channel Flow		Segment ID	BC						
16. Channel Geometry			Trapezoidal Ditch; Assume Depth = .33; Z1 = 4; Z2 = 4; Bw = 4						
17. Cross-sectional flow area, A	ft^2		1.7556						
18. Wetted perimeter, P_W	ft^2		6.7212						
19. Hydraulic radius, R	ft		0.2612						
20. Upstream elevation			111.89						
21. Downstream elevation			105.51						
22. Channel slope, S	ft/ft		0.0060						
23. Manning's roughness coeff., n			0.045						
24. Velocity	ft/s		1.04						
25. Flow length, L	ft		1070						
26. $T_t = L / 3600 * V$	hr		0.284					=	0.284

27. Watershed or subarea Tc or Tt hr **0.294**



Appendix F

HGL and EGL Calculations

Hydraulic and Energy Gradeline Computation From

Structure	**Project No.** T201504401 **Sheet No.** 1 **of** 4 **Computed By:** DEN **Chk. By:** JJK															
	Downstream Conduit	Hydraulic Grade Line (Out) (ft)	Energy Grade Line (Out) (ft)	Upstream Conduit	Deflection Angle (degrees)	Initial Headloss Coefficient (HEC-22, Second Edition)	Diameter Correction Factor	Flow Depth Correction Factor	Relative Flow Correction Factor	Plunging Flow Correction Factor	Benching Correction Factor	Adjusted Headloss Coefficient (HEC-22, Second Edition)	Headloss for Conduit (Hec-22, Second Edition) (ft)	Hydraulic Grade Line (In) (ft)	Energy Grade Line (In) (ft)	Top EL of MH or CB. (ft)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
DI-101	P-102	125.60	125.72	P-101	177.59	0.417	1	0.311	1	1	1	0.130	0.03	130.50	130.64	133.27
DI-102	P-103	117.88	118.08	P-102	172.05	0.546	1	0.362	1	1	1	0.198	0.06	125.57	125.79	128.06
DI-103	P-104	115.35	116.32	P-103	171.23	0.565	1	0.389	1.216	1	1	0.268	0.10	117.82	118.12	120.50
DI-104	P-105	110.24	111.33	P-104	178.59	0.394	1	0.419	1	1	1	0.165	0.07	115.50	115.87	118.00
DI-105	P-106	104.61	104.93	P-105	171.13	0.567	1	0.438	1	1	1	0.248	0.13	110.44	110.89	113.05
		102.54	102.93	P-106	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	104.48	105.01	107.28
DI-103	P-104	115.53	115.53	P-110	102.05	1.668	1	0.389	0.098	1	1	0.063	0.02	115.64	115.71	117.80
DI-122	P-123	107.39	107.39	P-117	179.47	0.270	1	0.405	1.972	1	1	0.216	0.05	108.66	108.70	112.00
DI-121	P-122	109.23	109.23	P-118	73.15	1.594	1	0.384	0.119	1	1	0.073	0.03	109.22	109.23	112.00
DI-120	P-121	110.52	110.56	P-119	60.61	1.478	1	0.357	0.441	1	1	0.233	0.08	110.53	110.61	114.00
DI-120	P-121	110.58	110.86	P-120	175.68	0.403	1	0.357	1.441	1	1	0.207	0.07	111.23	111.47	115.35
DI-121	P-122	109.26	109.49	P-121	179.63	0.31	1	0.384	1.332	1	1	0.158	0.07	110.43	110.78	114.41
DI-122	P-123	107.46	107.68	P-122	89.74	1.614	1	0.405	0.782	1	1	0.511	0.12	109.19	109.61	111.09
DI-123	P-124	107.26	107.42	P-123	178.41	0.207	1	0.416	1.424	1	1	0.122	0.04	107.34	107.58	109.55
		107.13	107.35	P-124	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	107.22	107.51	110.10
		111.90	112.10	P-125	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	113.28	113.43	116.85
DI-123	P-124	107.25	107.29	P-126	92.08	1.514	1	0.416	0.143	1	1	0.09	0.03	111.90	112.12	114.26
		107.13	107.35	P-127	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	108.87	109.22	112.00
		106.87	107.28	P-128	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	107.13	107.58	109.82
		106.75	107.11	P-129	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	106.87	107.24	108.43
DI-132	P-133	114.29	114.41	P-132	147.53	1.078	1	0.293	1	1	1	0.316	0.06	116.01	116.13	118.40
DI-133	P-134	113.84	113.93	P-133	146.43	1.100	1	0.323	1	1	1	0.355	0.08	114.23	114.42	116.80
DI-134	P-135	113.38	113.55	P-134	109.93	1.571	1	0.353	1	1	1	0.554	0.05	113.75	113.99	116.06
DI-135	P-136	113.34	113.38	P-135	117.32	1.501	1	0.45	1	1	1	0.676	0.03	113.33	113.43	115.86
DI-136	P-137	113.29	113.34	P-136	153.92	0.895	1	0.459	1	1	1	0.411	0.02	113.31	113.36	115.23
DI-137	P-138	113.26	113.31	P-137	140.86	1.153	1	0.466	1	1	1	0.538	0.04	113.27	113.33	115.12
		113.15	113.22	P-138	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	113.21	113.29	115.07
DI-140	P-141	110.33	110.43	P-140	176.2	0.308	1	0.473	1	1	1	0.146	0.02	110.34	110.44	113.00

Structure	Project No. T201504401 Sheet No. 2 of 4 Computed By: DEN Chk. By: JJK Downstream Conduit	Hydraulic Grade Line (Out) (ft)	Energy Grade Line (Out) (ft)	Upstream Conduit	Deflection Angle (degrees)	Initial Headloss Coefficient (HEC-22, Second Edition)	Diameter Correction Factor	Flow Depth Correction Factor	Relative Flow Correction Factor	Plunging Flow Correction Factor	Benching Correction Factor	Adjusted Headloss Coefficient (HEC-22, Second Edition)	Headloss for Conduit (Hec-22, Second Edition) (ft)	Hydraulic Grade Line (In) (ft)	Energy Grade Line (In) (ft)	Top EL of MH or CB. (ft)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
DI-141	P-142	110.27	110.38	P-141	169.16	0.473	1	0.491	1	1	1	0.232	0.03	110.32	110.43	112.20
		110.21	110.33	P-142	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	110.24	110.37	112.20
DI-151	P-152	102.25	102.77	P-151	168.3	0.632	1	0.302	1	1	1	0.191	0.04	104.69	104.84	107.46
DI-152	P-153	101.44	101.60	P-152	155.16	0.922	1	0.368	1	1	1	0.339	0.05	102.34	102.54	104.94
DI-153	P-154	101.41	101.48	P-153	152.25	0.889	1	0.599	1	1	1	0.533	0.15	101.39	101.55	103.67
DI-154	P-155	101.09	101.37	P-154	161.14	0.696	1	0.615	1	1	1	0.429	0.13	101.26	101.55	104.00
DI-155	Existing 54"	100.56	100.87	P-155	71.85	1.336	1	0.590	1	1	1	0.788	1.98	100.95	101.26	104.63
DI-155	Existing 54"	98.85	101.09	P-156	176.58	0.178	1	0.59	1	1	1	0.105	0.26	98.97	101.21	99.00
DI-161	P-161	102.05	102.64	P-160	177.05	0.37	1	0.281	1	1	1	0.104	0.02	104.27	104.44	107.56
MH-162	P-167	102.13	102.16	P-161	178.93	0.251	1	0.591	1.324	1	1	0.196	0.01	102.13	102.35	105.53
MH-162	P-167	102.13	102.13	P-162	94.34	1.578	1	0.591	0.188	1	1	0.175	0.01	102.13	102.13	103.61
DI-163	P-164	102.17	102.19	P-163	175.74	0.401	1	0.659	1	1	1	0.264	0.01	102.20	102.22	104.00
DI-164	P-165	102.11	102.16	P-164	172.6	0.475	1	0.678	1.455	1	1	0.469	0.10	102.15	102.20	103.98
		101.89	102.10	P-165	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	102.01	102.22	103.83
DI-153	P-154	101.42	101.66	P-166	151.61	0.903	1	0.599	1	1	1	0.541	0.15	101.63	101.88	104.09
DI-164	P-165	102.10	102.14	P-167	80.91	1.635	1	0.678	0.386	1	1	0.427	0.09	102.12	102.17	104.01
DI-165	P-166	101.74	101.94	P-168	165.86	0.631	1	0.678	1	1	1	0.428	0.11	101.89	102.10	104.62
DI-256	Existing 54"	98.07	98.11	P-256	111.84	1.251	1	0.557	0.15	1	1	0.104	0.27	102.56	102.77	105.65
DI-171	P-172	98.63	98.71	P-171	169.63	0.544	1	0.361	1	1	1	0.196	0	98.76	98.84	102.18
EX CB	Existing 42"	96.20	96.20	P-172	97	1.383	1	0.442	1	1	1	0.612	0.95	96.20	96.21	102.21
DI-181	P-182	98.37	98.38	P-181	169.9	0.538	1	0.404	1	1	1	0.217	0	98.32	98.45	101.72
		98.36	98.37	P-182	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	98.36	98.38	101.28
DI-202	P-202	115.72	115.91	P-200	140.66	1.157	1	0.333	0.922	1	1	0.355	0.11	120.19	120.45	123.50
DI-202	P-202	115.68	115.69	P-201	133.02	1.288	1	0.333	0.571	1	1	0.245	0.07	116.02	116.10	119.20
DI-203	P-203	114.13	114.41	P-202	147.96	1.017	1	0.355	1	1	1	0.362	0.13	115.61	115.91	118.78
DI-204	P-204	107.39	108.49	P-203	174.19	0.395	1	0.331	1	1	1	0.131	0.05	114.00	114.35	117.02
		106.52	106.61	P-204	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	107.52	107.87	110.31
DI-214	P-215	103.68	103.68	P-211	179.26	0.318	1	0.296	1.966	1	1	0.185	0.03	103.68	103.68	104.25

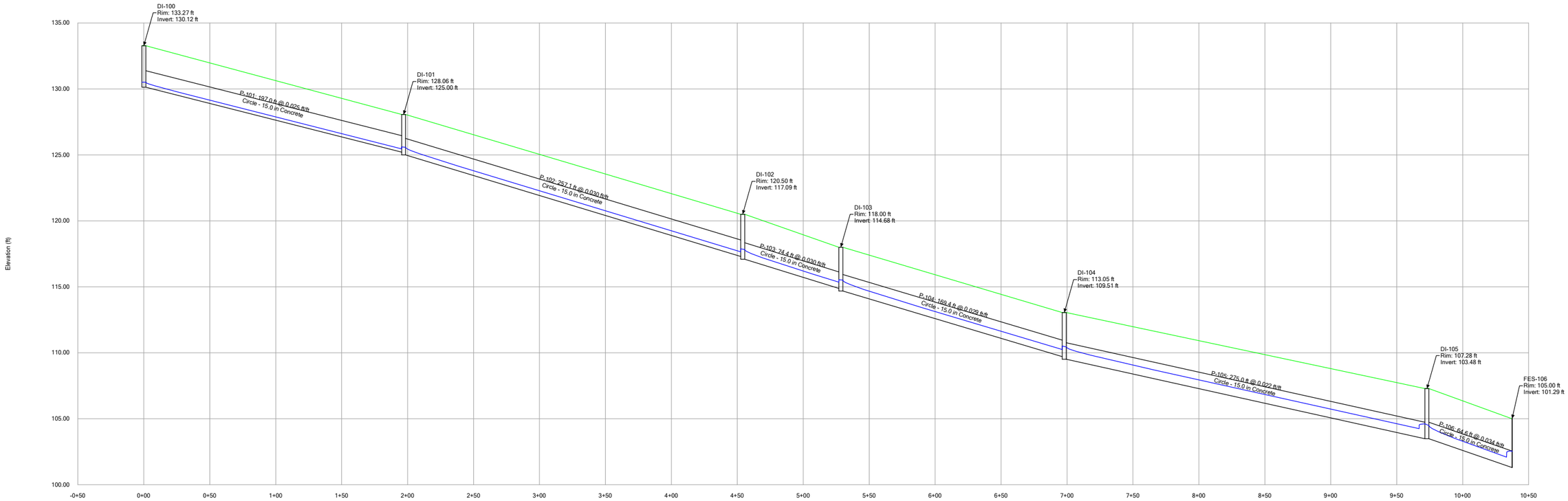
Structure	Project No. T201504401 Sheet No. 3 of 4 Computed By: DEN Chk. By: JJK															
	Downstream Conduit	Hydraulic Grade Line (Out) (ft)	Energy Grade Line (Out) (ft)	Upstream Conduit	Deflection Angle (degrees)	Initial Headloss Coefficient (HEC-22, Second Edition)	Diameter Correction Factor	Flow Depth Correction Factor	Relative Flow Correction Factor	Plunging Flow Correction Factor	Benching Correction Factor	Adjusted Headloss Coefficient (HEC-22, Second Edition)	Headloss for Conduit (Hec-22, Second Edition) (ft)	Hydraulic Grade Line (In) (ft)	Energy Grade Line (In) (ft)	Top EL of MH or CB. (ft)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
DI-214	P-215	103.66	103.68	P-214	92.71	1.65	1	0.296	0.192	1	1	0.094	0.02	103.62	103.73	105.77
DI-217	P-218	103.70	103.73	P-215	88.28	1.581	1	0.524	1	1	1	0.829	0.03	103.65	103.81	105.71
DI-216	P-217	103.69	103.71	P-216	176.76	0.377	1	0.552	1	1	1	0.208	0	103.71	103.74	106.24
DI-217	P-218	103.68	103.70	P-217	178.68	0.257	1	0.524	1.67	1	1	0.225	0.01	103.69	103.71	105.29
DI-218	P-219	103.66	103.70	P-218	87.02	1.58	1	0.531	1	1	1	0.838	0.05	103.67	103.71	105.23
OS-219	P-220	103.60	103.66	P-219	90.61	1.515	1	0.499	1	1	1	0.756	0.29	103.61	103.67	105.31
		103.19	103.58	P-220	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	103.30	103.69	104.75
DI-221	P-222	115.83	115.84	P-221	176.44	0.374	1	0.422	1	1	1	0.158	0	115.83	115.86	119.34
		115.83	115.83	P-222	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	115.83	115.84	117.84
DI-231	P-231	114.15	114.20	P-230	89.81	1.582	1	0.284	1	1	1	0.45	0.1	115.52	115.68	118.40
DI-232	P-233	113.89	113.97	P-231	87.95	1.651	1	0.39	0.327	1	1	0.211	0.07	114.06	114.27	116.69
DI-232	P-233	113.89	114.04	P-232	177.8	0.353	1	0.39	1.573	1	1	0.217	0.07	114.90	115.17	118.00
DI-233	P-234	113.31	113.58	P-233	179.94	0.292	1	0.471	1	1	1	0.137	0.03	113.82	114.16	116.39
		113.06	113.27	P-234	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	113.28	113.51	115.26
		101.01	101.01	P-241	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	101.01	101.03	106.97
DI-242	P-243	103.76	103.78	P-242	179.48	0.313	1	0.198	1	1	1	0.062	0.01	104.35	104.42	107.71
DI-243	P-244	103.35	103.46	P-243	179.56	0.311	1	0.219	1	1	1	0.068	0.01	103.75	103.86	106.63
		101.24	101.33	P-244	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	103.21	103.34	106.40
		100.67	100.91	P-245	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	101.24	101.48	103.98
		100.49	100.54	P-246	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	100.52	100.79	103.40
DI-271	P-272	100.82	101.01	P-270	97.65	1.64	1	0.307	0.53	1	1	0.267	0.07	101.03	101.23	103.59
DI-271	P-272	100.82	100.84	P-271	171	0.512	1	0.307	1.597	1	1	0.251	0.06	101.24	101.34	104.37
DI-272	P-273	100.45	100.77	P-272	164.25	0.667	1	0.32	1	1	1	0.213	0.06	100.76	101.01	103.71
DI-273	P-274	99.79	100.24	P-273	147.7	1.023	1	0.33	1	1	1	0.337	0.1	100.35	100.63	103.37
DI-274	P-275	99.34	99.62	P-274	155.36	0.864	1	0.36	1	1	1	0.311	0.1	99.75	100.04	102.79
DI-275	P-280	99.08	99.33	P-275	99.17	1.564	1	0.322	0.551	1	1	0.278	0.1	99.25	99.56	102.18
DI-275	P-280	99.00	99.03	P-276	87.88	1.581	1	0.322	0.117	1	1	0.06	0.02	98.96	99.07	101.97
DI-277	P-278	98.97	99.00	P-277	156.44	0.895	1	0.415	1	1	1	0.372	0.02	99.07	99.21	103.71
DI-278	P-279	98.94	98.97	P-278	80.66	1.564	1	0.453	0.141	1	1	0.1	0.02	98.96	99.00	103.05

Structure	Project No. T201504401 Computed By: DEN Sheet No. 4 of 4 Chk. By: JJK															
	Downstream Conduit	Hydraulic Grade Line (Out) (ft)	Energy Grade Line (Out) (ft)	Upstream Conduit	Deflection Angle (degrees)	Initial Headloss Coefficient (HEC-22, Second Edition)	Diameter Correction Factor	Flow Depth Correction Factor	Relative Flow Correction Factor	Plunging Flow Correction Factor	Benching Correction Factor	Adjusted Headloss Coefficient (HEC-22, Second Edition)	Headloss for Conduit (Hec-22, Second Edition) (ft)	Hydraulic Grade Line (In) (ft)	Energy Grade Line (In) (ft)	Top EL of MH or CB. (ft)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
		98.90	99.06	P-279	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	98.92	99.12	102.79
DI-278	P-279	98.96	99.08	P-280	178.09	0.271	1	0.453	1.365	1	1	0.167	0.03	98.98	99.35	101.90
DI-278	P-279	98.93	98.94	P-315	90.18	1.582	1	0.453	0.052	1	1	0.037	0.01	98.93	98.94	102.91
DI-281	P-286	96.90	96.97	P-281	90.76	1.614	1	0.304	0.247	1	1	0.121	0.04	100.25	100.41	102.79
DI-284	P-285	97.44	97.47	P-284	90.39	1.582	1	0.261	1	1	1	0.412	0.08	98.10	98.18	101.45
DI-281	P-286	96.90	97.02	P-285	178.93	0.283	1	0.304	1.644	1	1	0.141	0.04	97.37	97.55	101.18
		96.75	96.80	P-286	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	96.86	97.15	101.67
DI-291	P-292	98.43	98.46	P-291	177.72	0.414	1	0.313	1	1	1	0.13	0.03	99.08	99.20	101.24
DI-292	P-293	98.06	98.20	P-292	179.35	0.316	1	0.3	1	1	1	0.095	0.02	98.40	98.61	100.79
DI-293	P-294	97.79	97.84	P-293	90.88	1.614	1	0.459	1	1	1	0.74	0.03	98.04	98.28	100.58
		97.75	97.79	P-294	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	97.76	97.80	100.16
DI-321	P-322	105.15	105.51	P-321	169.03	0.425	1	0.367	1	1	1	0.156	0.08	106.15	106.60	109.00
		105.00	105.19	P-322	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	105.08	105.57	106.86
DI-401	P-402	102.98	103.15	P-401	172	0.489	1	0.221	1	1	1	0.108	0.01	103.61	103.70	106.69
DI-402	P-403	102.15	102.26	P-402	168.7	0.566	1	0.253	1	1	1	0.143	0.03	102.95	103.09	105.82
DI-403	P-404	101.49	101.72	P-403	178.02	0.348	1	0.275	1	1	1	0.095	0.02	102.12	102.30	105.01
DI-404	P-405	101.29	101.35	P-404	164.43	0.663	1	0.407	1	1	1	0.27	0.02	101.40	101.61	104.47
DI-405	P-406	101.27	101.31	P-405	170.96	0.439	1	0.454	1	1	1	0.199	0.01	101.28	101.34	104.28
		101.23	101.27	P-406	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)	101.26	101.31	102.61

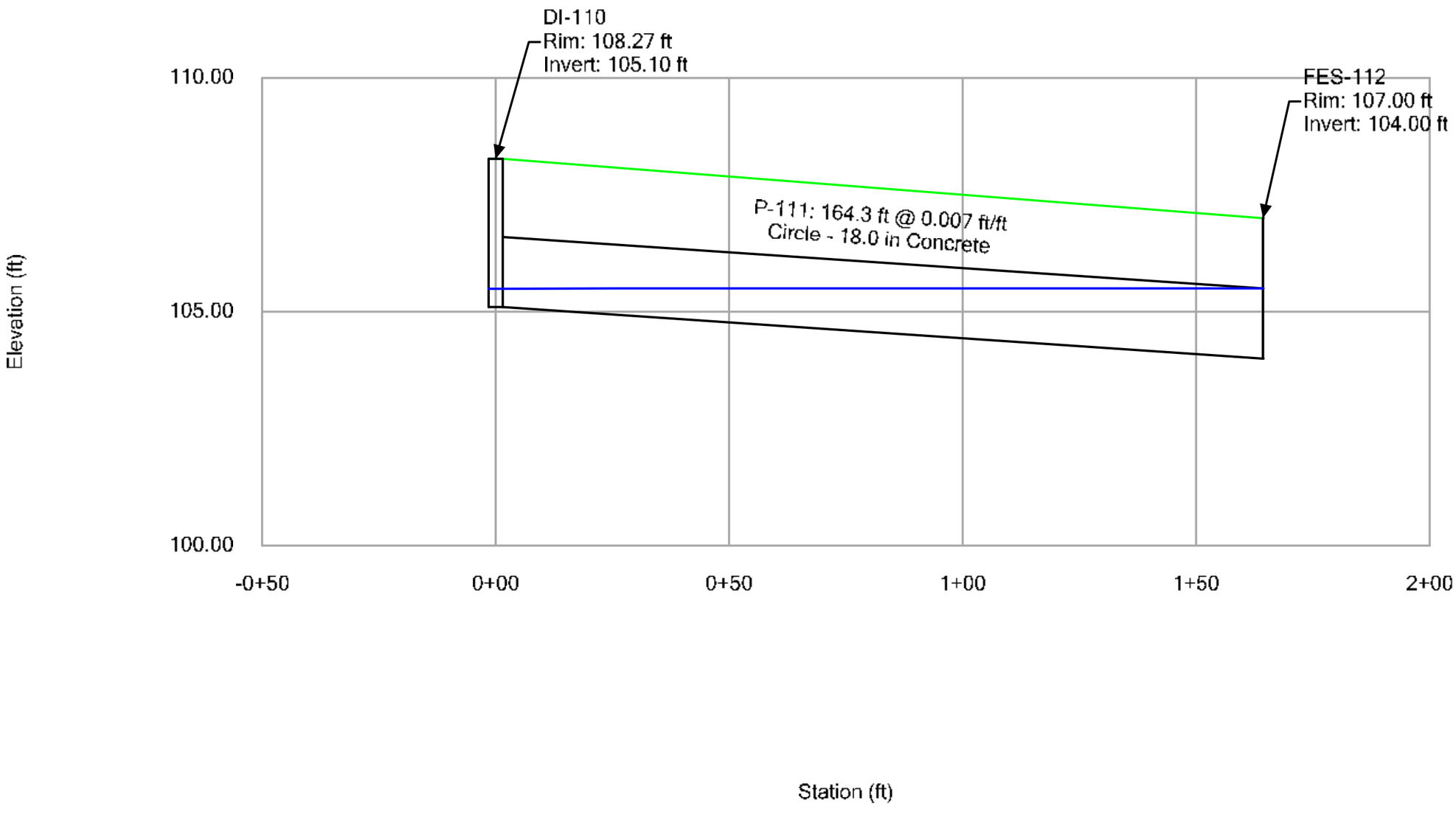
Appendix F.1

HGL and EGL Profiles

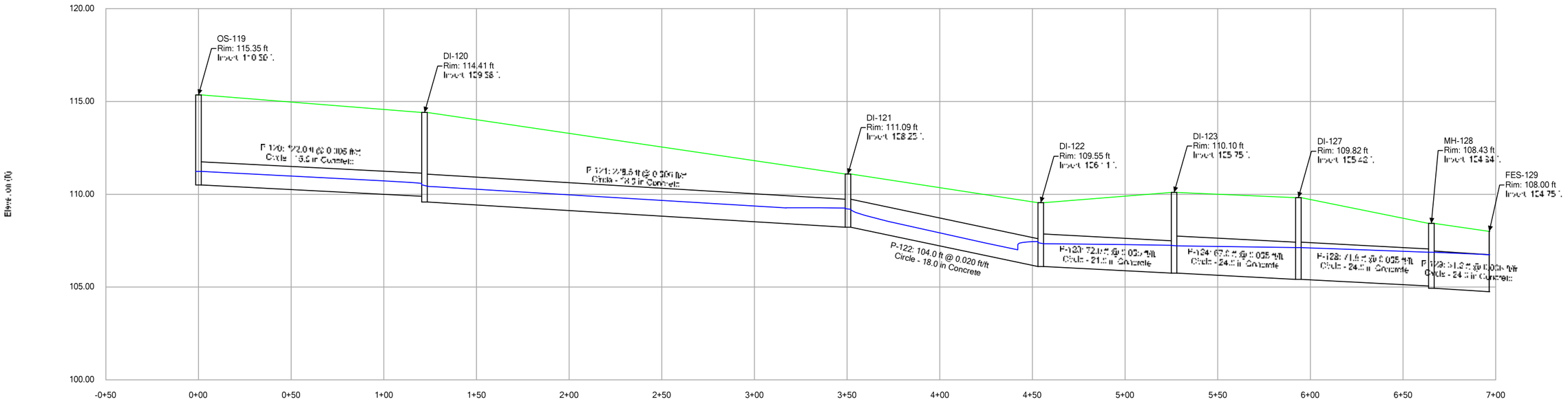
Profile Report
Engineering Profile - 100s (Elkton_Final.stsw)



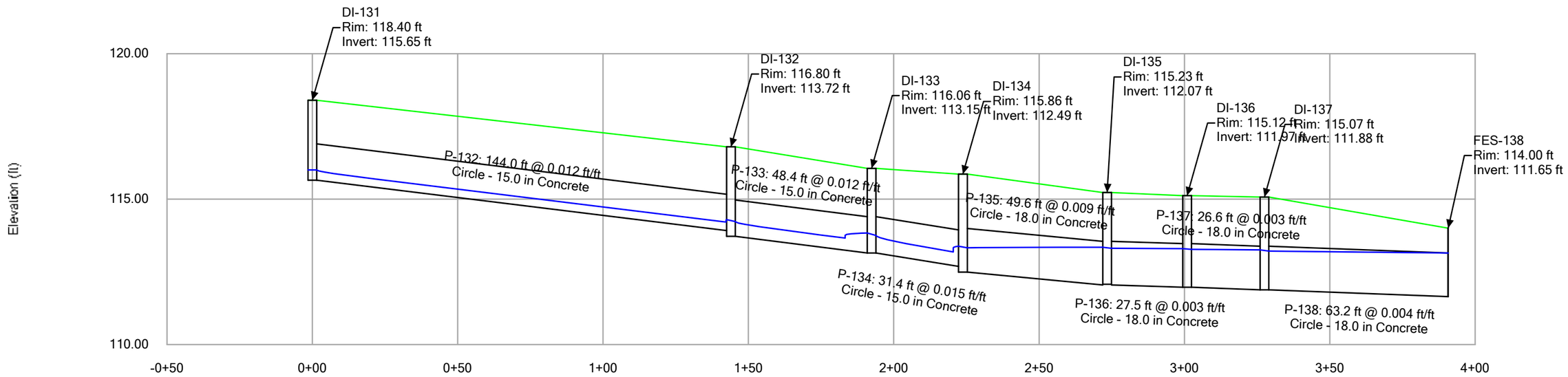
Profile Report
Engineering Profile - 111 (Elkton_Final.stsw)



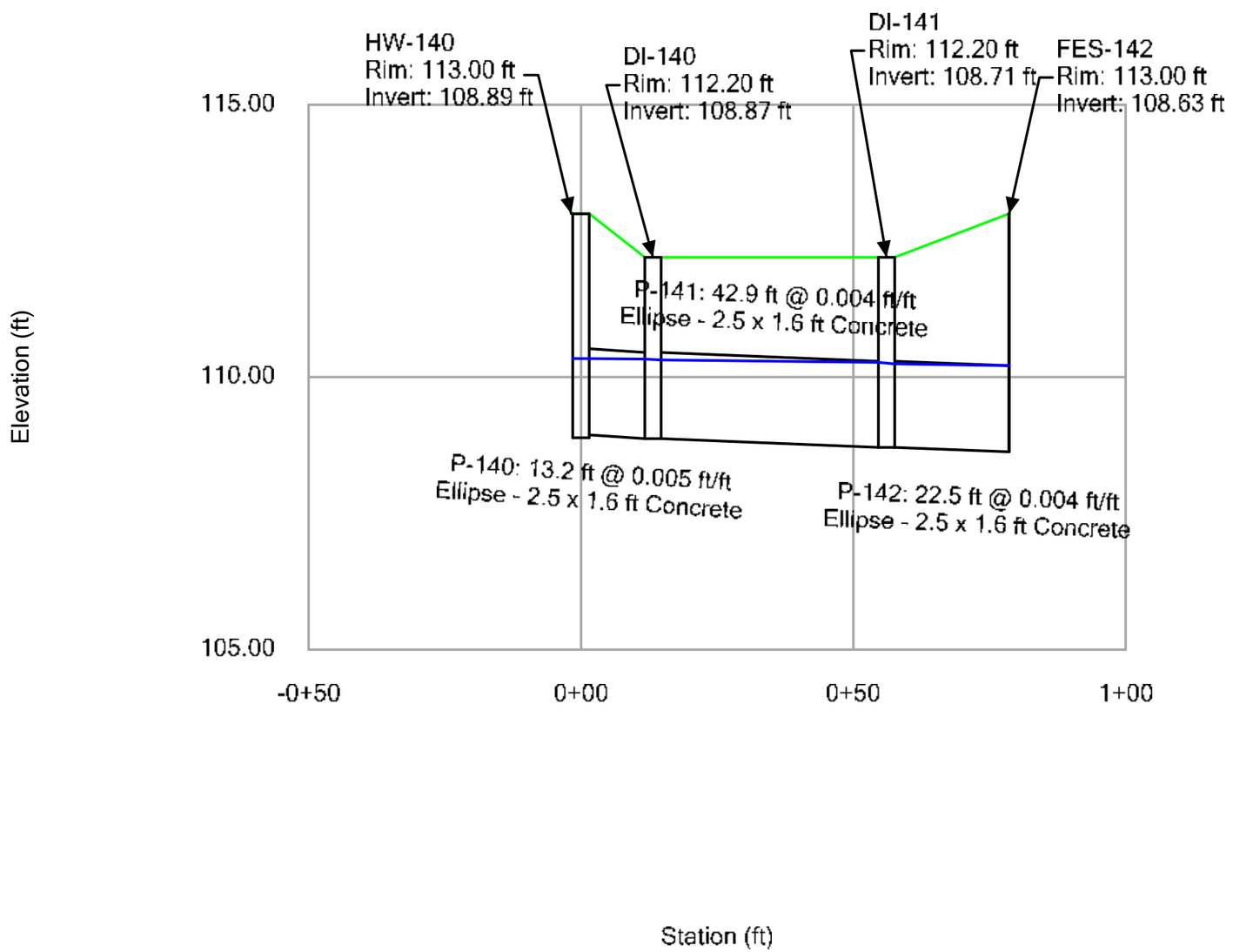
Profile Report
Engineering Profile - 120s (Elkton_Final.stsw)



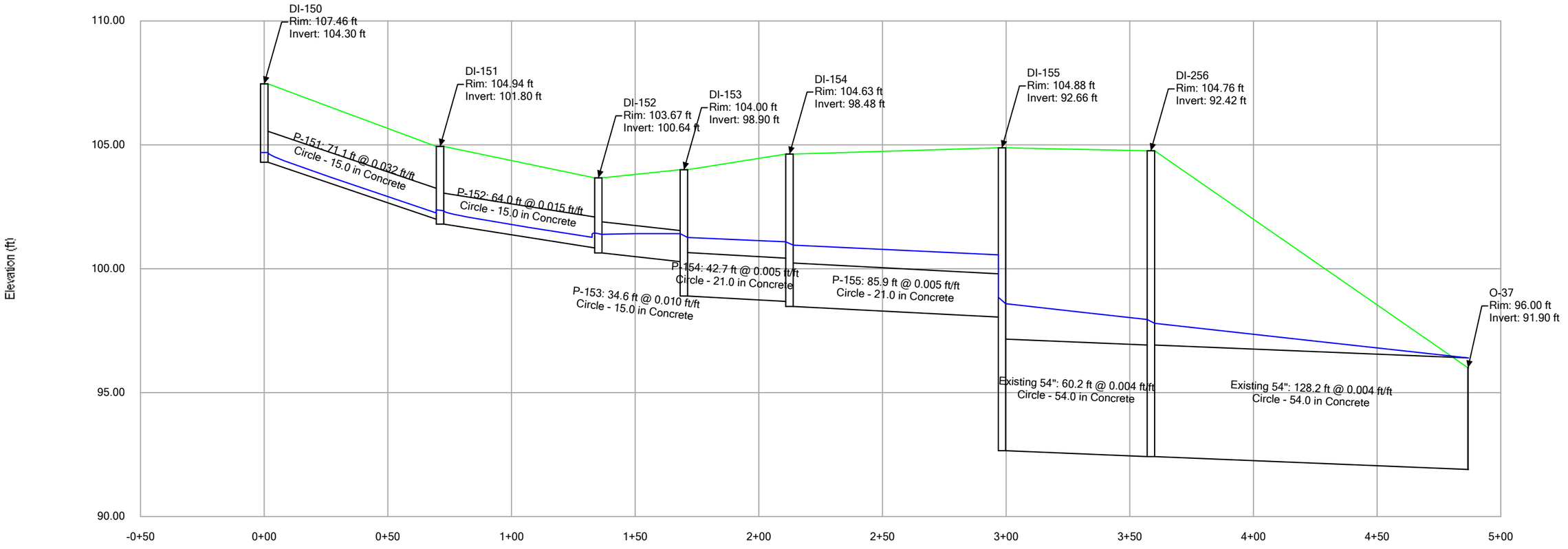
Profile Report
Engineering Profile - 130s (Elkton_Final.stsw)



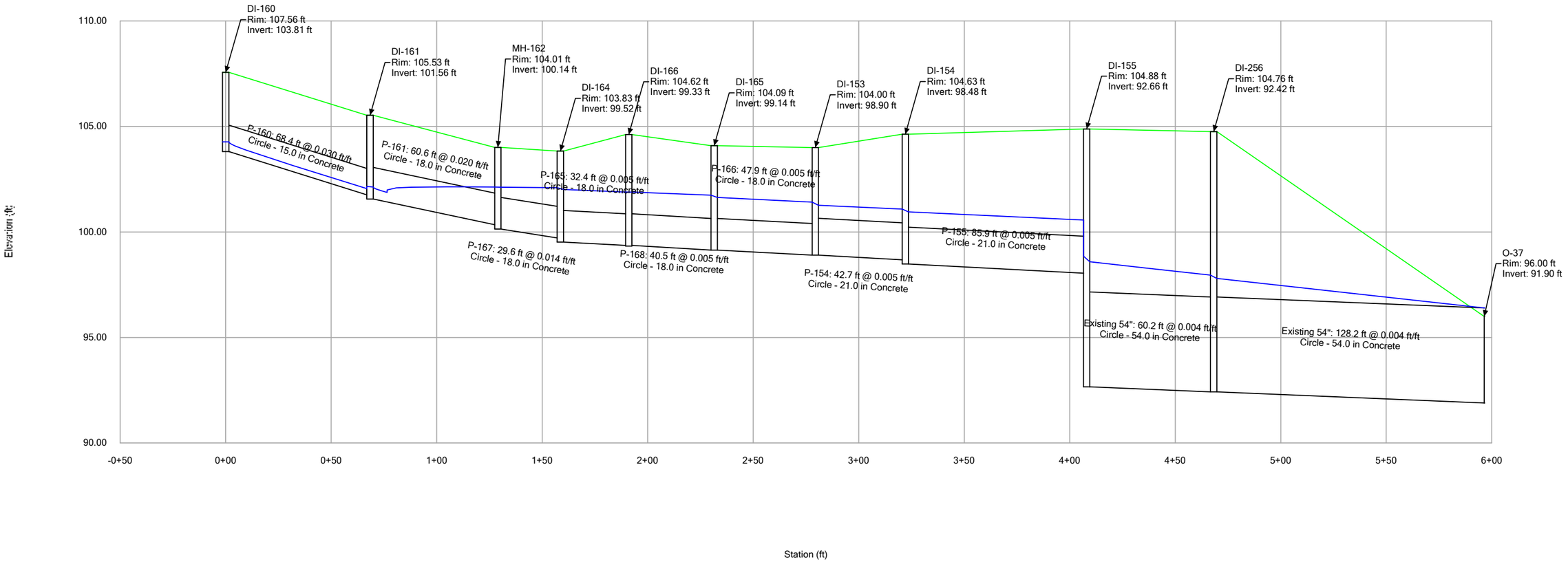
Profile Report
Engineering Profile - 140s (Elkton_Final.stsw)



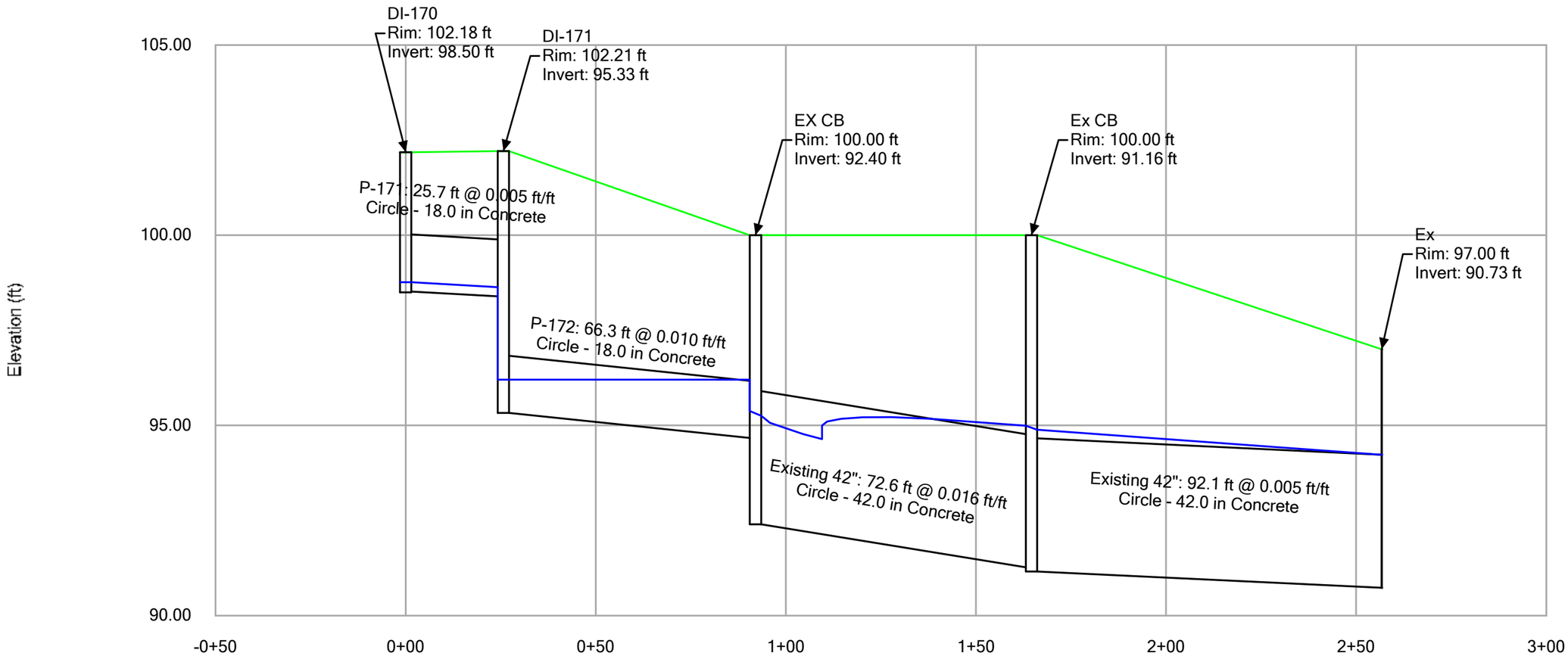
Profile Report
Engineering Profile - 150s (Elkton_Final.stsw)



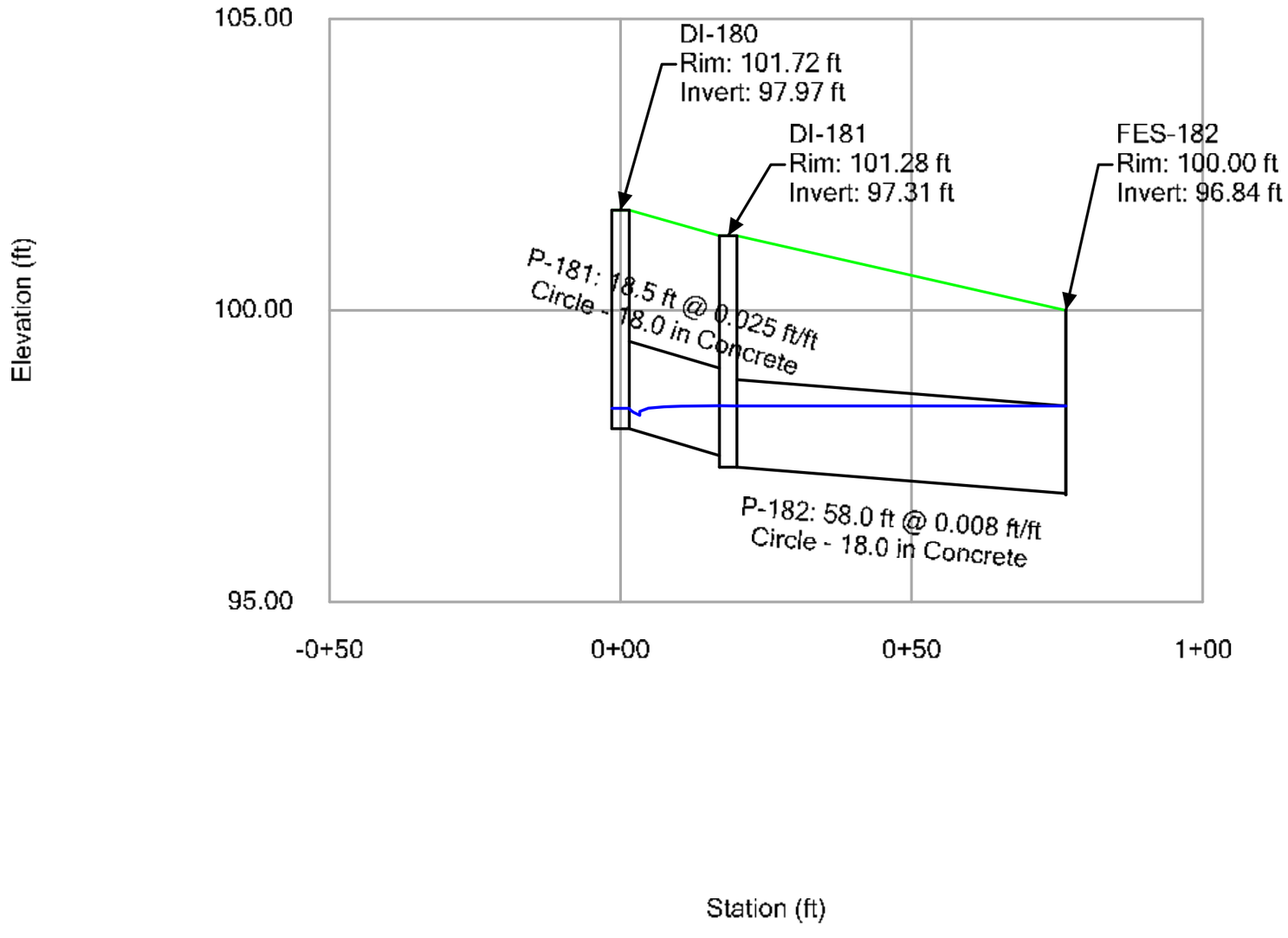
Profile Report
Engineering Profile - 160s (Elkton_Final.stsw)



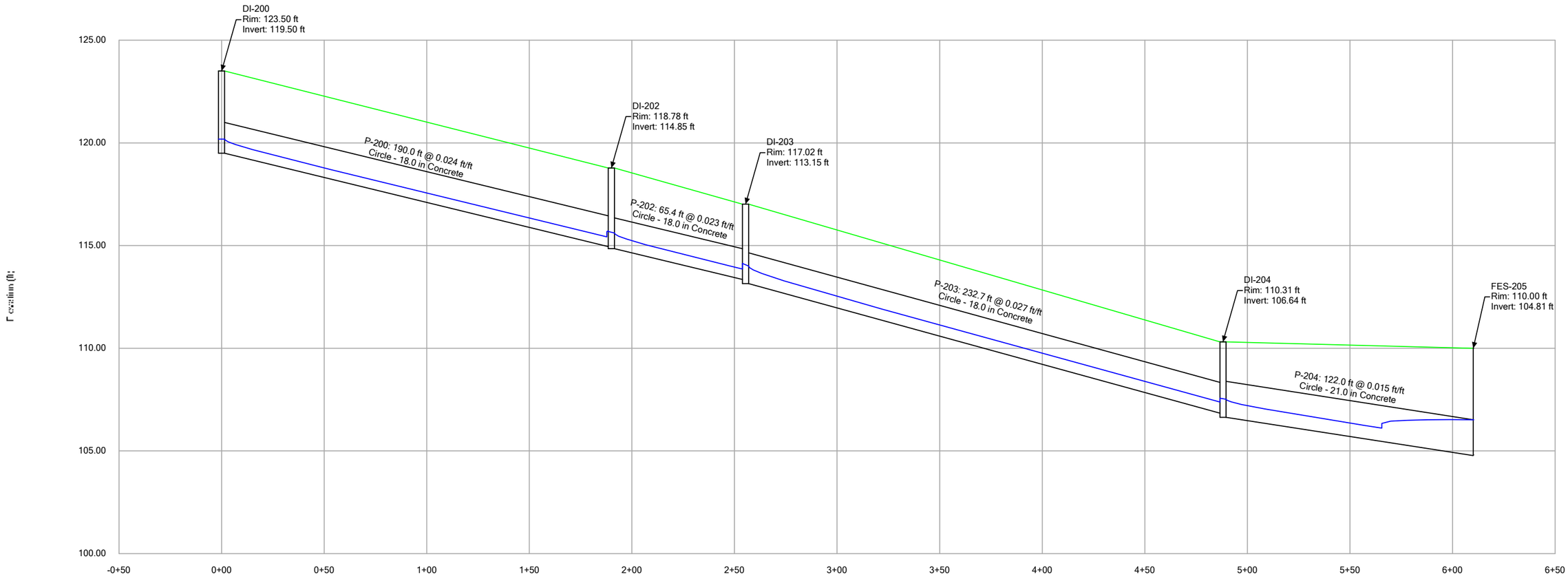
Profile Report
Engineering Profile - 170s (Elkton_Final.stsw)



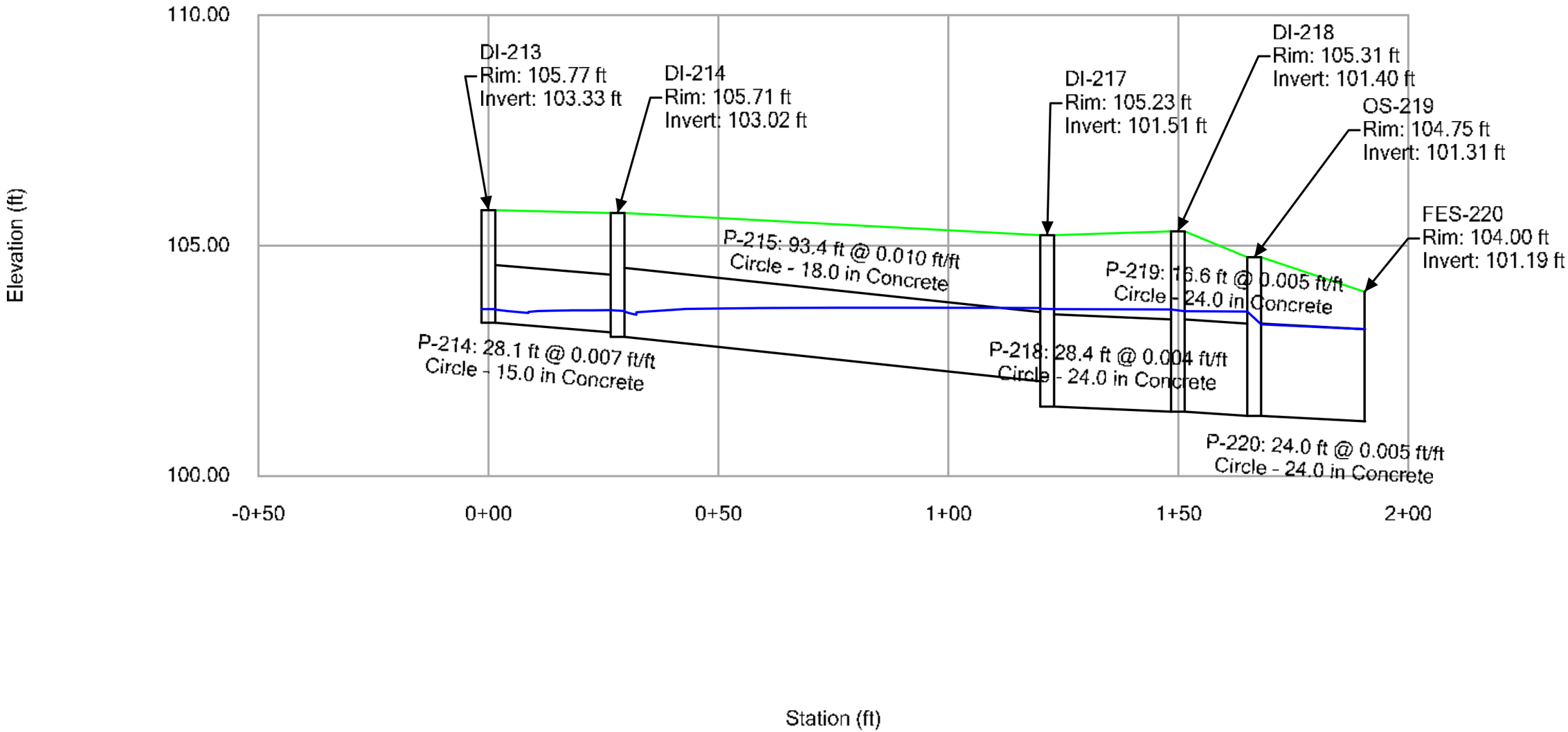
Profile Report
Engineering Profile - 180s (Elkton_Final.stsw)



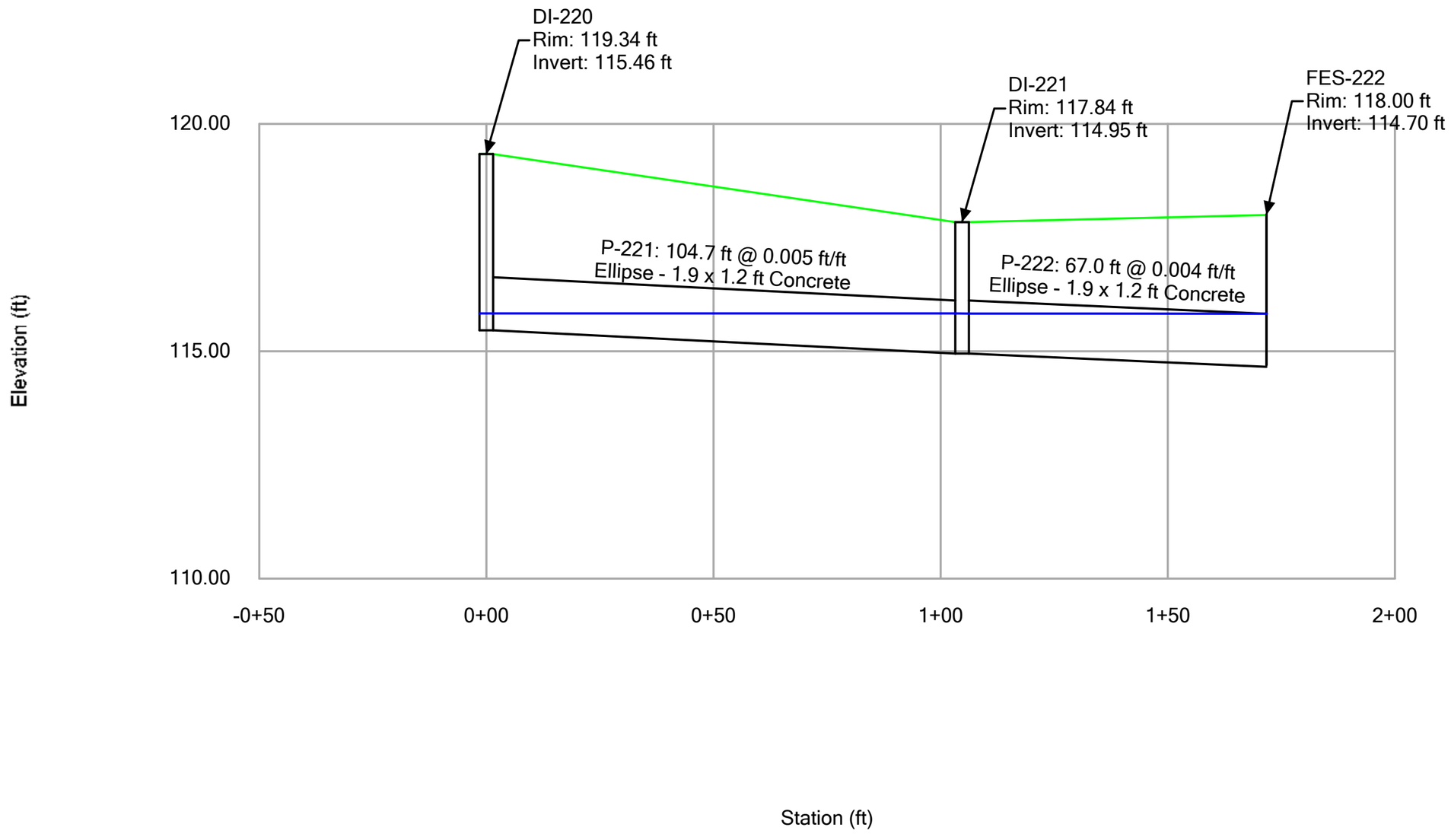
Profile Report
Engineering Profile - 200s (Elkton_Final.stsw)



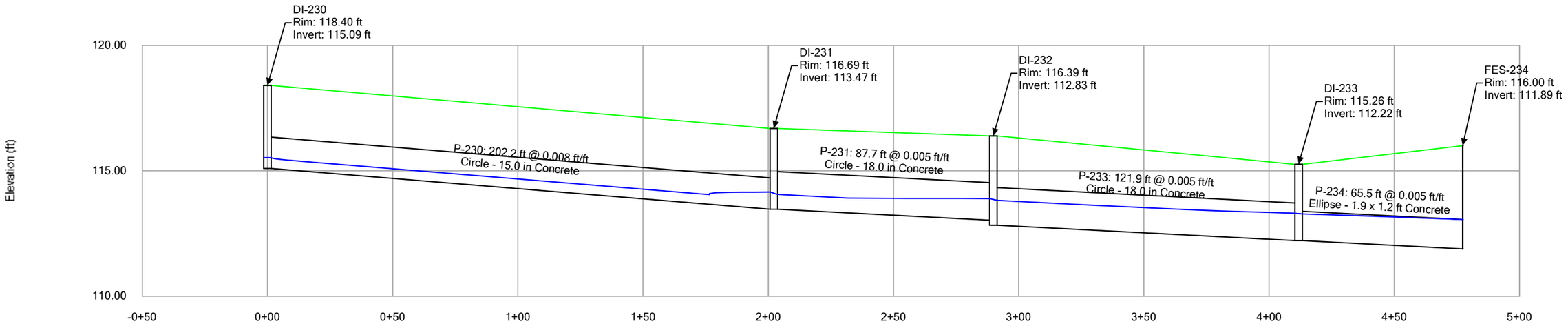
Profile Report
Engineering Profile - 215s (Elkton_Final.stsw)



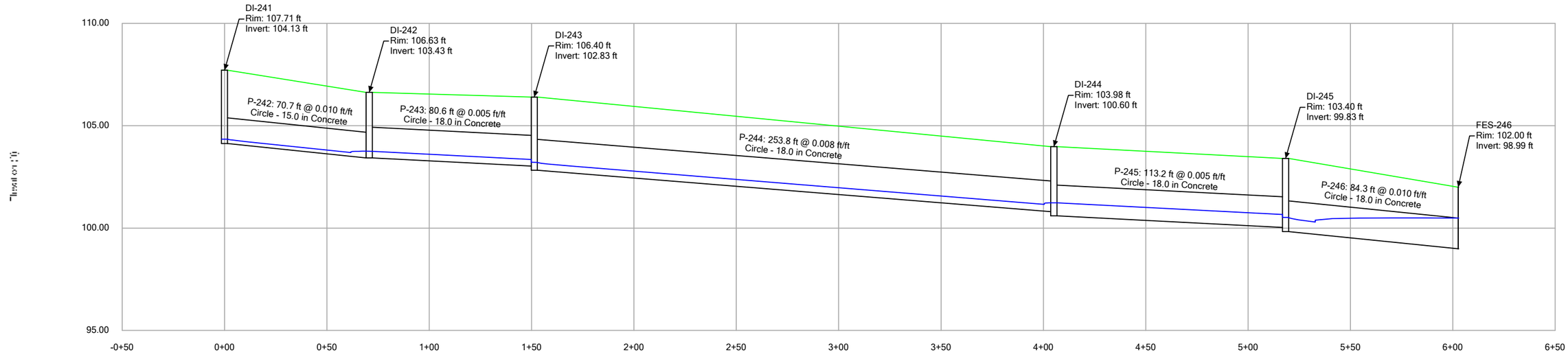
Profile Report
Engineering Profile - 220s (Elkton_Final.stsw)



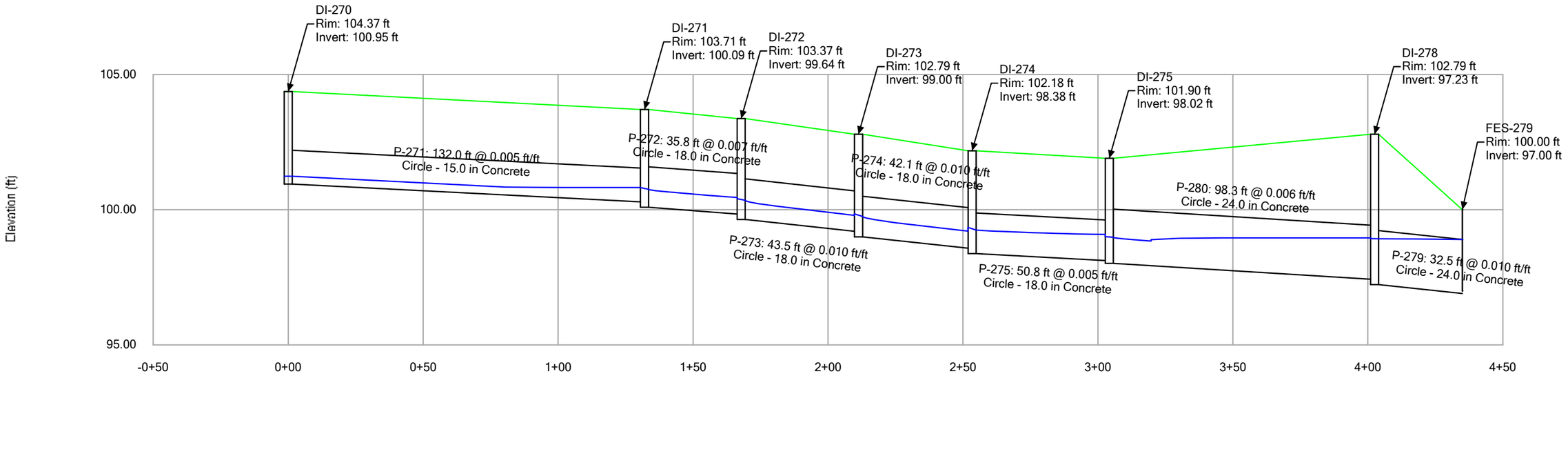
Profile Report
Engineering Profile - 230s (Elkton_Final.stsw)



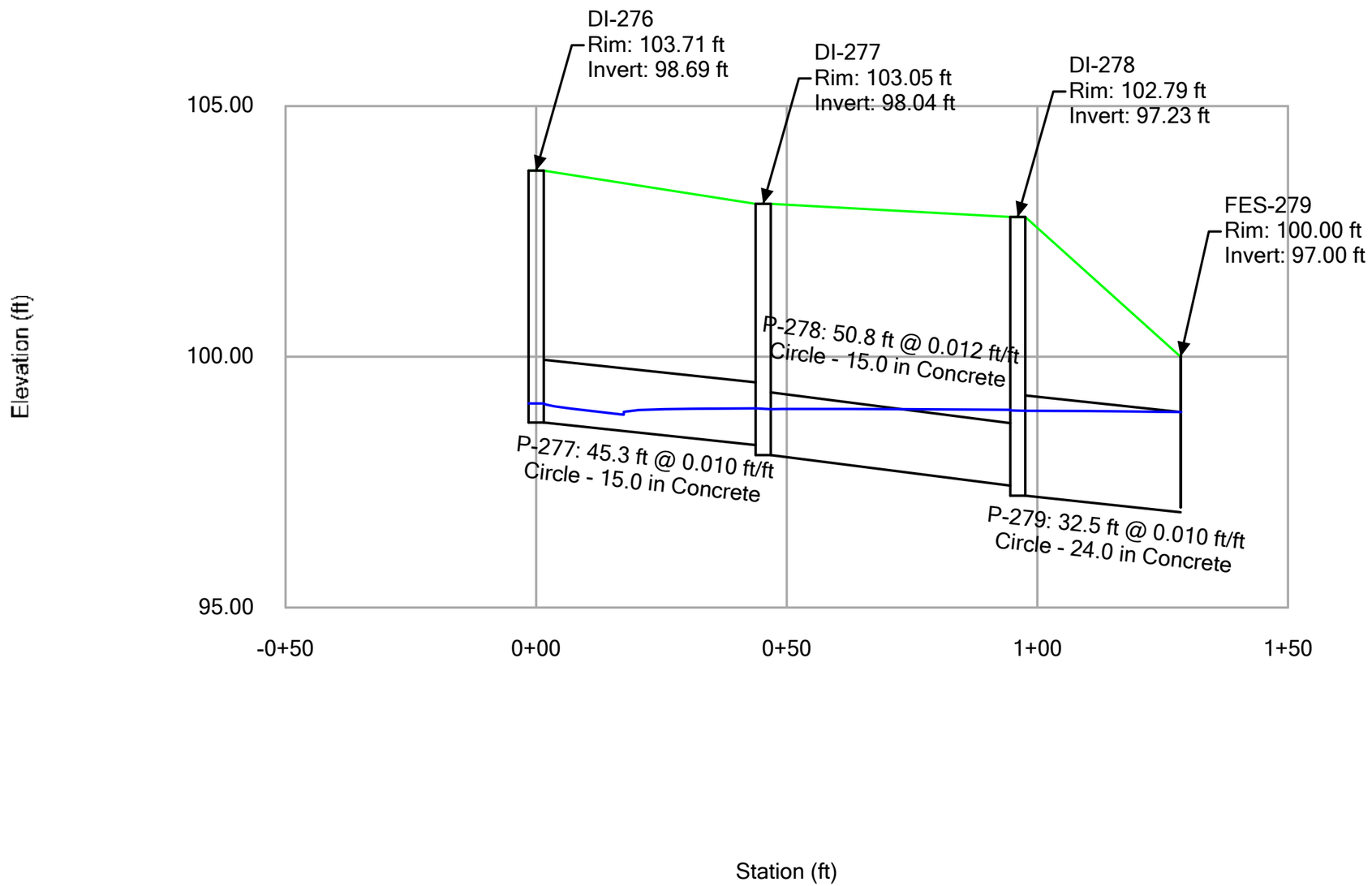
Profile Report
Engineering Profile - 240s (Elkton_Final.stsw)



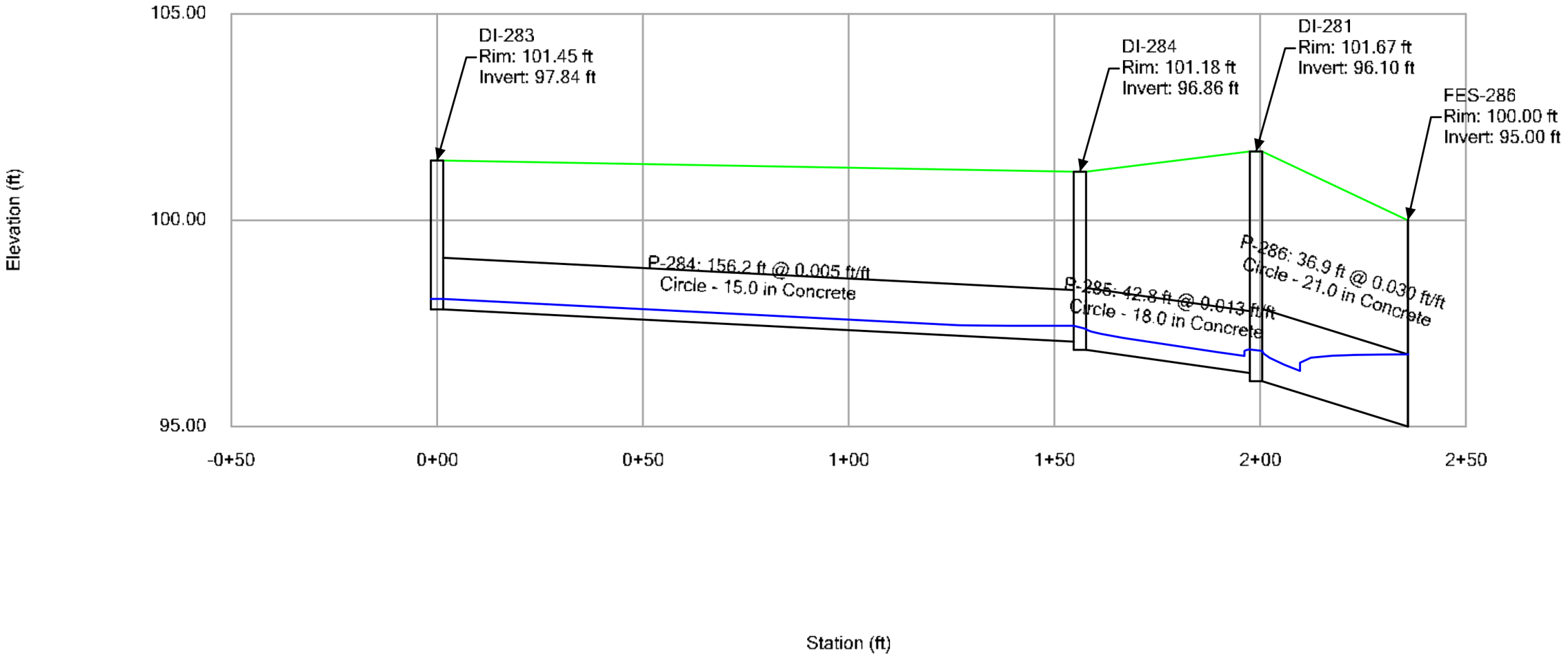
Profile Report
Engineering Profile - 270s (Elkton_Final.stsw)



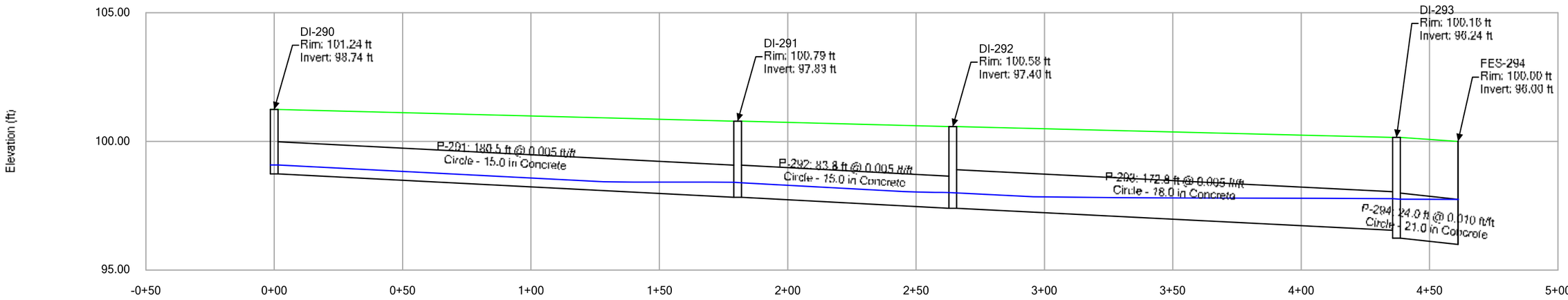
Profile Report
Engineering Profile - 270s (2) (Elkton_Final.stsw)



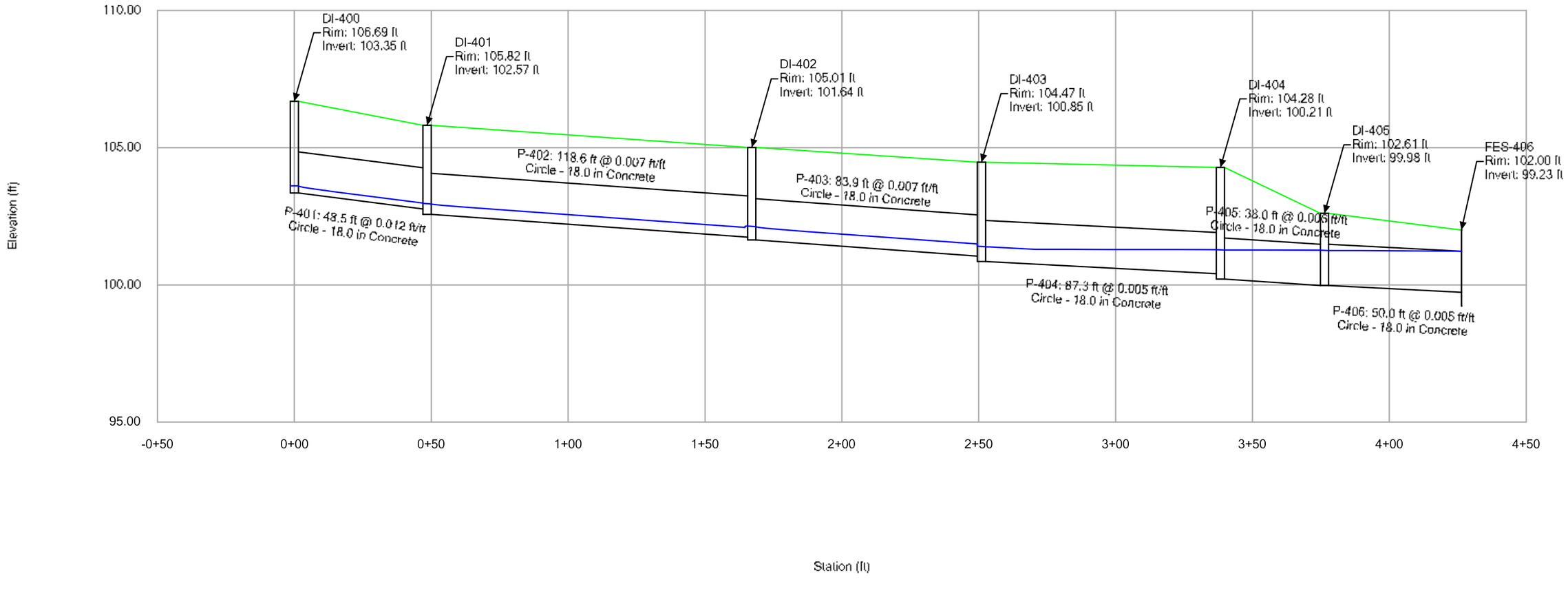
Profile Report
Engineering Profile - 280s (Elkton_Final.stsw)



Profile Report
Engineering Profile - 290s (Elkton_Final.stsw)

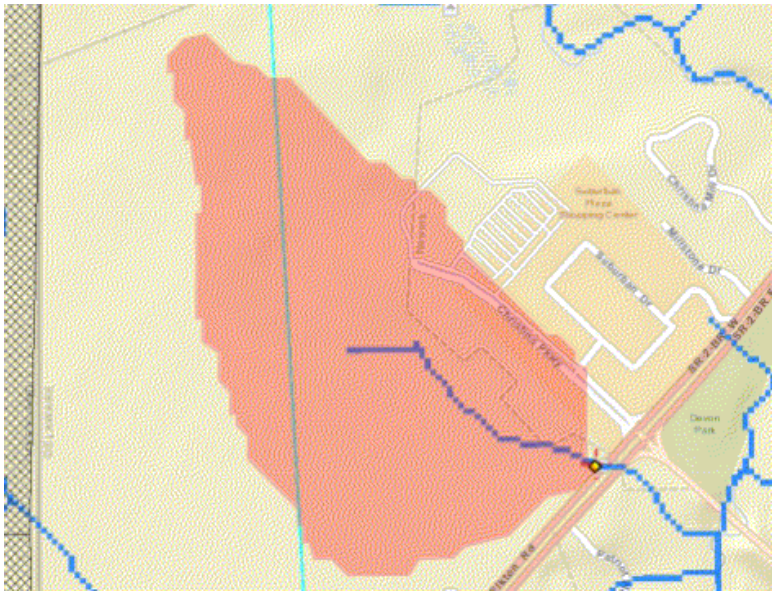


Profile Report
Engineering Profile - 400s (Elkton_Final.stsw)



Appendix G

Culvert Calculations



StreamStats contributing drainage boundary area and Basin Characteristics Report

StreamStats Version 3.0

Basin Characteristics Ungaged Site Report

Date: Thurs Apr 6, 2017 5:35:50 PM GMT-4
Study Area: Delaware
NAD 1983 Latitude: 39.665 (39 39 54)
NAD 1983 Longitude: -75.7768 (-75 46 37)

Label	Value	Units	Definition
DRNAREA	0.16	square miles	Area that drains to a point on a stream
BSLDEM10M	1.54	percent	Mean basin slope computed from 10 m DEM
FOREST	46.25	percent	Percentage of area covered by forest
IMPNLCD01	11.021	percent	Average percentage of impervious area determined from NLCD 2001 impervious dataset
SOILA	0	percent	Percentage of area of Hydrologic Soil Type A
STORNHD	0.2123	percent	Percent storage (wetlands and waterbodies) determined from 1:24K NHD
LC11IMP	17.1	percent	Average percentage of impervious area determined from NLCD 2011 impervious dataset
LC11DEV	48.8	percent	Percentage of developed (urban) land from NLCD 2011 classes 21-24

Written By: Ryan Sedar - 10/30/06
Updated to account for future conditions by: Emily Maurer - 3/26/07
Checked By: Keith Gray, PE - 3/27/07

Regression Equations

Find Design Variables from StreamStats at http://water.usgs.gov/osw/streamstats/delaware.html

Note: Enter all values are to be entered as unitless.

PI := 66.7	Prediction Interval: 50, 66.7, 75, 90
REGION := 0	Enter either "0" for Piedmont Region or "1" for Coastal Plain Region
DRNAREA := 0.16	Enter drainage area in square miles
SOILA := 0.00	Enter the percentage of soil type A, in percent.
HOMEDENS := 0.63	Enter the 2000 housing density in homes per acre
$HOMEDENS_{25}$:= 0.90	Enter the projected 25yr 2000 housing density in homes per acre (Bridge Design Manual requirement to design for future development)

Note: FOREST, IMPERV & STORNHD variables apply only to Piedmont Region

FOREST := 46.25	Enter percent forest, in percent.
IMPNLCD01 := 11.02	Enter percent impervious ground determined from the 2001 NLCD impervious dataset, in percent.
STORNHD := 0.21	Enter the percent storage from NHD, in percent.

Note: BSLDEM10M & SOILA variables apply only to Coastal Plain Region

BSLDEM10M := 1.54	Enter the mean slope determined from a 10-Meter DEM, in percent.

Mon Oct 30 11:00:43 2006

Mon Oct 30 11:46:46 2006

Future Urbanization Equations:

Current Flows:

$$UP_2 := 51.4 \cdot DRNAREA^{0.798} (HOMEDENS + 1)^{1.09}$$

$$\%Diff_2 := \left(\frac{UPF_2 - UP_2}{UP_2} \right)$$

25 Yr Predicted Flows:

$$UPF_2 := 51.4 \cdot DRNAREA^{0.798} \left(HOMEDENS_{25} + 1 \right)^{1.09}$$

$$\%Diff_2 = 18.1835 \cdot \%$$

$$UP_5 := 91.8 \cdot DRNAREA^{0.783} (HOMEDENS + 1)^{0.950}$$

$$\%Diff_5 := \left(\frac{UPF_5 - UP_5}{UP_5} \right)$$

$$UPF_5 := 91.8 \cdot DRNAREA^{0.783} \left(HOMEDENS_{25} + 1 \right)^{0.950}$$

$$\%Diff_5 = 15.6745 \cdot \%$$

$$UP_{10} := 126 \cdot DRNAREA^{0.775} (HOMEDENS + 1)^{0.870}$$

$$\%Diff_{10} := \left(\frac{UPF_{10} - UP_{10}}{UP_{10}} \right)$$

$$UPF_{10} := 126 \cdot DRNAREA^{0.775} \left(HOMEDENS_{25} + 1 \right)^{0.870}$$

$$\%Diff_{10} = 14.2648 \cdot \%$$

$$UP_{25} := 179 \cdot DRNAREA^{0.767} (HOMEDENS + 1)^{0.780}$$

$$\%Diff_{25} := \left(\frac{UPF_{25} - UP_{25}}{UP_{25}} \right)$$

$$UPF_{25} := 179 \cdot DRNAREA^{0.767} \left(HOMEDENS_{25} + 1 \right)^{0.780}$$

$$\%Diff_{25} = 12.6994 \cdot \%$$

$$UP_{50} := 225 \cdot DRNAREA^{0.762} (HOMEDENS + 1)^{0.719}$$

$$\%Diff_{50} := \left(\frac{UPF_{50} - UP_{50}}{UP_{50}} \right)$$

$$UPF_{50} := 225 \cdot DRNAREA^{0.762} \left(HOMEDENS_{25} + 1 \right)^{0.719}$$

$$\%Diff_{50} = 11.6506 \cdot \%$$

$$UP_{100} := 277 \cdot DRNAREA^{0.758} (HOMEDENS + 1)^{0.663}$$

$$\%Diff_{100} := \left(\frac{UPF_{100} - UP_{100}}{UP_{100}} \right)$$

$$UPF_{100} := 277 \cdot DRNAREA^{0.758} \left(HOMEDENS_{25} + 1 \right)^{0.663}$$

$$\%Diff_{100} = 10.6963 \cdot \%$$

$$UP_{200} := 334 \cdot DRNAREA^{0.754} (HOMEDENS + 1)^{0.611}$$

$$\%Diff_{200} := \left(\frac{UPF_{200} - UP_{200}}{UP_{200}} \right)$$

$$UPF_{200} := 334 \cdot DRNAREA^{0.754} \left(HOMEDENS_{25} + 1 \right)^{0.611}$$

$$\%Diff_{200} = 9.8176 \cdot \%$$

$$UP_{500} := 420 \cdot DRNAREA^{0.751} (HOMEDENS + 1)^{0.546}$$

$$\%Diff_{500} := \left(\frac{UPF_{500} - UP_{500}}{UP_{500}} \right)$$

$$UPF_{500} := 420 \cdot DRNAREA^{0.751} \left(HOMEDENS_{25} + 1 \right)^{0.546}$$

$$\%Diff_{500} = 8.7289 \cdot \%$$

Calculation of Design Flows

All Design Flows are given in Cubic Feet per Second.

Design flows with confidence intervals:

$Q_2 := T_2 \cdot PK2$

$Q_2 = 84.5136$

$Q_5 := T_5 \cdot PK5$

$Q_5 = 142.9251$

$Q_{10} := T_{10} \cdot PK10$

$Q_{10} = 149.7334$

$Q_{25} := T_{25} \cdot PK25$

$Q_{25} = 218.1915$

$Q_{50} := T_{50} \cdot PK50$

$Q_{50} = 278.0692$

$Q_{100} := T_{100} \cdot PK100$

$Q_{100} = 350.1639$

$Q_{200} := T_{200} \cdot PK200$

$Q_{200} = 430.8949$

$Q_{500} := T_{500} \cdot PK500$

$Q_{500} = 558.1021$

Design flows with confidence intervals and future development factor:

$Qf_2 := Q_2 + Q_2 \cdot \%Diff_2$

$Qf_2 = 99.8812$

$Qf_5 := Q_5 + Q_5 \cdot \%Diff_5$

$Qf_5 = 165.328$

$Qf_{10} := Q_{10} + Q_{10} \cdot \%Diff_{10}$

$Qf_{10} = 171.0925$

$Qf_{25} := Q_{25} + Q_{25} \cdot \%Diff_{25}$

$Qf_{25} = 245.9005$

$Qf_{50} := Q_{50} + Q_{50} \cdot \%Diff_{50}$

$Qf_{50} = 310.4658$

$Qf_{100} := Q_{100} + Q_{100} \cdot \%Diff_{100}$

$Qf_{100} = 387.6186$

$Qf_{200} := Q_{200} + Q_{200} \cdot \%Diff_{200}$

$Qf_{200} = 473.1983$

$Qf_{500} := Q_{500} + Q_{500} \cdot \%Diff_{500}$

$Qf_{500} = 606.8183$

HY-8 Culvert Analysis Report

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 0 cfs

Design Flow: 278 cfs

Maximum Flow: 350 cfs

Table 1 - Summary of Culvert Flows at Crossing: Pipe 156 Culvert

Headwater Elevation (ft)	Total Discharge (cfs)	Existing Discharge (cfs)	Proposed Discharge (cfs)	Roadway Discharge (cfs)	Iterations
92.74	0.00	0.00	0.00	0.00	0
94.38	35.00	18.15	16.85	0.00	5
95.12	70.00	35.90	34.07	0.00	3
95.77	105.00	54.37	50.62	0.00	4
96.33	140.00	73.03	66.94	0.00	3
96.85	175.00	91.82	83.18	0.00	3
97.37	210.00	110.53	99.47	0.00	4
97.98	245.00	127.97	117.02	0.00	4
98.55	278.00	147.27	130.73	0.00	4
99.27	315.00	165.97	149.05	0.00	4
100.14	350.00	183.21	166.81	0.00	3
105.37	521.97	275.04	246.94	0.00	Overtopping

Table 2 - Culvert Summary Table: Existing

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)
0.00	0.00	92.74	0.000	0.000	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
35.00	18.15	94.38	1.641	0.406	1-S2n	1.087	1.206	1.087	0.889	5.916	4.028
70.00	35.90	95.12	2.377	1.031	1-S2n	1.547	1.716	1.591	1.315	6.890	5.010
105.00	54.37	95.77	3.035	1.653	1-S2n	1.941	2.138	1.941	1.644	8.003	5.659
140.00	73.03	96.33	3.592	2.292	1-S2n	2.304	2.491	2.371	1.921	8.320	6.155
175.00	91.82	96.85	4.109	2.979	1-S2n	2.660	2.806	2.660	2.164	9.094	6.561
210.00	110.53	97.37	4.631	3.717	5-S2n	3.029	3.090	3.029	2.382	9.430	6.908
245.00	127.97	97.98	5.158	5.236	7-M2c	3.421	3.326	3.326	2.581	10.156	7.211
278.00	147.27	98.55	5.812	5.812	7-M2c	4.500	3.558	3.558	2.755	10.918	7.467
315.00	165.97	99.27	6.534	6.526	7-M2c	4.500	3.756	3.756	2.938	11.704	7.727
350.00	183.21	100.14	7.285	7.395	7-M2c	4.500	3.911	3.911	3.100	12.483	7.952

****

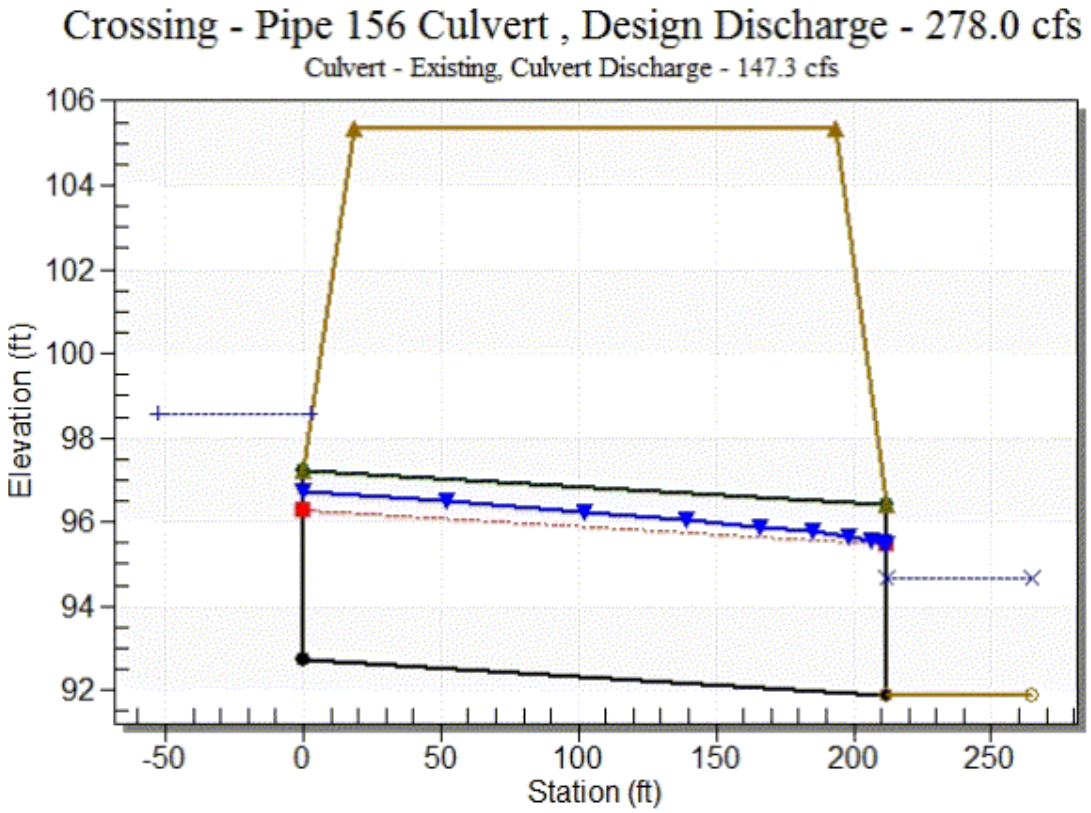
Straight Culvert

Inlet Elevation (invert): 92.74 ft, Outlet Elevation (invert): 91.90 ft

Culvert Length: 212.00 ft, Culvert Slope: 0.0040

****

Water Surface Profile Plot for Culvert: Existing



Site Data - Existing

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 92.74 ft

Outlet Station: 212.00 ft

Outlet Elevation: 91.90 ft

Number of Barrels: 1

Culvert Data Summary - Existing

Barrel Shape: Circular

Barrel Diameter: 4.50 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Grooved End Projecting

Inlet Depression: None

Table 3 - Culvert Summary Table: Proposed

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)
0.00	0.00	92.74	0.000	0.000	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
35.00	16.85	94.38	1.591	0.311	1-S2n	1.049	1.161	1.049	0.889	5.773	4.028
70.00	34.07	95.12	2.328	0.947	1-S2n	1.506	1.673	1.506	1.315	7.048	5.010
105.00	50.62	95.77	2.985	1.531	1-S2n	1.866	2.059	1.866	1.644	7.850	5.659
140.00	66.94	96.33	3.542	2.123	1-S2n	2.189	2.379	2.251	1.921	8.140	6.155
175.00	83.18	96.85	4.059	2.755	1-S2n	2.498	2.667	2.567	2.164	8.599	6.561
210.00	99.47	97.37	4.581	3.437	5-S2n	2.810	2.928	2.810	2.382	9.239	6.908
245.00	117.02	97.98	5.185	4.227	5-S2n	3.168	3.180	3.168	2.581	9.511	7.211
278.00	130.73	98.55	5.705	5.763	7-M2c	3.496	3.361	3.361	2.755	10.263	7.467
315.00	149.05	99.27	6.484	6.329	7-M2c	4.500	3.578	3.578	2.938	10.990	7.727
350.00	166.81	100.14	7.345	7.109	7-M2c	4.500	3.764	3.764	3.100	11.740	7.952

****

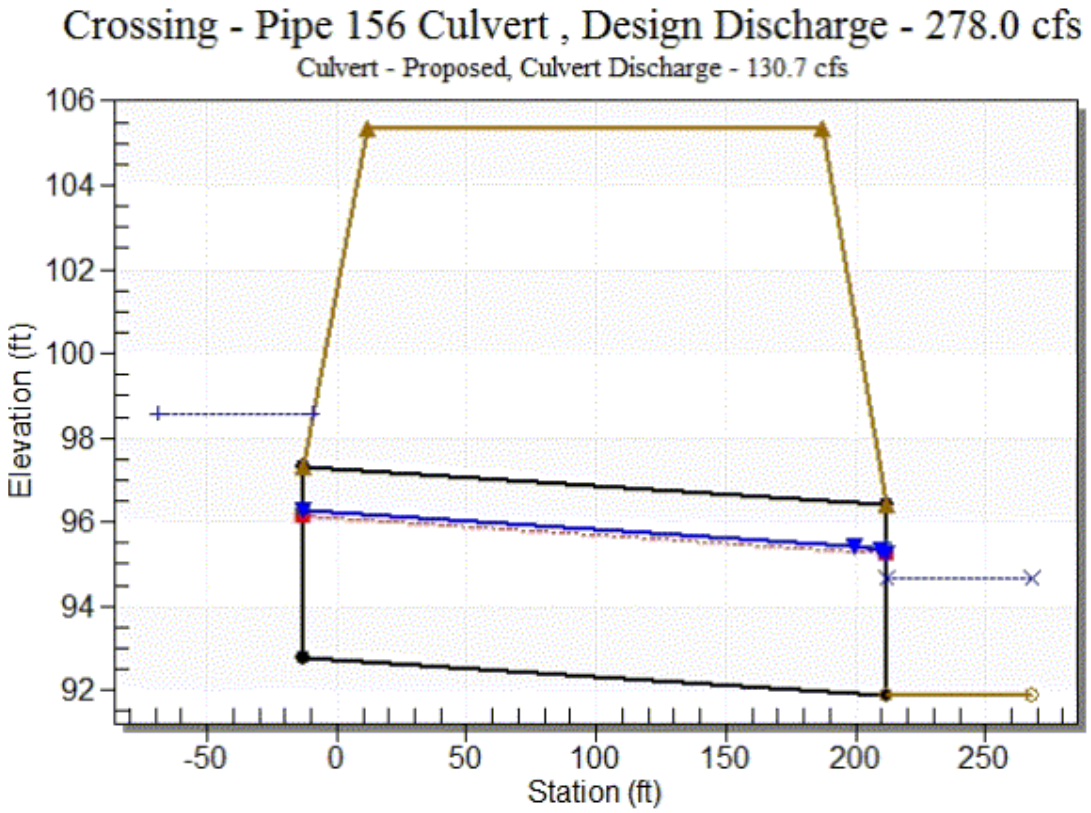
Straight Culvert

Inlet Elevation (invert): 92.79 ft, Outlet Elevation (invert): 91.90 ft

Culvert Length: 225.00 ft, Culvert Slope: 0.0040

****

Water Surface Profile Plot for Culvert: Proposed



Site Data - Proposed

Site Data Option: Culvert Invert Data

Inlet Station: -13.00 ft

Inlet Elevation: 92.79 ft

Outlet Station: 212.00 ft

Outlet Elevation: 91.90 ft

Number of Barrels: 1

Culvert Data Summary - Proposed

Barrel Shape: Circular

Barrel Diameter: 4.50 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall

Inlet Depression: None

Table 4 - Downstream Channel Rating Curve (Crossing: Pipe 156 Culvert)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
0.00	91.90	0.00	0.00	0.00	0.00
35.00	92.79	0.89	4.03	0.77	0.82
70.00	93.21	1.31	5.01	1.13	0.86
105.00	93.54	1.64	5.66	1.42	0.88
140.00	93.82	1.92	6.16	1.65	0.90
175.00	94.06	2.16	6.56	1.86	0.91
210.00	94.28	2.38	6.91	2.05	0.92
245.00	94.48	2.58	7.21	2.22	0.93
278.00	94.66	2.76	7.47	2.37	0.94
315.00	94.84	2.94	7.73	2.53	0.95
350.00	95.00	3.10	7.95	2.67	0.95

Tailwater Channel Data - Pipe 156 Culvert

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 8.00 ft

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

Channel Slope: 0.0138

Channel Manning's n: 0.0350

Channel Invert Elevation: 91.90 ft

Roadway Data for Crossing: Pipe 156 Culvert

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 150.00 ft

Crest Elevation: 105.37 ft

Roadway Surface: Paved

Roadway Top Width: 175.00 ft

Appendix H

Riprap Outlet Stabilization Calculations

Riprap Outlet Protection Calculations

Outfall Number	Design Flow Q (cfs)	Pipe Diameter (ft)	Riprap Type	Riprap Width (ft)	Riprap Length (ft)
(1)	(2)	(3)	(4)	(5)	(6)
107	3.17	1.50	R-4	8	6
106	6.13	1.25	R-4	8	12
108			R-4	8	10
110			R-5	8	25
111			R-5	8	25
117			R-4	8	6
205	5.73	1.75	R-4	10	7
406	2.94	1.50	R-4	8	6
410			R-4	8	10
112			R-4	8	14
116	3.37	1.50	R-4	8	6
129	15.16	2.00	R-4	13	13
409			R-4	8	10
220	15.71	2.00	R-4	8	6
501	1.02	1.25	R-4	8	6
222	1.1	1.50	R-4	8	6
119			R-4	8	10
138	3.7	1.50	R-4	8	6
139	1.19	1.50	R-4	8	18
140			R-5	12	18
234	6.51	1.50	R-4	8	6
142	8.68	2.00	R-4	10	12
144	11.48	2.00	R-4	12	14
322	11.10	2.00	R-4	6	12
326			R-5	12	53
331	1.09	1.50	R-4	8	6
163			R-4	8	10
246	3.31	1.50	R-4	8	6
279	10.12	2.00	R-5	8	23
341	3.09	1.25	R-4	8	6
342			R-5	12	6
150			R-5	22	17
182			R-4	16	16
286	4.34	1.75	R-4	8	8
294			R-5	8	75

Hydraulic Analysis Report

Project Data

Project Title: Elkton Road, Casho Mill Road to State Line

Designer: JMT

Project Date: Friday, August 11, 2017

Project Units: U.S. Customary Units

Notes:

Riprap Analysis: Riprap 234

Notes:

Input Parameters

Riprap Type: Culvert Outlet Protection

Flow: 6.51 cfs

Culvert Diameter: 1.5 ft

Normal Depth in Culvert: 1.08848 ft

Tailwater Depth: 0.6 ft

If tailwater is unknown, use 0.4D

flow is sbcritical

Result Parameters

Tailwater Depth Used in Computations: 0.6 ft

Culvert Diameter Used in Computations: 1.5 ft

Computed D50: 2.79926 in

Riprap Class

Riprap shape should be angular

Riprap Class Name: CLASS I

Riprap Class Order: 1

The following values are an 'average' of the size fraction range for the selected riprap class.

d100: 12 in

d85: 9 in

d50: 6.5 in

d15: 4.5 in

Layout Recommendations

Apron Length: 6 ft

Apron Depth: 1.89583 ft

Apron Width (at end): 8.5 ft

Delaware Department of Transportation

Drainage Plan Submission Checklist for Division of Transportation Solutions Projects

Directions for Completing the Checklist

- This checklist indicates what content should be included with each required submission to the Department.
- The Checkboxes ☐ indicate that information is required and must be included in the submission.
- For each submission, indicate that the required information has been included in the plan submission by completing the appropriate checkbox.
- Items may need to be added for some projects and may not be required for others. Please discuss with the DelDOT Drainage Reviewers to determine if an item is not required. If the item is not required place a strikethrough line through the item that is not required.
- The DelDOT project manager shall review this checklist with the Designer/Consultant at each required submission to verify that all necessary information has been included in the report and shall sign below for each submission to attest to the completeness of the plan submission.
- The Preliminary Drainage Report Submission will occur with internal Preliminary Plan submission and will include all items in this checklist. Final Drainage Report Submission will occur with internal Semi-Final Plan Submission and include all items in this checklist.
- This checklist shall be completed, signed and submitted with each submission.

Project Information			
Contract #:	T201504401	Primavera ID:	TBD
Contract Name:	ELKTON ROAD, MD LINE TO CASHO MILL ROAD		
Designer:	JMT	Project Manager:	Michael Nauman, P.E.

Verification of Submission Completeness		
Submission	Designer Approval	Project Manager Approval
Preliminary Plans		
Semi-Final Plans		

Cover Sheet		
	Prelim	Semi
Project title	☐	■
Project contract number	☐	■
P3E number	☐	■
Date submitted for review	☐	■
Name of designer(s) that the report was prepared by	☐	■
Phone number of designer(s)	☐	■
E-mail address of the designer(s)	☐	■

Table of Contents		
	Prelim	Semi
Table of contents showing the order of the report. The report order shall follow the order presented in the checklist	☐	■

Narrative		
	Prelim	Semi
Project summary included providing a brief history of the project	☐	■
Design methodology describing the following items:		
• Inlet spacing	☐	■
• Roadside ditches	☐	■
• Storm drain system	☐	■
• EGL and HGL Calculations	☐	■

Support Calculations/ Appendices		
	Prelim	Semi
Drainage area Maps in PDF or CADD format which include the following:		
• North arrow	☐	■
• Legend on each map describing information shown in map	☐	■
• Proposed drainage area's boundaries	☐	■
• Label each drainage area based on DI number on construction plans	☐	■
• Roadway names labeled	☐	■
• Aerial Photo in background	☐	■
• Proposed contours in project limits	☐	■
• Existing contours in project limits (shown in different color than proposed and on line a lighter line weight)	☐	■
• Proposed Impervious limits	☐	■
• The Tc path shown for each drainage area in a different color than the contours and drainage boundaries	☐	■

Support Calculations/ Appendices Cont.		
	Prelim	Semi
Provide Tables in PDF Format which Show Each Drainage Area Specifics Including:		
• Each land type present listed with its associated area and "C" value	☐	■
• Weighted "C" value listed for entire drainage area	☐	■
• Total area of each drainage area in acres	☐	■
• Calculated overland sheet flow time, shallow concentrated flow time and concentrated flow time summed into total Tc time. (Sample calculations can be submitted on larger projects)	☐	■
• "I" values corresponding to chapter 6 of the Road Design Manual	☐	■
• Total "Q" to the drainage area	☐	■
Inlet spacing Calculations Performed and Submitted in PDF Format Including:		
• List design storm event	☐	■
• Associated inlet number identified	☐	■
• Longitudinal slope listed	☐	■
• Cross slope of shoulder/ travel Lane listed	☐	■
• Total gutter flow including previous bypass flow	☐	■
• Gutter depth	☐	■
• Actual Gutter spread	☐	■
• Allowable spread	☐	■
• Efficiency factor listed	☐	■
• Bypass flow calculated	☐	■
• Perform flanking inlet calculations for sags	☐	■
Ditch Sizing Calculations Performed and Submitted in PDF Format Including:		
• List design storm event	☐	■
• List the drainage areas (which were calculated in previous steps) contributing to the ditch flow	☐	■
• Each land type present listed with its associated area and "C" value	☐	■
• Weighted "C" value listed for combined drainage area to each ditch run	☐	■
• Total area of each combined drainage area in acres	☐	■
• Calculated overland sheet flow time, shallow concentrated flow time, and concentrated flow time summed into total Tc time. (Sample calculations can be submitted on larger projects)	☐	■
• "I" Values corresponding to chapter 6 of the Road Design Manual	☐	■
• Total Q to the ditch	☐	■
• Ditch bottom width listed	☐	■
• Composite longitudinal slope of the ditch section	☐	■
• Ditch side slopes listed (for both sides)	☐	■
• Calculated depth of water in the ditch	☐	■
• Calculated water velocity in the ditch	☐	■
• Calculated shear stress in the ditch	☐	■
• Permissible shear stress for the ditch lining	☐	■

Support Calculations/ Appendices Cont.		
	Prelim	Semi
Pipe Sizing Calculations Submitted in Table Format:		
• List design storm event		■
• Identify the pipe number associated with calculation		■
• Identify the length of the pipe		■
• Use previously created drainage area maps and inlet spacing calculations to identify the associated drainage area of both the individual pipe and total system		■
• Identify individual “C” value as well as aggregate total “C” value for each pipe		■
• Use previously created drainage area maps and inlet spacing calculations to identify the associated Tc of the of both the individual pipe and the total system		■
• Calculate associated “I” using Chapter 6 of the Road Design Manual		■
• Determine Runoff “Q” to the pipe being designed		■
• Identify the slope of each pipe		■
• Perform Manning’s calculation to determine the design and full flow velocity		■
• Identify invert and discharge elevations for each pipe		■
• Calculate crown drop for each pipe		■
HGL and EGL Calculations Submitted in Table Format:		
• Provide summary of HGL and EGL calculation results		■
• Include sample HGL and EGL calculations for the project		■
Culvert Analysis:		
• Design flow		■
• Maximum flow		■
• Headwater elevation		■
• Tailwater elevation		■
• Outlet velocity		■
• Tailwater velocity		■
Energy Dissipater Design:		
• Perform appropriate energy dissipater calculations		■
• Determine outlet velocity with proposed energy dissipater		■