

Location Hydraulics Report
SR 659 (Combee Rd)
From US 98 to North Crystal Lake Drive
POLK COUNTY
FPID 440274-1-22-01
ETDM Number: 14326

Prepared For:
FLORIDA DEPARTMENT OF TRANSPORTATION
District I



The environmental review, consultation, and other actions required by applicable federal environmental laws for this project are being or have been carried out by FDOT pursuant 23 U.S.C. § 327 and a Memorandum of Understanding dated December 14, 2016 and executed by FHWA and FDOT.

Prepared By:
Patel, Greene & Associates, LLC
12570 Telecom Drive
Temple Terrace, Florida 33637

Submitted in Association with:
Kimley-Horn
189 South Orange Avenue, Suite 1000
Orlando, Florida 32801

December 2021

Signature Page Professional Engineer's Seal

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Kenneth D. Yinger, State of Florida, Professional Engineer, License No. 75595

This item has been digitally sealed by Kenneth D. Yinger on the date indicated here.

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Table of Contents

TABLE OF CONTENTS.....	I
LIST OF TABLES	I
LIST OF FIGURES	I
1.0 PROJECT DESCRIPTION.....	1
2.0 LOCATION HYDRAULICS	2
2.1 GENERAL INFORMATION AND PURPOSE	2
2.2 BASE FLOODPLAIN.....	2
2.3 HYDROLOGY.....	2
2.4 HYDRAULIC ANALYSIS.....	3
2.5 FLOODPLAIN ENCROACHMENTS	3
2.5.1 PROPOSED ROAD ALIGNMENTS AND DRAINAGE CONDITION	3
2.5.2 CROSS DRAIN EXTENSIONS.....	6
3.0 RISK ASSESSMENT	6

List of Tables

Table 2-1: Cross Drain Headwater Elevations.....	6
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List of Figures

Figure 1-1 - Location Map.....	1
Figure 2-1 - Existing Typical Section	3
Figure 2-2: Typical Section for Build Alternative No. 1	5
Figure 2-3: Typical Section for Build Alternative No. 2	5

Appendices

APPENDIX A: Floodplain Information	
Flood Zone Map	
FIRM Maps	
Cross Drain Analysis	
APPENDIX B: Correspondence	
Polk County Floodplain Management	

1.0 PROJECT DESCRIPTION

The Florida Department of Transportation (FDOT) is conducting a Project Development & Environment (PD&E) Study to evaluate a 1.4-mile segment of SR 659 (Combee Road) from US 98 to North Crystal Lake Drive in Polk County, Florida. Combee Road is a two-lane undivided minor arterial roadway with 4-foot wide paved shoulders and little to no sidewalk. The area adjacent to the roadway is a mix of industrial, retail/office, and residential land uses. The proposed improvements will enhance the multimodal mobility along the roadway with the addition of a two-way left turn lane for left-turning traffic and accommodations for pedestrians and bicyclists. Intersection improvements will be made to enhance safety and traffic flow. Additionally, the roadway will be converted from a rural typical section to an urban typical section with curb and gutter and a storm water collection system to improve drainage conditions.

This project is located in western Polk County within Township 28, Range 24, Sections 27 and 28. See **Figure 1** for the Project Location Map.



Figure 1-1 - Location Map

2.0 LOCATION HYDRAULICS

2.1 GENERAL INFORMATION AND PURPOSE

The purpose of this Location Hydraulics Report (LHR) is to address the potential 100-year (base) floodplain encroachments resulting from the roadway improvements evaluated in this study. In accordance with 23 Code of Federal Regulation (CFR) 650 Subpart A, Section 650.111, floodplains are to be protected. The intent of these regulations is to avoid possible long- and short-term adverse impacts associated with the modification of floodplains as a result of development. These regulations urge that where impacts are anticipated, alternatives should be sought out where practical and that development incompatible with floodplain values should be avoided.

2.2 BASE FLOODPLAIN

The study area is included on the Federal Emergency Management Agency's (FEMA) Flood Insurance Rate Map (FIRM) Panel No. 12105C0320G, with an effective date of December 22, 2016. The proposed improvements would result in a minimal encroachment on the floodplain.

Most of the project falls within an area of minimal flood hazard. At the intersection of Combee Road and North Crystal Lake Drive, there is a floodplain designated Zone A. In addition, Crystal Lake has a 100-year floodplain designated Zone AE (elevation 139.1). Zone AE is defined as an area subject to inundation by the 1-percent-annual-chance flood or event or the 100-year base flood elevation. Because the existing roadway is proposed to be widened within this area, floodplain impacts are anticipated and will need to be addressed during design. During the design phase for this project, the Southwest Florida Water Management District (SWFWMD) hydraulic models will need to be updated to include the proposed improvements to Combee Road. Refer to **Appendix A** for excerpts from the FEMA FIRMs and the FEMA Map. Correspondence with Polk County regarding floodplain risks for this project are provided in **Appendix B**.

2.3 HYDROLOGY

Currently, the project area entails a two-lane undivided rural roadway. See **Figure 2-1**. Roadway stormwater runoff sheet flows to roadside swales and continues to existing cross drains or ditches. The project area is in the Saddle Creek basin, waterbody identification (WBID) 1497, and the Banana Lake Canal basin, WBID 1549A. There are three outfalls within the study area: the southern portion discharges to US 98, the middle portion discharges into existing neighborhoods to the west from Commerce Point Drive to Kiwanis Avenue, and the northern portion discharges to Crystal Lake.

The land use throughout the study area is primarily commercial with some industrial and residential areas. The project can be divided into two basins with one sub-basin. Basin 1 is the southern portion of the corridor that discharges to US 98. The limits of Basin 1 are from US 98 to Kiwanis Avenue. The sub-basin within Basin 1 is a portion which discharges into existing neighborhoods to the west from Commerce Point Drive to Kiwanis Avenue. Basin 2 is the northern portion which discharges to Crystal Lake. The limits of Basin 2 are from Kiwanis Avenue to North Crystal Lake Drive.

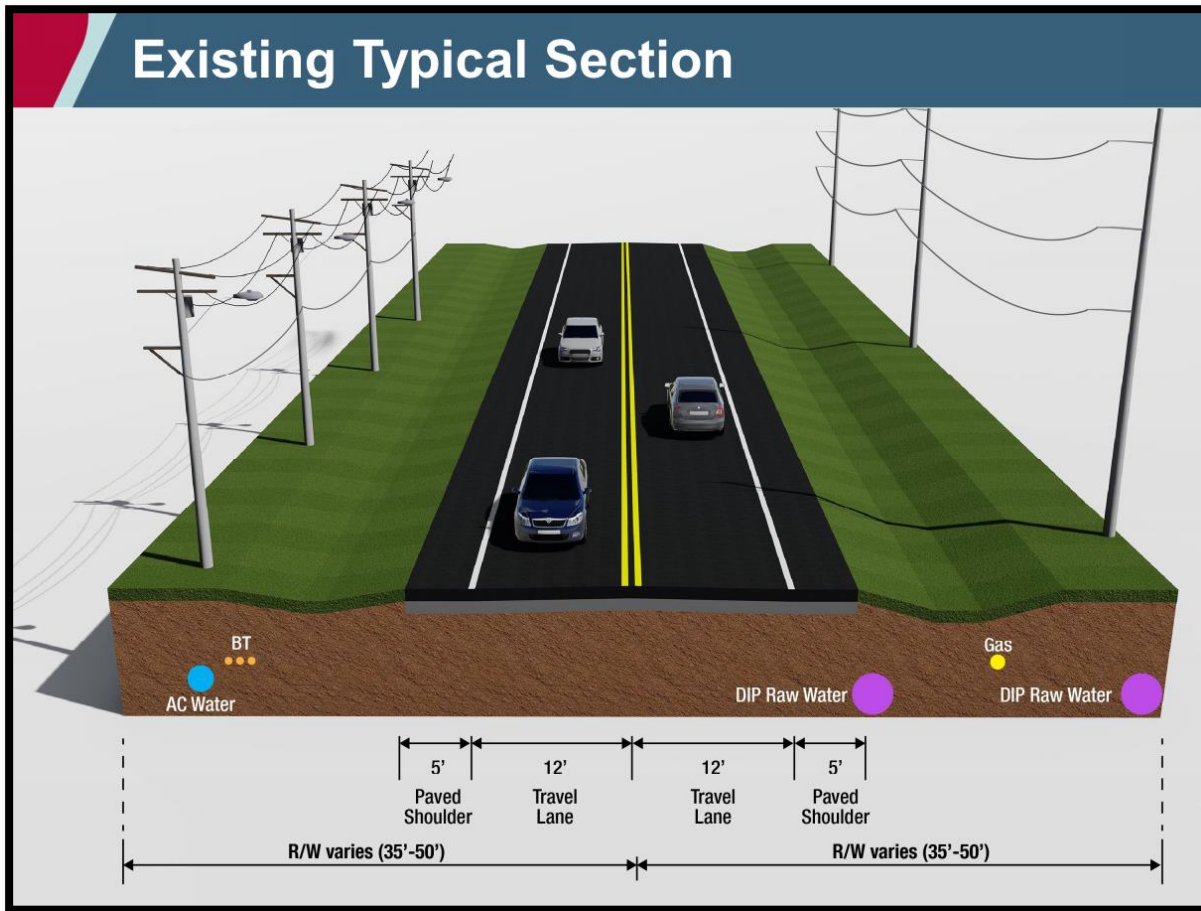


Figure 2-1 - Existing Typical Section

2.4 HYDRAULIC ANALYSIS

A hydraulic analysis was conducted for the existing cross drains within the study corridor. Cross drain calculations are based on the Hydraulic Design of Highway Culverts Publication by the U.S. Department of Transportation.

It is recommended to replace the entire drainage system. The system is in poor condition, exhibiting multiple locations of failure. It is expected that the runoff will be conveyed via gutters to new curb inlets and a new closed storm sewer system.

2.5 FLOODPLAIN ENCROACHMENTS

2.5.1 PROPOSED ROAD ALIGNMENTS AND DRAINAGE CONDITION

Alternatives evaluated for this PD&E Study include Alternative 1, Alternative 2, and the No-Build Alternative. The Preferred Alternative is Alternative 2. See **Figure 2-1** for the existing typical and **Figures 2-2** and **Figure 2-3** for the proposed typical sections.

Alternative 1

Alternative 1 proposes one 12-foot wide travel lane in each direction separated by a 13-foot wide two-way left turn lane. This alternative includes 6-foot wide sidewalks for pedestrians and 7-foot wide buffered bicycle lanes for cyclists. The existing roadside stormwater ditches would be replaced by a closed drainage system with curb and gutter. As part of this alternative, roundabouts were considered at the intersections of Maine Avenue and Skyview Drive.

Alternative 2

Alternative 2 provides a more comfortable environment for pedestrians and cyclists. This includes 8-foot wide sidewalks and a 4-foot wide minimum buffer between the sidewalk and back of curb. Similar to Alternative 1, Alternative 2 provides one lane in each direction separated by a 13-foot wide two-way left turn lane; however, no separate bicycle lanes are proposed. The proposed 12-foot wide travel lanes provide greater maneuverability for trucks and transit vehicles that regularly use the corridor. The existing roadside stormwater ditches would be replaced by a closed drainage system with curb and gutter. As part of this alternative, roundabouts were considered at the intersections of Maine Avenue and Skyview Drive.

No-Build Alternative

The No-Build Alternative assumes no improvement to Combee Road other than routine maintenance. It provides a benchmark for comparative purposes with the Build Alternatives.

The advantages of the No-Build Alternative include the following:

- No impact to the adjacent natural, physical, and human environments
- No expenditure of funds for right-of-way acquisition or construction
- No utility impacts

The disadvantages of the No-Build Alternative include the following:

- Not consistent with the Polk TPO's Complete Streets Action Plan
- Does not enhance pedestrian and bicycle accommodations along the roadway
- Does not improve safety conditions
- Does not improve vehicular traffic operations

The No-Build Alternative remains a viable alternative throughout the study and the public involvement process.

For both build alternatives, closed storm sewer systems utilizing curb and gutter inlets and back of sidewalk inlets are recommended to accommodate the proposed typical section. The secondary system will be provided in the design phase.

It is worth noting that there is a potential for the project to encounter contaminated surficial groundwater along the corridor. Further investigation is needed to determine if there are areas of contamination and their extent and severity.

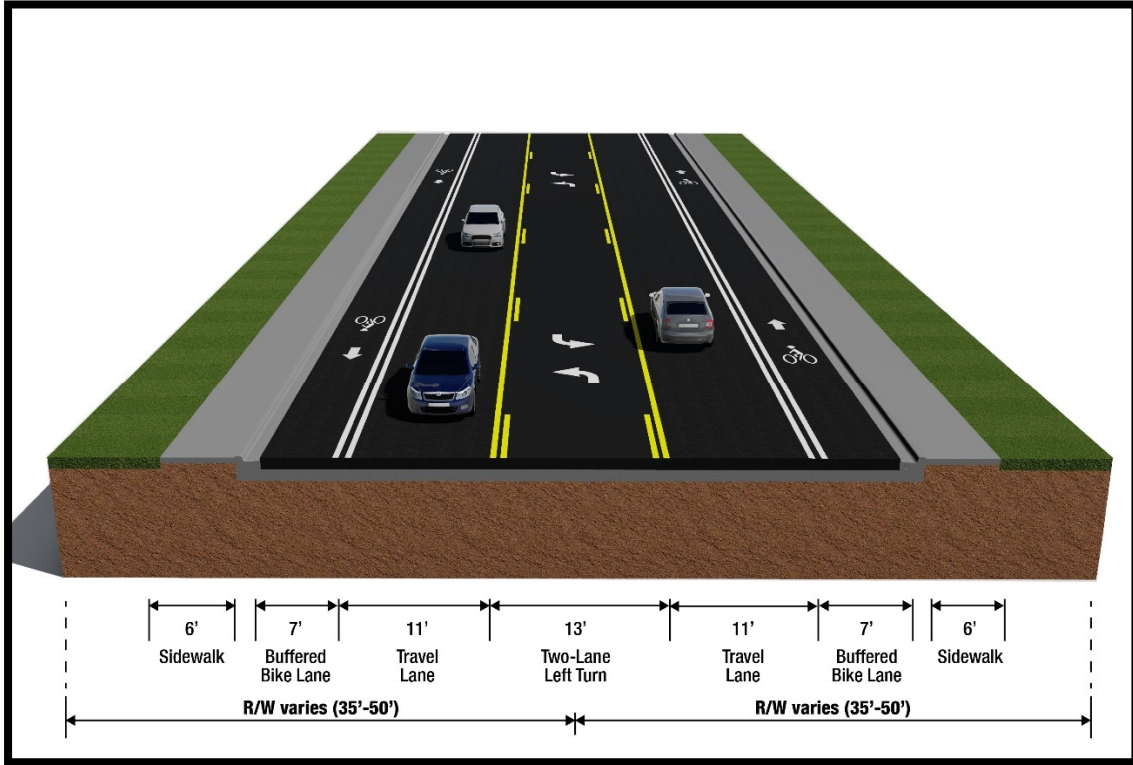


Figure 2-2: Typical Section for Build Alternative No. 1

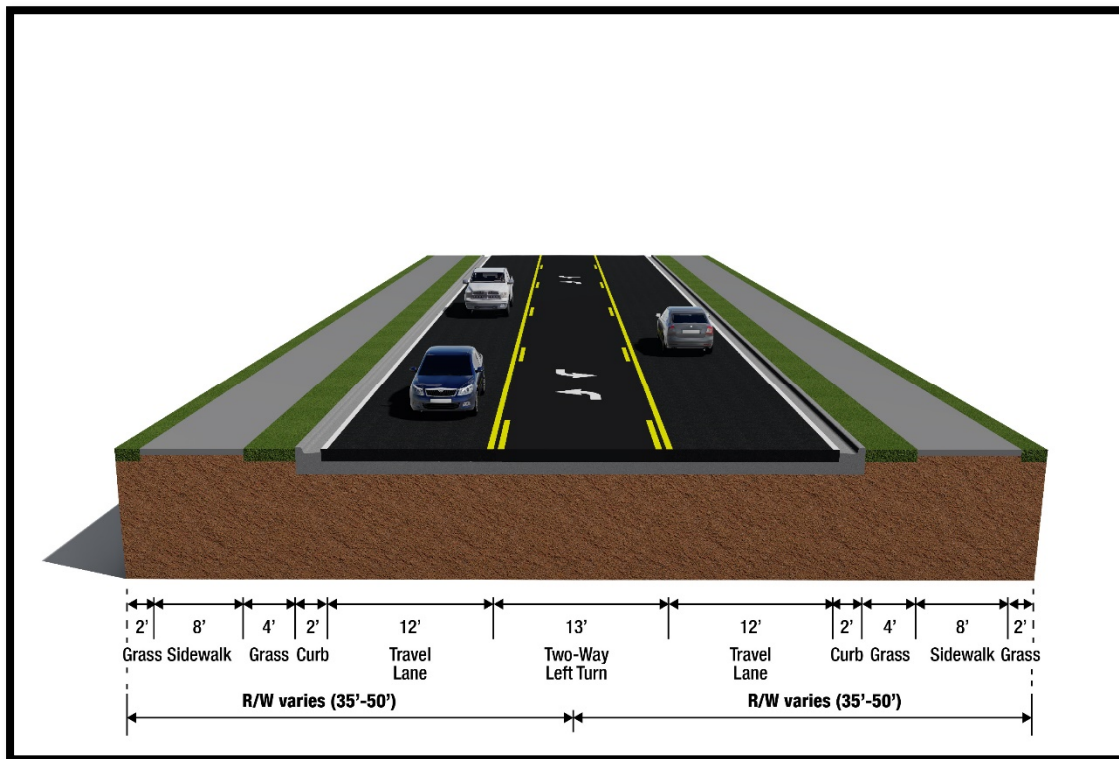


Figure 2-3: Typical Section for Build Alternative No. 2

2.5.2 CROSS DRAIN EXTENSIONS

Both build alternatives will require cross drain extensions to accommodate the proposed typical sections. There are two cross drains within the project limits. One is a 36-inch concrete culvert south of North Crystal Lake Drive that connects Crystal Lake to the wetland east of Combee Road. The existing culvert length is approximately 72 feet and extends into Crystal Lake and the wetland. The other cross drain is a double 24-inch concrete culvert at the Maine Avenue intersection that flows from the east to the west side of Combee Road. The existing culvert length is approximately 137 feet. For Build Alternative No. 2, this intersection is being converted from a three-way intersection to a roundabout.

Build Alternative No. 2 presents the worst-case scenario for cross drain extensions. To accommodate tie downs and the road widening, the cross drain south of North Crystal Lake Drive will need to be extended to approximately 103 feet. To accommodate new roundabout and sidewalks, the cross drain at Maine Avenue will need to be extended to approximately 140 feet.

Table 2-1 provides the headwater elevations for the existing and proposed cross drain for various storm frequency events. The cross drain information was based on survey information from the Combee Road resurfacing in 2001 (FPID 197692-1-52-01). **Appendix A** provides calculations for the cross drain extensions.

Table 2-1: Cross Drain Headwater Elevations

Storm Frequency	Cross Drain at MP 0.215			Cross Drain at MP 1.323		
	Existing Headwater	Proposed Headwater Alternative 1	Proposed Headwater Alternative 2	Existing Headwater	Proposed Headwater Alternative 1	Proposed Headwater Alternative 2
25-year	145.19	144.99	145.21	141.78	141.78	141.78
50-year	145.78	145.50	145.81	142.38	142.38	142.38
100-year	146.61	146.21	146.64	142.98	142.98	142.98
500-year	152.07	150.92	152.17	146.88	146.88	146.88

Table 2-1 indicates that there is no significant rise in the headwaters; the cross drain extensions should not adversely affect the floodplain.

3.0 RISK ASSESSMENT

The proposed improvements in this project were evaluated to determine whether there would be adverse floodplain impacts. It is anticipated that this project will not cause significant adverse upstream or downstream impacts, nor will it cause adverse floodplain impacts.

The following floodplain statement shown below in italics is a modified version of statements Number 5 in the FDOT PD&E Manual tailored for this project: (See Chapter 13, Part 2 of the PD&E Manual).

Replacement of drainage structures for this project are limited to hydraulically equivalent structures which are not expected to increase the backwater surface elevations. The limitations to the hydraulic equivalency being proposed are basically due to restrictions imposed by the geometrics of design, existing development, cost feasibility, or practicability. An alternative encroachment location is not considered since it does not meet the project's purpose and need or is economically unfeasible. Since

flooding conditions in the project area are inherent in the topography or are a result of other outside contributing sources, and there is no practical alternative to eradicate flooding problems in any significant amount, existing flooding will continue, but will not increase as the result of the construction of this project. Furthermore, the project will not affect existing flood heights or floodplain limits. There will be no significant change in the potential for interruption or termination of emergency service or emergency evacuation routes as the result of construction of this project. Therefore, it has been determined that this encroachment is not significant.



APPENDIX A

Flood Zone Map

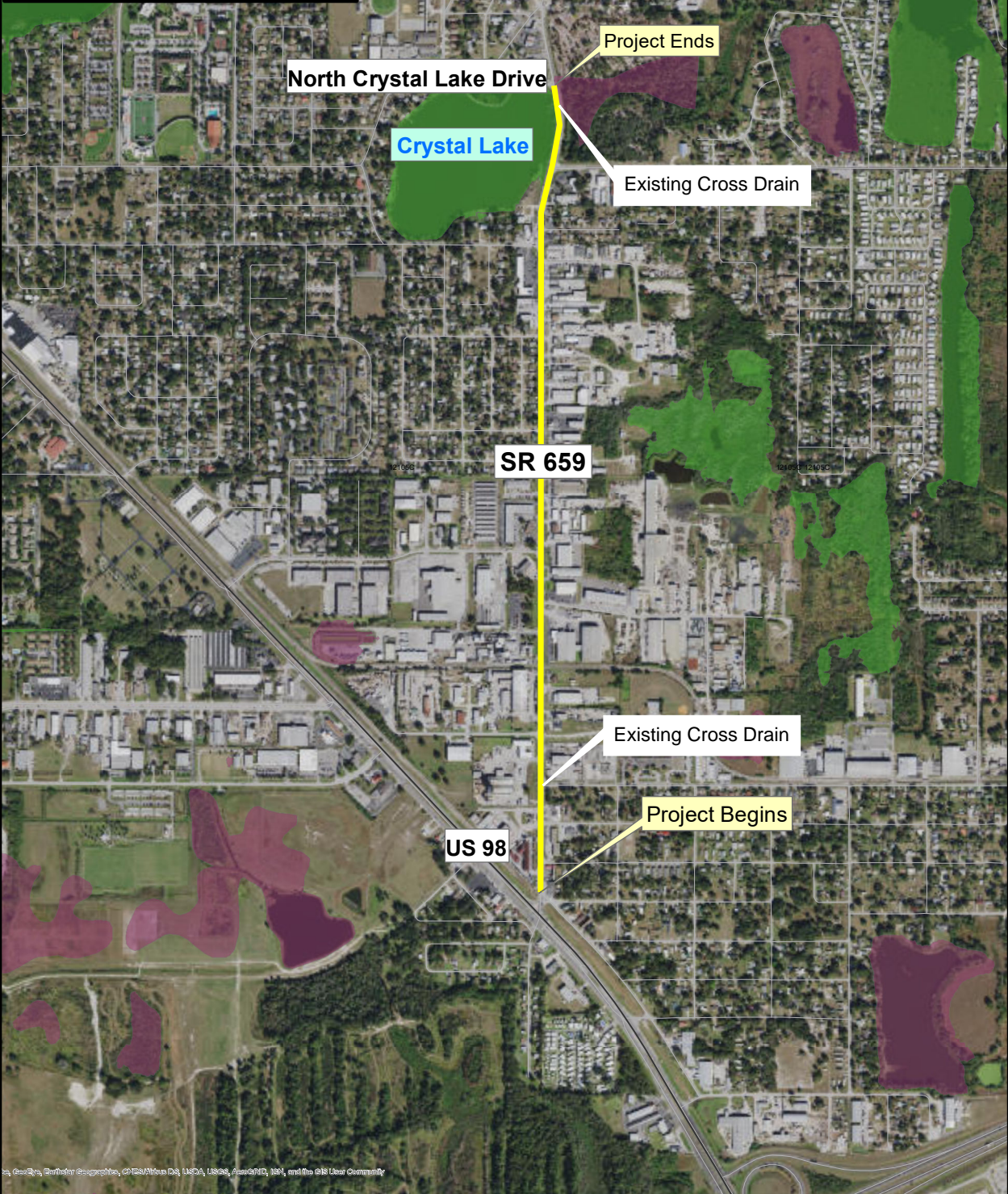
FIRM Maps

Cross Drain Analysis

FEMA Floodplains

Flood Zones :

- A
- AE



Map data by Esri, Garmin, GeoEye, GEBCO, IGN, Intermap, Inc., USDA, CNES, SwireCity, Swire, and the GIS User Community

Floodplain Map

SR 659/Combee Road | FPID: 440274-1-22-01



Combee Road PD&E

Alternative 1

N Crystal Lake Dr

Zone A

PANEL
12105G0320G
eff. 12/22/2016

AREA OF MINIMAL FLOOD HAZ

Zone AE
(EL 139.1 Feet)

Skyview Dr

Co Rd 33A
659



Combee Road PD&E

Alternative 2

AREA OF MINIMAL FLOOD HAZARD Zone X

N Crystal Lake Dr

Zone A

659

PANEL
Polk County
12105C0320G
eff. 12/22/2016

Zone AE
(EL 139.1 Feet)

Skyview Dr

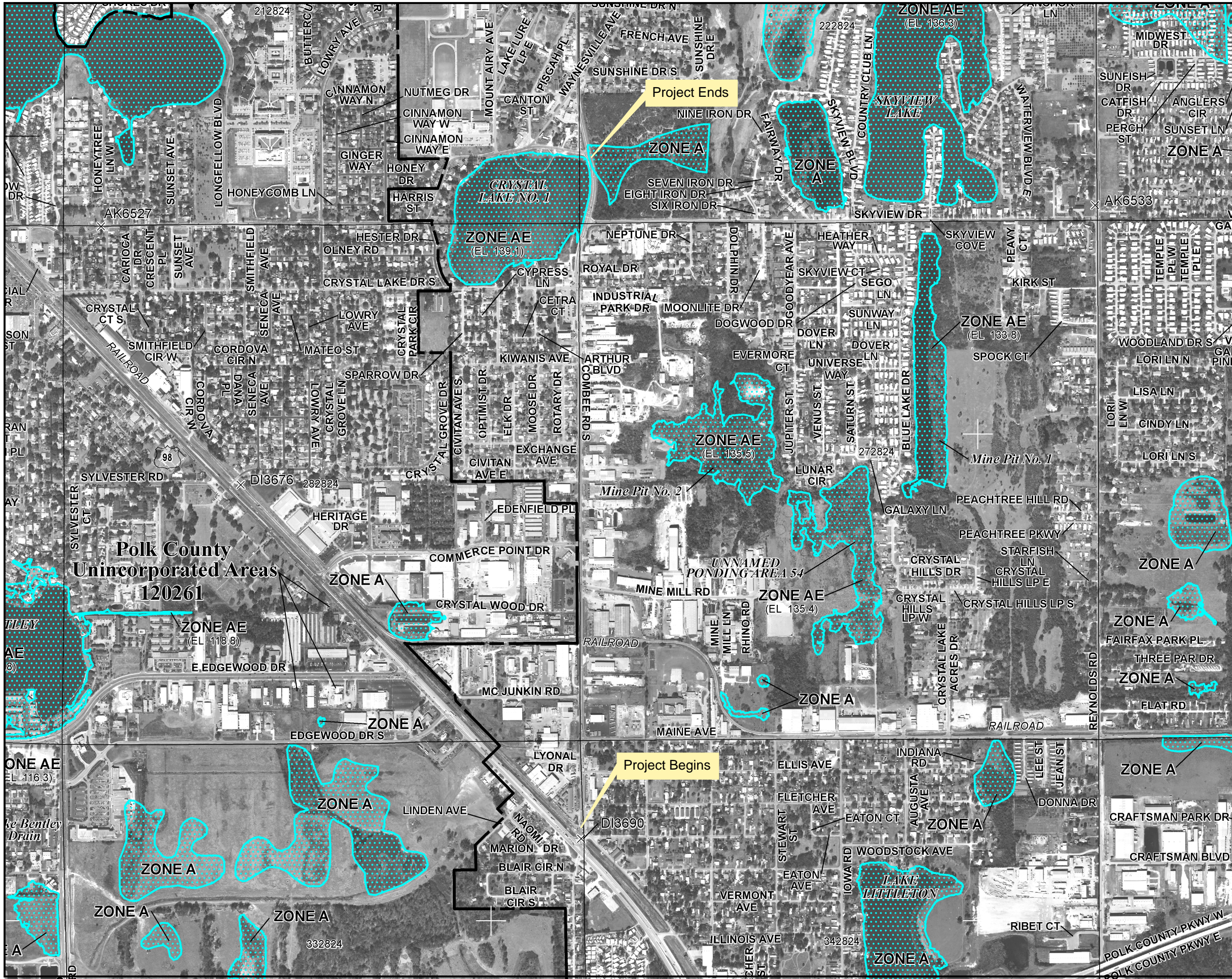
Co Rd 33A

Google Earth

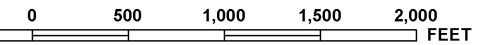
© 2020 Google

500 ft





MAP SCALE 1" = 1000'



NFIP

PANEL 0320G

FIRM

FLOOD INSURANCE RATE MAP
POLK COUNTY,
FLORIDA
AND INCORPORATED AREAS

PANEL 320 OF 1025

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
LAKELAND, CITY OF	120267	0320	G
POLK COUNTY	120261	0320	G

Notice to User: The Map Number shown below should be used when placing map orders; the Community Number shown above should be used on insurance applications for the subject community.



MAP NUMBER
12105C0320G

MAP REVISED
DECEMBER 22, 2016

Federal Emergency Management Agency

This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov

Subject: FPID 440274-1-22-01, SR 659 Combee Road
Cross Drain Analysis (MP 0.215) Alternative 1

Structure Number:
Station:

Existing Cross Drain

Culvert Height/Pipe Size: (D) 2.00 ft (24-in Pipe)
Culvert Depth: N/A
Number of pipes: 2
Pipe Type: RCP
Outfall: Ditch
Flow Direction: West
Culvert Length: 136.95 ft
Upstream Invert El.: 143.96 ft
Downstream Invert El.: 141.72 ft
Pipe Slope (ft/ft): 0.0164
Road Pop-Over El.: 142.95 ft
Basin Pop-Over El.: N/A (Rough Approximation)

Proposed Cross Drain

Culvert Height/Pipe Size: (D) 2.00 ft (24-in Pipe)
Culvert Depth: N/A
Number of pipes: 2
Pipe Type: RCP
Outfall: Ditch
Flow Direction: West
Upstream End Treatment: ST- EW (If using a metered-end section, enter MES as text)
Downstream End Treatment: ST- EW (If using a metered-end section, enter MES as text)
Culvert Length: 102.32 ft
Upstream Invert El.: 143.96 ft
Downstream Invert El.: 142.30 ft
Pipe Slope (ft/ft): 0.0162
Road Pop-Over EL: 143.00
Basin Pop-Over El.: N/A

Proposed Typical Section:

Number of Lanes: 1
Lane Width: 72.7 ft (FDM 122.5.2.1)
Required Clear Zone: 0.0 ft (FDM 215.2.3, See FDM Table 215.2.1)
Median Width: 17.7 ft
Additional Clearance: 5.0 ft

Subject: FPID 440274-1-22-01, SR 659 Combee Road
Existing Cross Drain Method 1: Flow Rate Calculations

DETERMINATION OF FLOW RATES (Q) USING Q = VA

Cross Drain Characteristics

Culvert Size: (D) 2.00 ft
 (B) N/A
 Cross-Sectional Area: 6.28 sf
 Culvert Length: 136.95 ft

Estimated Discharge (Q)

*Estimated Stream Velocity: **6.00 fps**

Q (25 yr) = *Cross-Sect. Area x V X 2 = 37.699
 Q (100 yr) = *1.4 x Q (25 yr) = 52.779
 Q (500 yr) = *1.7 x Q (100 yr) = 89.724

*Method 1 from Drainage Design Guide, Section 4.7.1 This is a conservative estimate for the velocity of a 25-yr Storm Event (pipe may have been designed originally with this velocity at 50-yr Storm Event).

Log Interpolated Q (50 yr):

$$Q (50 yr) = (\text{Log} (Q[100 yr]) - (\text{Log}(100) - \text{Log}(50)) \frac{(\text{Log} (Q[100 yr]) - \text{Log} (Q[25 yr]))}{(\text{Log}(100) - \text{Log}(25))}) = **$$

$$= \text{Log} (Q[50 yr]) \implies 10^{\text{Log} (Q[50 yr])} = 44.606**$$

***It does not matter whether natural log or log 10 is used*

Q (25 yr) =	37.7 cfs
Q (50 yr) =	44.6 cfs
Q (100 yr) =	52.8 cfs
Q (500 yr) =	89.7 cfs

Subject: FPID 440274-1-22-01, SR 659 Combee Road
Existing Cross Drain Headwater Analysis

CROSS DRAIN CHARACTERISTICS

Culvert Size: (D) 2.00 ft
(B) N/A
Culvert Length: 136.95 ft
Pipe X-Sectional Area: 3.14 sf
Wetted Perimeter: 6.28 ft
Pipe Hydraulic Radius: 0.50 ft
Upstream Invert: 143.96 ft
Downstream Invert: 141.72 ft
Road Pop-Over Elevation: 142.95 ft
Allowable HW Elevation: 141.50 ft (Edge of Pavement)

Pipe Type: RCP
Number of pipes: 2
Outfall: Ditch
Flow Direction: West
Manning's roughness: 0.012 (FDOT Drainage Design Guide Table B-1)
Entrance Coefficient (ke): 0.2 (Table C.2. Entrance Loss Coefficients FHWA Hydraulic design Series 5)

FLOW RATES (Q), Q = VA

Q (25 yr) = 37.7 cfs
Q (50 yr) = 44.6 cfs
Q (100 yr) = 52.8 cfs
Q (500 yr) = 89.7 cfs

TAILWATER

The crown of the outlet elevation was used for the tailwater elevations as follows:

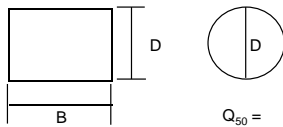
TW (25 yr) = 143.72 ft
TW (50 yr) = 143.72 ft
TW (100 yr) = 143.72 ft
TW (500 yr) = 143.72 ft

Subject: FPID 440274-1-22-01, SR 659 Combee Road
Existing Cross Drain Headwater Analysis

WORKSHEET FOR CULVERT CAPACITY CALCULATIONS
 FIGURE 8-2 (FDOT DRAINAGE MANUAL VOL. 2)

PROJECT: FPID 440274-1-22-01, SR 659 Combee Road
Existing Cross Drain Headwater Analysis

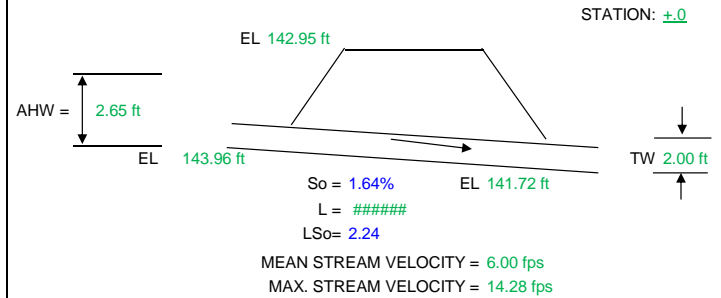
HYDROLOGIC AND CHANNEL INFORMATION



D = Diameter or Height
 B = Span

Q₅₀ = 22.3 cfs TW₅₀ = 143.72 ft
 Q₁₀₀ = 26.4 cfs TW₁₀₀ = 143.72 ft
 (Q1 = DESIGN DISCHARGE, SAY Q50)
 (Q2 = CHECK DISCHARGE, SAY Q100)

SKETCH



CULVERT DESCRIPTION (ENTRANCE TYPE)	Q (CFS) (PER PIPE)	SIZE (FT)		HEADWATER COMPUTATIONS										CON-TROLLING HW	OUTLET VELOCITY (FPS)	PEAK STAGE (FT)	PEAK STAGE (M)	
				INLET CONTROL			OUTLET CONTROL											
				D	B	Q/B	HW/D ₍₃₎	HW	k _e	H ₍₁₎	dc ₍₂₎	(dc+D)/2	TW					DTW
25	18.8	2.0	N/A	N/A	0.00	0.00	0.2	1.47	0.00	1.00	2.00	2.00	2.24	1.23	1.23	6.00	145.19	44.26
50	22.3	2.0	N/A	N/A	0.00	0.00	0.2	2.06	0.00	1.00	2.00	2.00	2.24	1.82	1.82	7.10	145.78	44.44
100	26.4	2.0	N/A	N/A	0.00	0.00	0.2	2.89	0.00	1.00	2.00	2.00	2.24	2.65	2.65	8.40	146.61	44.69
500	44.9	2.0	N/A	N/A	0.00	0.00	0.2	8.35	0.00	1.00	2.00	2.00	2.24	8.11	8.11	14.28	152.07	46.35

SUMMARY & RECOMMENDATIONS:

- H @ Outlet Control = $(1 + k_e + (29 \cdot n^2 \cdot L) / R^{1.33}) \cdot ((Q/A)^2 / (2 \cdot g))$ Eq. 3.5 FHWA Hydraulic Design Series 5
- Critical Depth (dc) was found using the FHWA Hydraulic Design Series 5 charts. Note that dc cannot exceed D.
- HW/D for all storm events was found using the FHWA Hydraulic Design Series 5.

Designed by: MGB

Checked by: TAP

Designed By: MGB
 Date: 11/2/2020
 Checked By: TAP
 Date: 11/2/2020

Subject: FPID 440274-1-22-01, SR 659 Combee Road
Existing Cross Drain Headwater Analysis

***ONLY ENTER dc VALUES HERE. DO NOT ENTER IN CHART ABOVE. CHART USES THESE VALUES TO CALCULATE dc FOR CIRCULAR PIPE.**

Verify that existing flow below is same as existing flow for project cross drain. Change all values in table if flows do not match.

[Figures Start on PDF pg. 218 for the FHWA Hydraulic Design Series 5](#)

Q - 2-ft	HW/D	n = 0.012	1	1.75	2	2.25	2.5	2.75	3	3.5	4
25	0.00	37.7 cfs							1.10		
50	0.00	44.6 cfs							1.30		
100	0.00	52.8 cfs							1.50		
500	0.00	89.7 cfs							2.80		

[Figures Start on PDF pg. 218 for the FHWA Hydraulic Design Series 5](#)

Q - 2-ft	dc	n = 0.012	1	1.75	2	2.25	2.5	2.75	3	3.5	4
25	0.00	37.7 cfs							2.10		
50	0.00	44.6 cfs							2.30		
100	0.00	52.8 cfs							2.50		
500	0.00	89.7 cfs							3.00		

Subject: FPID 440274-1-22-01, SR 659 Combee Road
Proposed Cross Drain Headwater Analysis

CROSS DRAIN CHARACTERISTICS

Culvert Size: (D) 2.00 ft
(B) N/A
Culvert Length: 102.32 ft
Pipe X-Sectional Area: 3.14 sf
Wetted Perimeter: 6.28 ft
Pipe Hydraulic Radius: 0.50 ft
Upstream Invert: 143.96 ft
Downstream Invert: 142.30 ft
Road Pop-Over Elevation: 143.00 ft
Allowable HW Elevation: 141.55 ft (Edge of Pavement)

Pipe Type: RCP
Number of pipes: 2
Outfall: Ditch
Flow Direction: West
Manning's roughness: 0.012 (FDOT Drainage Design Guide Table B-1)
Entrance Coefficient (ke): 0.2 (Table C.2. Entrance Loss Coefficients FHWA Hydraulic design Series 5)

FLOW RATES (Q), Q = VA

Q (25 yr) = 37.7 cfs
Q (50 yr) = 44.6 cfs
Q (100 yr) = 52.8 cfs
Q (500 yr) = 89.7 cfs

TAILWATER

Tailwater from existing conditions.

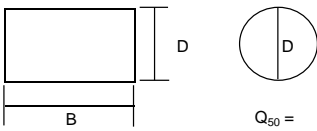
TW (25 yr) = 143.72 ft
TW (50 yr) = 143.72 ft
TW (100 yr) = 143.72 ft
TW (500 yr) = 143.72 ft

Subject: FPID 440274-1-22-01, SR 659 Combee Road
Proposed Cross Drain Headwater Analysis

WORKSHEET FOR CULVERT CAPACITY CALCULATIONS
FIGURE 8-2 (FDOT DRAINAGE MANUAL VOL. 2)

PROJECT: FPID 440274-1-22-01, SR 659 Combee Road
Proposed Cross Drain Headwater Analysis

HYDROLOGIC AND CHANNEL INFORMATION



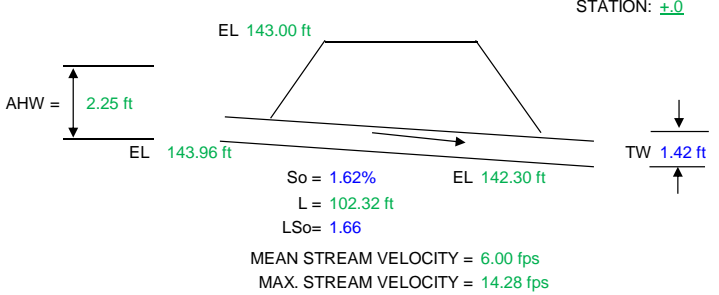
D = Diameter or Height
 B = Span

Q₅₀ = 22.3 cfs TW₅₀ = 143.72 ft
 Q₁₀₀ = 26.4 cfs TW₁₀₀ = 143.72 ft

(Q1 = DESIGN DISCHARGE, SAY Q50)
 (Q2 = CHECK DISCHARGE, SAY Q100)

SKETCH

STATION: ±.0



EL 143.00 ft
 AHW = 2.25 ft
 EL 143.96 ft EL 142.30 ft
 So = 1.62% L = 102.32 ft
 LSo = 1.66
 MEAN STREAM VELOCITY = 6.00 fps
 MAX. STREAM VELOCITY = 14.28 fps
 TW 1.42 ft

CULVERT DESCRIPTION (ENTRANCE TYPE)	Q (CFS) (PER PIPE)	SIZE (FT)		HEADWATER COMPUTATIONS											CON-TROLLING HW	OUTLET VELOCITY (FPS)	PEAK STAGE (FT)	PEAK STAGE (M)
				INLET CONTROL			OUTLET CONTROL HW = H + DTW - LSo											
				D	B	Q/B	HW/D ₍₃₎	HW	k _e	H ₍₁₎	dc ₍₂₎	(dc+D)/2	TW	DTW				
25	18.8	2.0	N/A	N/A	0.00	0.00	0.2	1.27	0.00	1.00	1.42	1.42	1.66	1.03	1.03	6.00	144.99	44.19
50	22.3	2.0	N/A	N/A	0.00	0.00	0.2	1.78	0.00	1.00	1.42	1.42	1.66	1.54	1.54	7.10	145.50	44.35
100	26.4	2.0	N/A	N/A	0.00	0.00	0.2	2.49	0.00	1.00	1.42	1.42	1.66	2.25	2.25	8.40	146.21	44.56
500	44.9	2.0	N/A	N/A	0.00	0.00	0.2	7.20	0.00	1.00	1.42	1.42	1.66	6.96	6.96	14.28	150.92	46.00

SUMMARY & RECOMMENDATIONS:

- H @ Outlet Control = $(1 + k_e + (29 \cdot n^2 \cdot L) / R^{1.33}) \cdot ((Q/A)^2 / (2 \cdot g))$ Eq. 3.5 FHWA Hydraulic Design Series 5
- Critical Depth (dc) was found using the FHWA Hydraulic Design Series 5 charts. Note that dc cannot exceed D.
- HW/D for all storm events was found using the FHWA Hydraulic Design Series 5.

Designed by: 0 Checked by: JR

Designed By: MGB
 Date: 11/2/2020
 Checked By: TAP
 Date: 11/2/2020

Subject: FPID 440274-1-22-01, SR 659 Combee Road
Proposed Cross Drain Headwater Analysis

***ONLY ENTER dc VALUES HERE. DO NOT ENTER IN CHART ABOVE. CHART USES THESE VALUES TO CALCULATE dc FOR CIRCULAR PIPE.**
 Verify that existing flow below is same as existing flow for project cross drain. Change all values in table if flows do not match.

[Figures Start on PDF pg. 218 for the FHWA Hydraulic Design Series 5](#)

Q - 2-ft	HW/D	n = 0.012	1	1.75	2	2.25	2.5	2.75	3	3.5	4
25	0.00	37.7 cfs							1.10		
50	0.00	44.6 cfs							1.30		
100	0.00	52.8 cfs							1.50		
500	0.00	89.7 cfs							2.80		

[Figures Start on PDF pg. 218 for the FHWA Hydraulic Design Series 5](#)

Q - 2-ft	dc	n = 0.012	1	1.75	2	2.25	2.5	2.75	3	3.5	4
25	0.00	37.7 cfs							2.10		
50	0.00	44.6 cfs							2.30		
100	0.00	52.8 cfs							2.50		
500	0.00	89.7 cfs							3.00		

Subject: FPID 440274-1-22-01, SR 659 Combee Road
Cross Drain Analysis (MP 1.323) Alternative 1

Structure Number:
Station:

Existing Cross Drain

Culvert Height/Pipe Size: (D)	3.00 ft	(36-in Pipe)
Culvert Depth:	N/A	
Number of pipes:	1	
Pipe Type:	RCP	
Outfall:	Wetland	
Flow Direction:	East	
Culvert Length:	72.40 ft	
Upstream Invert El.:	138.48 ft	
Downstream Invert El.:	134.92 ft	
Pipe Slope (ft/ft):	0.0492	
Road Pop-Over El.:	142.95 ft	
Basin Pop-Over El.:	N/A	(Rough Approximation)

Proposed Cross Drain

Culvert Height/Pipe Size: (D)	3.00 ft	(36-in Pipe)
Culvert Depth:	N/A	
Number of pipes:	1	
Pipe Type:	RCP	
Outfall:	Wetland	
Flow Direction:	East	
Upstream End Treatment:	ST- EW	(If using a metered-end section, enter MES as text)
Downstream End Treatment	ST- EW	(If using a metered-end section, enter MES as text)
Culvert Length:	95.00 ft	
Upstream Invert El.:	138.48 ft	
Downstream Invert El.:	133.80 ft	
Pipe Slope (ft/ft):	0.0493	
Road Pop-Over EL:	143.00	
Basin Pop-Over El.:	N/A	

Proposed Typical Section:

Number of Lanes:	2	
Lane Width:	11.0 ft	(FDM 122.5.2.1)
Required Clear Zone:	0.0 ft	(FDM 215.2.3, See FDM Table 215.2.1)
Median Width:	13.0 ft	
Additional Clearance:	29.0 ft	

Subject: FPID 440274-1-22-01, SR 659 Combee Road
Existing Cross Drain Method 1: Flow Rate Calculations

DETERMINATION OF FLOW RATES (Q) USING Q = VA

Cross Drain Characteristics

Culvert Size: (D) 3.00 ft
 (B) N/A
 Cross-Sectional Area: 7.07 sf
 Culvert Length: 72.40 ft

Estimated Discharge (Q)

*Estimated Stream Velocity: 6.00 fps

Q (25 yr) = *Cross-Sect. Area x V = 42.412
 Q (100 yr) = *1.4 x Q (25 yr) = 59.376
 Q (500 yr) = *1.7 x Q (100 yr) = 100.939

*Method 1 from Drainage Design Guide, Section 4.7.1 This is a conservative estimate for the velocity of a 25-yr Storm Event (pipe may have been designed originally with this velocity at 50-yr Storm Event).

Log Interpolated Q (50 yr):

$$Q (50 \text{ yr}) = (\text{Log} (Q[100 \text{ yr}]) - (\text{Log}(100) - \text{Log}(50)) \frac{(\text{Log} (Q[100 \text{ yr}]) - \text{Log} (Q[25 \text{ yr}])))}{(\text{Log}(100) - \text{Log}(25))} = **$$

$$= \text{Log} (Q[50 \text{ yr}]) \implies 10^{\text{Log} (Q[50 \text{ yr}])} = 50.182**$$

***It does not matter whether natural log or log 10 is used*

Q (25 yr) =	42.4 cfs
Q (50 yr) =	50.2 cfs
Q (100 yr) =	59.4 cfs
Q (500 yr) =	100.9 cfs

Subject: FPID 440274-1-22-01, SR 659 Combee Road
Existing Cross Drain Headwater Analysis

CROSS DRAIN CHARACTERISTICS

Culvert Size: (D) 3.00 ft
(B) N/A
Culvert Length: 72.40 ft
Pipe X-Sectional Area: 7.07 sf
Wetted Perimeter: 9.42 ft
Pipe Hydraulic Radius: 0.75 ft
Upstream Invert: 138.48 ft
Downstream Invert: 134.92 ft
Road Pop-Over Elevation: 142.95 ft
Allowable HW Elevation: 142.73 ft (Edge of Pavement)

Pipe Type: RCP
Number of pipes: 1
Outfall: Wetland
Flow Direction: East
Manning's roughness: 0.012 (FDOT Drainage Design Guide Table B-1)
Entrance Coefficient (ke): 0.2 (Table C.2. Entrance Loss Coefficients FHWA Hydraulic design Series 5)

FLOW RATES (Q), Q = VA

Q (25 yr) = 42.4 cfs
Q (50 yr) = 50.2 cfs
Q (100 yr) = 59.4 cfs
Q (500 yr) = 100.9 cfs

TAILWATER

The crown of the outlet elevation was used for the tailwater elevations as follows:

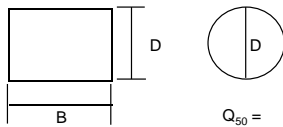
TW (25 yr) = 137.92 ft
TW (50 yr) = 137.92 ft
TW (100 yr) = 137.92 ft
TW (500 yr) = 137.92 ft

Subject: FPID 440274-1-22-01, SR 659 Combee Road
Existing Cross Drain Headwater Analysis

WORKSHEET FOR CULVERT CAPACITY CALCULATIONS
 FIGURE 8-2 (FDOT DRAINAGE MANUAL VOL. 2)

PROJECT: FPID 440274-1-22-01, SR 659 Combee Road
Existing Cross Drain Headwater Analysis

HYDROLOGIC AND CHANNEL INFORMATION

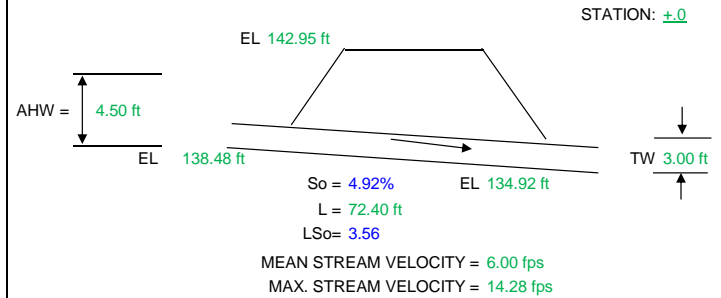


D = Diameter or Height
 B = Span

$Q_{50} = 50.2$ cfs $TW_{50} = 137.92$ ft
 $Q_{100} = 59.4$ cfs $TW_{100} = 137.92$ ft

(Q1 = DESIGN DISCHARGE, SAY Q50)
 (Q2 = CHECK DISCHARGE, SAY Q100)

SKETCH



CULVERT DESCRIPTION (ENTRANCE TYPE)	Q (CFS) (PER PIPE)	SIZE (FT)		HEADWATER COMPUTATIONS											CON-TROLLING HW	OUTLET VELOCITY (FPS)	PEAK STAGE (FT)	PEAK STAGE (M)
				INLET CONTROL			OUTLET CONTROL											
				D	B	Q/B	HW/D ₍₃₎	HW	k_e	$H_{(1)}$	$dc_{(2)}$	$(dc+D)/2$	TW	DTW				
25	42.4	3.0	N/A	N/A	1.10	3.30	0.2	0.92	2.10	2.55	3.00	3.00	3.56	0.36	3.30	6.00	141.78	43.21
50	50.2	3.0	N/A	N/A	1.30	3.90	0.2	1.29	2.30	2.65	3.00	3.00	3.56	0.73	3.90	7.10	142.38	43.40
100	59.4	3.0	N/A	N/A	1.50	4.50	0.2	1.80	2.50	2.75	3.00	3.00	3.56	1.24	4.50	8.40	142.98	43.58
500	100.9	3.0	N/A	N/A	2.80	8.40	0.2	5.20	3.00	3.00	3.00	3.00	3.56	4.64	8.40	14.28	146.88	44.77

SUMMARY & RECOMMENDATIONS:

- H @ Outlet Control = $(1 + k_e + (29 \cdot n^2 \cdot L) / R^{1.33}) \cdot ((Q/A)^2 / (2 \cdot g))$ Eq. 3.5 FHWA Hydraulic Design Series 5
- Critical Depth (dc) was found using the FHWA Hydraulic Design Series 5 charts. Note that dc cannot exceed D.
- HW/D for all storm events was found using the FHWA Hydraulic Design Series 5.

Designed by: GLSP

Checked by: TAP

Designed By: GLSP
 Date: 2/18/2019
 Checked By: TAP
 Date: 2/21/2019

Subject: FPID 440274-1-22-01, SR 659 Combee Road
Existing Cross Drain Headwater Analysis

***ONLY ENTER dc VALUES HERE. DO NOT ENTER IN CHART ABOVE. CHART USES THESE VALUES TO CALCULATE dc FOR CIRCULAR PIPE.**

Verify that existing flow below is same as existing flow for project cross drain. Change all values in table if flows do not match.

[Figures Start on PDF pg. 218 for the FHWA Hydraulic Design Series 5](#)

Q - 2-ft	HW/D	n = 0.012	1	1.75	2	2.25	2.5	2.75	3	3.5	4
25	1.10	42.4 cfs							1.10		
50	1.30	50.2 cfs							1.30		
100	1.50	59.4 cfs							1.50		
500	2.80	100.9 cfs							2.80		

[Figures Start on PDF pg. 218 for the FHWA Hydraulic Design Series 5](#)

Q - 2-ft	dc	n = 0.012	1	1.75	2	2.25	2.5	2.75	3	3.5	4
25	2.10	42.4 cfs							2.10		
50	2.30	50.2 cfs							2.30		
100	2.50	59.4 cfs							2.50		
500	3.00	100.9 cfs							3.00		

Subject: FPID 440274-1-22-01, SR 659 Combee Road
Proposed Cross Drain Headwater Analysis

CROSS DRAIN CHARACTERISTICS

Culvert Size: (D) 3.00 ft
(B) N/A
Culvert Length: 95.00 ft
Pipe X-Sectional Area: 7.07 sf
Wetted Perimeter: 9.42 ft
Pipe Hydraulic Radius: 0.75 ft
Upstream Invert: 138.48 ft
Downstream Invert: 133.80 ft
Road Pop-Over Elevation: 143.00 ft
Allowable HW Elevation: 142.78 ft (Edge of Pavement)

Pipe Type: RCP
Number of pipes: 1
Outfall: Wetland
Flow Direction: East
Manning's roughness: 0.012 (FDOT Drainage Design Guide Table B-1)
Entrance Coefficient (ke): 0.2 (Table C.2. Entrance Loss Coefficients FHWA Hydraulic design Series 5)

FLOW RATES (Q), Q = VA

Q (25 yr) = 42.4 cfs
Q (50 yr) = 50.2 cfs
Q (100 yr) = 59.4 cfs
Q (500 yr) = 100.9 cfs

TAILWATER

Tailwater from existing conditions.

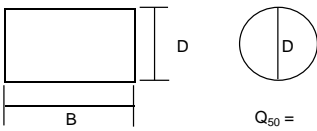
TW (25 yr) = 137.92 ft
TW (50 yr) = 137.92 ft
TW (100 yr) = 137.92 ft
TW (500 yr) = 137.92 ft

Subject: FPID 440274-1-22-01, SR 659 Combee Road
Proposed Cross Drain Headwater Analysis

WORKSHEET FOR CULVERT CAPACITY CALCULATIONS
FIGURE 8-2 (FDOT DRAINAGE MANUAL VOL. 2)

PROJECT: FPID 440274-1-22-01, SR 659 Combee Road
Proposed Cross Drain Headwater Analysis

HYDROLOGIC AND CHANNEL INFORMATION

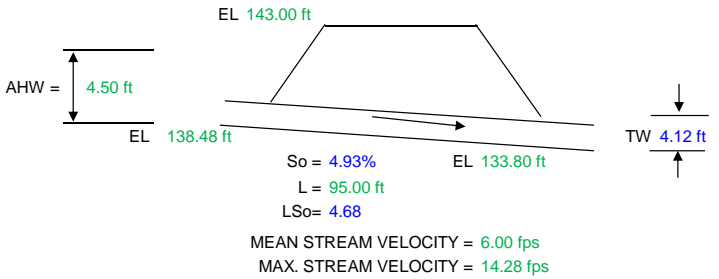


D = Diameter or Height
 B = Span

Q₅₀ = 50.2 cfs TW₅₀ = 137.92 ft
 Q₁₀₀ = 59.4 cfs TW₁₀₀ = 137.92 ft

(Q1 = DESIGN DISCHARGE, SAY Q50)
 (Q2 = CHECK DISCHARGE, SAY Q100)

STATION: ±.0



EL 143.00 ft
 AHW = 4.50 ft
 EL 138.48 ft
 TW 4.12 ft
 EL 133.80 ft
 So = 4.93%
 L = 95.00 ft
 LSo = 4.68
 MEAN STREAM VELOCITY = 6.00 fps
 MAX. STREAM VELOCITY = 14.28 fps

CULVERT DESCRIPTION (ENTRANCE TYPE)	Q (CFS) (PER PIPE)	SIZE (FT)		HEADWATER COMPUTATIONS											CON-TROLLING HW	OUTLET VELOCITY (FPS)	PEAK STAGE (FT)	PEAK STAGE (M)
				INLET CONTROL			OUTLET CONTROL HW = H + DTW - LSo											
				D	B	Q/B	HW/D ₍₃₎	HW	k _e	H ₍₁₎	dc ₍₂₎	(dc+D)/2	TW	DTW				
25	42.4	3.0	N/A	N/A	1.10	3.30	0.2	1.00	2.10	2.55	4.12	4.12	4.68	0.44	3.30	6.00	141.78	43.21
50	50.2	3.0	N/A	N/A	1.30	3.90	0.2	1.39	2.30	2.65	4.12	4.12	4.68	0.83	3.90	7.10	142.38	43.40
100	59.4	3.0	N/A	N/A	1.50	4.50	0.2	1.95	2.50	2.75	4.12	4.12	4.68	1.39	4.50	8.40	142.98	43.58
500	100.9	3.0	N/A	N/A	2.80	8.40	0.2	5.64	3.00	3.00	4.12	4.12	4.68	5.08	8.40	14.28	146.88	44.77

SUMMARY & RECOMMENDATIONS:

- H @ Outlet Control = $(1 + k_e + (29 \cdot n^2 \cdot L) / R^{1.33}) \cdot ((Q/A)^2 / (2 \cdot g))$ Eq. 3.5 FHWA Hydraulic Design Series 5
- Critical Depth (dc) was found using the FHWA Hydraulic Design Series 5 charts. Note that dc cannot exceed D.
- HW/D for all storm events was found using the FHWA Hydraulic Design Series 5.

Designed by: 0 Checked by: JR

Designed By: GLSP
 Date: 2/18/2019
 Checked By: TAP
 Date: 2/21/2019

Subject: FPID 440274-1-22-01, SR 659 Combee Road
Proposed Cross Drain Headwater Analysis

***ONLY ENTER dc VALUES HERE. DO NOT ENTER IN CHART ABOVE. CHART USES THESE VALUES TO CALCULATE dc FOR CIRCULAR PIPE.**
 Verify that existing flow below is same as existing flow for project cross drain. Change all values in table if flows do not match.

[Figures Start on PDF pg. 218 for the FHWA Hydraulic Design Series 5](#)

Q - 2-ft	HW/D	n = 0.012	1	1.75	2	2.25	2.5	2.75	3	3.5	4
25	1.10	42.4 cfs							1.10		
50	1.30	50.2 cfs							1.30		
100	1.50	59.4 cfs							1.50		
500	2.80	100.9 cfs							2.80		

[Figures Start on PDF pg. 218 for the FHWA Hydraulic Design Series 5](#)

Q - 2-ft	dc	n = 0.012	1	1.75	2	2.25	2.5	2.75	3	3.5	4
25	2.10	42.4 cfs							2.10		
50	2.30	50.2 cfs							2.30		
100	2.50	59.4 cfs							2.50		
500	3.00	100.9 cfs							3.00		

Subject: FPID 440274-1-22-01, SR 659 Combee Road
Cross Drain Analysis (MP 0.215) Alternative 2

Structure Number:
Station:

Existing Cross Drain

Culvert Height/Pipe Size: (D)	2.00 ft	(24-in Pipe)
Culvert Depth:	N/A	
Number of pipes:	2	
Pipe Type:	RCP	
Outfall:	Ditch	
Flow Direction:	West	
Culvert Length:	136.95 ft	
Upstream Invert El.:	143.96 ft	
Downstream Invert El.:	141.72 ft	
Pipe Slope (ft/ft):	0.0164	
Road Pop-Over El.:	142.95 ft	
Basin Pop-Over El.:	N/A	(Rough Approximation)

Proposed Cross Drain

Culvert Height/Pipe Size: (D)	2.00 ft	(24-in Pipe)
Culvert Depth:	N/A	
Number of pipes:	2	
Pipe Type:	RCP	
Outfall:	Ditch	
Flow Direction:	West	
Upstream End Treatment:	ST- EW	(If using a metered-end section, enter MES as text)
Downstream End Treatment	ST- EW	(If using a metered-end section, enter MES as text)
Culvert Length:	139.78 ft	
Upstream Invert El.:	143.96 ft	
Downstream Invert El.:	141.70 ft	
Pipe Slope (ft/ft):	0.0162	
Road Pop-Over EL:	143.00	
Basin Pop-Over El.:	N/A	

Proposed Typical Section:

Number of Lanes:	1	
Lane Width:	85.2 ft	(FDM 122.5.2.1)
Required Clear Zone:	0.0 ft	(FDM 215.2.3, See FDM Table 215.2.1)
Median Width:	42.6 ft	
Additional Clearance:	5.0 ft	

Subject: FPID 440274-1-22-01, SR 659 Combee Road
Existing Cross Drain Method 1: Flow Rate Calculations

DETERMINATION OF FLOW RATES (Q) USING Q = VA

Cross Drain Characteristics

Culvert Size: (D) 2.00 ft
 (B) N/A
 Cross-Sectional Area: 6.28 sf
 Culvert Length: 136.95 ft

Estimated Discharge (Q)

*Estimated Stream Velocity: **6.00 fps**

Q (25 yr) = *Cross-Sect. Area x V X 2 = 37.699
 Q (100 yr) = *1.4 x Q (25 yr) = 52.779
 Q (500 yr) = *1.7 x Q (100 yr) = 89.724

*Method 1 from Drainage Design Guide, Section 4.7.1 This is a conservative estimate for the velocity of a 25-yr Storm Event (pipe may have been designed originally with this velocity at 50-yr Storm Event).

Log Interpolated Q (50 yr):

$$Q (50 yr) = (\text{Log} (Q[100 yr]) - (\text{Log}(100) - \text{Log}(50)) \frac{(\text{Log} (Q[100 yr]) - \text{Log} (Q[25 yr]))}{(\text{Log}(100) - \text{Log}(25))}) = **$$

$$= \text{Log} (Q[50 yr]) \implies 10^{\text{Log} (Q[50 yr])} = 44.606**$$

***It does not matter whether natural log or log 10 is used*

Q (25 yr) =	37.7 cfs
Q (50 yr) =	44.6 cfs
Q (100 yr) =	52.8 cfs
Q (500 yr) =	89.7 cfs

Subject: FPID 440274-1-22-01, SR 659 Combee Road
Existing Cross Drain Headwater Analysis

CROSS DRAIN CHARACTERISTICS

Culvert Size: (D) 2.00 ft
(B) N/A
Culvert Length: 136.95 ft
Pipe X-Sectional Area: 3.14 sf
Wetted Perimeter: 6.28 ft
Pipe Hydraulic Radius: 0.50 ft
Upstream Invert: 143.96 ft
Downstream Invert: 141.72 ft
Road Pop-Over Elevation: 142.95 ft
Allowable HW Elevation: 141.25 ft (Edge of Pavement)

Pipe Type: RCP
Number of pipes: 2
Outfall: Ditch
Flow Direction: West
Manning's roughness: 0.012 (FDOT Drainage Design Guide Table B-1)
Entrance Coefficient (ke): 0.2 (Table C.2. Entrance Loss Coefficients FHWA Hydraulic design Series 5)

FLOW RATES (Q), Q = VA

Q (25 yr) = 37.7 cfs
Q (50 yr) = 44.6 cfs
Q (100 yr) = 52.8 cfs
Q (500 yr) = 89.7 cfs

TAILWATER

The crown of the outlet elevation was used for the tailwater elevations as follows:

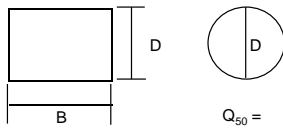
TW (25 yr) = 143.72 ft
TW (50 yr) = 143.72 ft
TW (100 yr) = 143.72 ft
TW (500 yr) = 143.72 ft

Subject: FPID 440274-1-22-01, SR 659 Combee Road
Existing Cross Drain Headwater Analysis

WORKSHEET FOR CULVERT CAPACITY CALCULATIONS
 FIGURE 8-2 (FDOT DRAINAGE MANUAL VOL. 2)

PROJECT: FPID 440274-1-22-01, SR 659 Combee Road
Existing Cross Drain Headwater Analysis

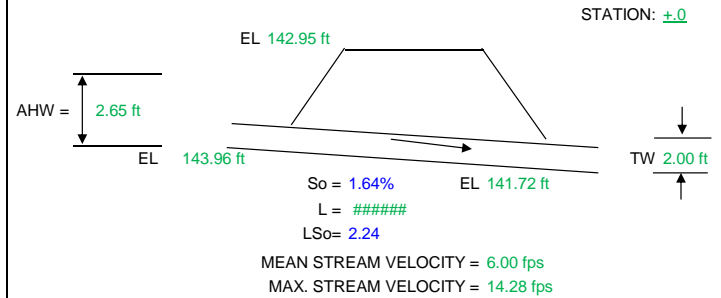
HYDROLOGIC AND CHANNEL INFORMATION



D = Diameter or Height
 B = Span

Q₅₀ = 22.3 cfs TW₅₀ = 143.72 ft
 Q₁₀₀ = 26.4 cfs TW₁₀₀ = 143.72 ft
 (Q1 = DESIGN DISCHARGE, SAY Q50)
 (Q2 = CHECK DISCHARGE, SAY Q100)

SKETCH



CULVERT DESCRIPTION (ENTRANCE TYPE)	Q (CFS) (PER PIPE)	SIZE (FT)		HEADWATER COMPUTATIONS										CON-TROLLING HW	OUTLET VELOCITY (FPS)	PEAK STAGE (FT)	PEAK STAGE (M)	
				INLET CONTROL			OUTLET CONTROL											
				D	B	Q/B	HW/D ₍₃₎	HW	k _e	H ₍₁₎	dc ₍₂₎	(dc+D)/2	TW					DTW
25	18.8	2.0	N/A	N/A	0.00	0.00	0.2	1.47	0.00	1.00	2.00	2.00	2.24	1.23	1.23	6.00	145.19	44.26
50	22.3	2.0	N/A	N/A	0.00	0.00	0.2	2.06	0.00	1.00	2.00	2.00	2.24	1.82	1.82	7.10	145.78	44.44
100	26.4	2.0	N/A	N/A	0.00	0.00	0.2	2.89	0.00	1.00	2.00	2.00	2.24	2.65	2.65	8.40	146.61	44.69
500	44.9	2.0	N/A	N/A	0.00	0.00	0.2	8.35	0.00	1.00	2.00	2.00	2.24	8.11	8.11	14.28	152.07	46.35

SUMMARY & RECOMMENDATIONS:

- H @ Outlet Control = $(1 + k_e + (29 \cdot n^2 \cdot L) / R^{1.33}) \cdot ((Q/A)^2 / (2 \cdot g))$ Eq. 3.5 FHWA Hydraulic Design Series 5
- Critical Depth (dc) was found using the FHWA Hydraulic Design Series 5 charts. Note that dc cannot exceed D.
- HW/D for all storm events was found using the FHWA Hydraulic Design Series 5.

Designed by: MGB

Checked by: TAP

Designed By: MGB
 Date: 11/2/2020
 Checked By: TAP
 Date: 11/2/2020

Subject: FPID 440274-1-22-01, SR 659 Combee Road
Existing Cross Drain Headwater Analysis

***ONLY ENTER dc VALUES HERE. DO NOT ENTER IN CHART ABOVE. CHART USES THESE VALUES TO CALCULATE dc FOR CIRCULAR PIPE.**

Verify that existing flow below is same as existing flow for project cross drain. Change all values in table if flows do not match.

[Figures Start on PDF pg. 218 for the FHWA Hydraulic Design Series 5](#)

Q - 2-ft	HW/D	n = 0.012	1	1.75	2	2.25	2.5	2.75	3	3.5	4
25	0.00	37.7 cfs							1.10		
50	0.00	44.6 cfs							1.30		
100	0.00	52.8 cfs							1.50		
500	0.00	89.7 cfs							2.80		

[Figures Start on PDF pg. 218 for the FHWA Hydraulic Design Series 5](#)

Q - 2-ft	dc	n = 0.012	1	1.75	2	2.25	2.5	2.75	3	3.5	4
25	0.00	37.7 cfs							2.10		
50	0.00	44.6 cfs							2.30		
100	0.00	52.8 cfs							2.50		
500	0.00	89.7 cfs							3.00		

Subject: FPID 440274-1-22-01, SR 659 Combee Road
Proposed Cross Drain Headwater Analysis

CROSS DRAIN CHARACTERISTICS

Culvert Size: (D) 2.00 ft
(B) N/A
Culvert Length: 139.78 ft
Pipe X-Sectional Area: 3.14 sf
Wetted Perimeter: 6.28 ft
Pipe Hydraulic Radius: 0.50 ft
Upstream Invert: 143.96 ft
Downstream Invert: 141.70 ft
Road Pop-Over Elevation: 143.00 ft
Allowable HW Elevation: 141.30 ft (Edge of Pavement)

Pipe Type: RCP
Number of pipes: 2
Outfall: Ditch
Flow Direction: West
Manning's roughness: 0.012 (FDOT Drainage Design Guide Table B-1)
Entrance Coefficient (ke): 0.2 (Table C.2. Entrance Loss Coefficients FHWA Hydraulic design Series 5)

FLOW RATES (Q), Q = VA

Q (25 yr) = 37.7 cfs
Q (50 yr) = 44.6 cfs
Q (100 yr) = 52.8 cfs
Q (500 yr) = 89.7 cfs

TAILWATER

Tailwater from existing conditions.

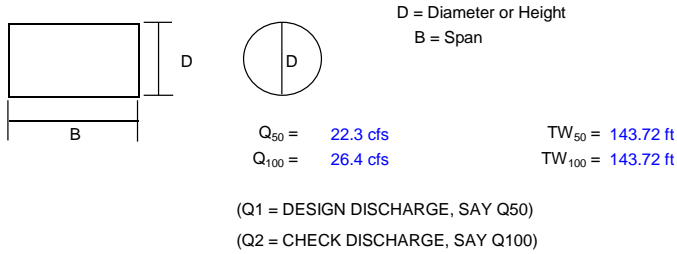
TW (25 yr) = 143.72 ft
TW (50 yr) = 143.72 ft
TW (100 yr) = 143.72 ft
TW (500 yr) = 143.72 ft

Subject: FPID 440274-1-22-01, SR 659 Combee Road
Proposed Cross Drain Headwater Analysis

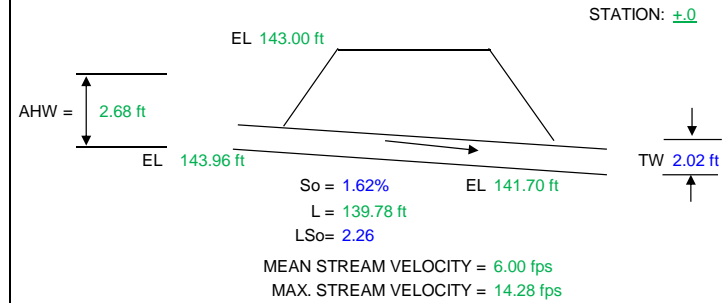
WORKSHEET FOR CULVERT CAPACITY CALCULATIONS
FIGURE 8-2 (FDOT DRAINAGE MANUAL VOL. 2)

PROJECT: FPID 440274-1-22-01, SR 659 Combee Road
Proposed Cross Drain Headwater Analysis

HYDROLOGIC AND CHANNEL INFORMATION



SKETCH



CULVERT DESCRIPTION (ENTRANCE TYPE)	Q (CFS) (PER PIPE)	SIZE (FT)		HEADWATER COMPUTATIONS											CON-TROLLING HW	OUTLET VELOCITY (FPS)	PEAK STAGE (FT)	PEAK STAGE (M)
				INLET CONTROL			OUTLET CONTROL $HW = H + DTW - LSo$											
				D	B	Q/B	HW/D ₍₃₎	HW	k_e	$H_{(1)}$	$dc_{(2)}$	$(dc+D)/2$	TW	DTW				
25	18.8	2.0	N/A	N/A	0.00	0.00	0.2	1.49	0.00	1.00	2.02	2.02	2.26	1.25	1.25	6.00	145.21	44.26
50	22.3	2.0	N/A	N/A	0.00	0.00	0.2	2.09	0.00	1.00	2.02	2.02	2.26	1.85	1.85	7.10	145.81	44.44
100	26.4	2.0	N/A	N/A	0.00	0.00	0.2	2.92	0.00	1.00	2.02	2.02	2.26	2.68	2.68	8.40	146.64	44.69
500	44.9	2.0	N/A	N/A	0.00	0.00	0.2	8.45	0.00	1.00	2.02	2.02	2.26	8.21	8.21	14.28	152.17	46.38

SUMMARY & RECOMMENDATIONS:

- H @ Outlet Control = $(1 + k_e + (29 \cdot n^2 \cdot L) / R^{1.33}) \cdot ((Q/A)^2 / (2 \cdot g))$ Eq. 3.5 FHWA Hydraulic Design Series 5
- Critical Depth (dc) was found using the FHWA Hydraulic Design Series 5 charts. Note that dc cannot exceed D.
- HW/D for all storm events was found using the FHWA Hydraulic Design Series 5.

Designed by: 0

Checked by: JR

Designed By: MGB
 Date: 11/2/2020
 Checked By: TAP
 Date: 11/2/2020

Subject: FPID 440274-1-22-01, SR 659 Combee Road
Proposed Cross Drain Headwater Analysis

***ONLY ENTER dc VALUES HERE. DO NOT ENTER IN CHART ABOVE. CHART USES THESE VALUES TO CALCULATE dc FOR CIRCULAR PIPE.**
 Verify that existing flow below is same as existing flow for project cross drain. Change all values in table if flows do not match.

Figures Start on PDF pg. 218 for the FHWA Hydraulic Design Series 5

Q - 2-ft	HW/D	n = 0.012	1	1.75	2	2.25	2.5	2.75	3	3.5	4
25	0.00	37.7 cfs							1.10		
50	0.00	44.6 cfs							1.30		
100	0.00	52.8 cfs							1.50		
500	0.00	89.7 cfs							2.80		

Figures Start on PDF pg. 218 for the FHWA Hydraulic Design Series 5

Q - 2-ft	dc	n = 0.012	1	1.75	2	2.25	2.5	2.75	3	3.5	4
25	0.00	37.7 cfs							2.10		
50	0.00	44.6 cfs							2.30		
100	0.00	52.8 cfs							2.50		
500	0.00	89.7 cfs							3.00		

Subject: FPID 440274-1-22-01, SR 659 Combee Road
Cross Drain Analysis (MP 1.323) Alternative 2

Structure Number:
Station:

Existing Cross Drain

Culvert Height/Pipe Size: (D)	3.00 ft	(36-in Pipe)
Culvert Depth:	N/A	
Number of pipes:	1	
Pipe Type:	RCP	
Outfall:	Wetland	
Flow Direction:	East	
Culvert Length:	72.40 ft	
Upstream Invert El.:	138.48 ft	
Downstream Invert El.:	134.92 ft	
Pipe Slope (ft/ft):	0.0492	
Road Pop-Over El.:	142.95 ft	
Basin Pop-Over El.:	N/A	(Rough Approximation)

Proposed Cross Drain

Culvert Height/Pipe Size: (D)	3.00 ft	(36-in Pipe)
Culvert Depth:	N/A	
Number of pipes:	1	
Pipe Type:	RCP	
Outfall:	Wetland	
Flow Direction:	East	
Upstream End Treatment:	ST- EW	(If using a metered-end section, enter MES as text)
Downstream End Treatment	ST- EW	(If using a metered-end section, enter MES as text)
Culvert Length:	103.00 ft	
Upstream Invert El.:	138.48 ft	
Downstream Invert El.:	133.40 ft	
Pipe Slope (ft/ft):	0.0493	
Road Pop-Over EL:	143.00	
Basin Pop-Over El.:	N/A	

Proposed Typical Section:

Number of Lanes:	2	
Lane Width:	12.0 ft	(FDM 122.5.2.1)
Required Clear Zone:	0.0 ft	(FDM 215.2.3, See FDM Table 215.2.1)
Median Width:	13.0 ft	
Additional Clearance:	32.0 ft	

Subject: FPID 440274-1-22-01, SR 659 Combee Road
Existing Cross Drain Method 1: Flow Rate Calculations

DETERMINATION OF FLOW RATES (Q) USING Q = VA

Cross Drain Characteristics

Culvert Size: (D) 3.00 ft
 (B) N/A
 Cross-Sectional Area: 7.07 sf
 Culvert Length: 72.40 ft

Estimated Discharge (Q)

*Estimated Stream Velocity: **6.00 fps**

Q (25 yr) = *Cross-Sect. Area x V = 42.412
 Q (100 yr) = *1.4 x Q (25 yr) = 59.376
 Q (500 yr) = *1.7 x Q (100 yr) = 100.939

*Method 1 from Drainage Design Guide, Section 4.7.1 This is a conservative estimate for the velocity of a 25-yr Storm Event (pipe may have been designed originally with this velocity at 50-yr Storm Event).

Log Interpolated Q (50 yr):

$$Q (50 \text{ yr}) = (\text{Log} (Q[100 \text{ yr}]) - (\text{Log}(100) - \text{Log}(50)) \frac{(\text{Log} (Q[100 \text{ yr}]) - \text{Log} (Q[25 \text{ yr}])))}{(\text{Log}(100) - \text{Log}(25))} = **$$

$$= \text{Log} (Q[50 \text{ yr}]) \implies 10^{\text{Log} (Q[50 \text{ yr}])} = 50.182**$$

***It does not matter whether natural log or log 10 is used*

Q (25 yr) =	42.4 cfs
Q (50 yr) =	50.2 cfs
Q (100 yr) =	59.4 cfs
Q (500 yr) =	100.9 cfs

Subject: FPID 440274-1-22-01, SR 659 Combee Road
Existing Cross Drain Headwater Analysis

CROSS DRAIN CHARACTERISTICS

Culvert Size: (D) 3.00 ft
(B) N/A
Culvert Length: 72.40 ft
Pipe X-Sectional Area: 7.07 sf
Wetted Perimeter: 9.42 ft
Pipe Hydraulic Radius: 0.75 ft
Upstream Invert: 138.48 ft
Downstream Invert: 134.92 ft
Road Pop-Over Elevation: 142.95 ft
Allowable HW Elevation: 142.71 ft (Edge of Pavement)

Pipe Type: RCP
Number of pipes: 1
Outfall: Wetland
Flow Direction: East
Manning's roughness: 0.012 (FDOT Drainage Design Guide Table B-1)
Entrance Coefficient (ke): 0.2 (Table C.2. Entrance Loss Coefficients FHWA Hydraulic design Series 5)

FLOW RATES (Q), Q = VA

Q (25 yr) = 42.4 cfs
Q (50 yr) = 50.2 cfs
Q (100 yr) = 59.4 cfs
Q (500 yr) = 100.9 cfs

TAILWATER

The crown of the outlet elevation was used for the tailwater elevations as follows:

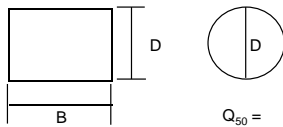
TW (25 yr) = 137.92 ft
TW (50 yr) = 137.92 ft
TW (100 yr) = 137.92 ft
TW (500 yr) = 137.92 ft

Subject: FPID 440274-1-22-01, SR 659 Combee Road
Existing Cross Drain Headwater Analysis

WORKSHEET FOR CULVERT CAPACITY CALCULATIONS
 FIGURE 8-2 (FDOT DRAINAGE MANUAL VOL. 2)

PROJECT: FPID 440274-1-22-01, SR 659 Combee Road
Existing Cross Drain Headwater Analysis

HYDROLOGIC AND CHANNEL INFORMATION

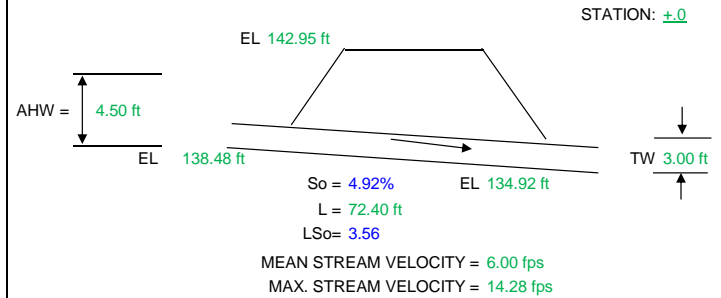


D = Diameter or Height
 B = Span

$Q_{50} = 50.2$ cfs $TW_{50} = 137.92$ ft
 $Q_{100} = 59.4$ cfs $TW_{100} = 137.92$ ft

(Q1 = DESIGN DISCHARGE, SAY Q50)
 (Q2 = CHECK DISCHARGE, SAY Q100)

SKETCH



CULVERT DESCRIPTION (ENTRANCE TYPE)	Q (CFS) (PER PIPE)	SIZE (FT)		HEADWATER COMPUTATIONS											CON-TROLLING HW	OUTLET VELOCITY (FPS)	PEAK STAGE (FT)	PEAK STAGE (M)
				INLET CONTROL			OUTLET CONTROL											
				D	B	Q/B	HW/D ₍₃₎	HW	k_e	$H_{(1)}$	$dc_{(2)}$	$(dc+D)/2$	TW	DTW				
25	42.4	3.0	N/A	N/A	1.10	3.30	0.2	0.92	2.10	2.55	3.00	3.00	3.56	0.36	3.30	6.00	141.78	43.21
50	50.2	3.0	N/A	N/A	1.30	3.90	0.2	1.29	2.30	2.65	3.00	3.00	3.56	0.73	3.90	7.10	142.38	43.40
100	59.4	3.0	N/A	N/A	1.50	4.50	0.2	1.80	2.50	2.75	3.00	3.00	3.56	1.24	4.50	8.40	142.98	43.58
500	100.9	3.0	N/A	N/A	2.80	8.40	0.2	5.20	3.00	3.00	3.00	3.00	3.56	4.64	8.40	14.28	146.88	44.77

SUMMARY & RECOMMENDATIONS:

- H @ Outlet Control = $(1 + k_e + (29 \cdot n^2 \cdot L) / R^{1.33}) \cdot ((Q/A)^2 / (2 \cdot g))$ Eq. 3.5 FHWA Hydraulic Design Series 5
- Critical Depth (dc) was found using the FHWA Hydraulic Design Series 5 charts. Note that dc cannot exceed D.
- HW/D for all storm events was found using the FHWA Hydraulic Design Series 5.

Designed by: GLSP

Checked by: TAP

Designed By: GLSP
 Date: 2/18/2019
 Checked By: TAP
 Date: 2/21/2019

Subject: FPID 440274-1-22-01, SR 659 Combee Road
Existing Cross Drain Headwater Analysis

***ONLY ENTER dc VALUES HERE. DO NOT ENTER IN CHART ABOVE. CHART USES THESE VALUES TO CALCULATE dc FOR CIRCULAR PIPE.**

Verify that existing flow below is same as existing flow for project cross drain. Change all values in table if flows do not match.

[Figures Start on PDF pg. 218 for the FHWA Hydraulic Design Series 5](#)

Q - 2-ft	HW/D	n = 0.012	1	1.75	2	2.25	2.5	2.75	3	3.5	4
25	1.10	42.4 cfs							1.10		
50	1.30	50.2 cfs							1.30		
100	1.50	59.4 cfs							1.50		
500	2.80	100.9 cfs							2.80		

[Figures Start on PDF pg. 218 for the FHWA Hydraulic Design Series 5](#)

Q - 2-ft	dc	n = 0.012	1	1.75	2	2.25	2.5	2.75	3	3.5	4
25	2.10	42.4 cfs							2.10		
50	2.30	50.2 cfs							2.30		
100	2.50	59.4 cfs							2.50		
500	3.00	100.9 cfs							3.00		

Subject: FPID 440274-1-22-01, SR 659 Combee Road
Proposed Cross Drain Headwater Analysis

CROSS DRAIN CHARACTERISTICS

Culvert Size: (D) 3.00 ft
(B) N/A
Culvert Length: 103.00 ft
Pipe X-Sectional Area: 7.07 sf
Wetted Perimeter: 9.42 ft
Pipe Hydraulic Radius: 0.75 ft
Upstream Invert: 138.48 ft
Downstream Invert: 133.40 ft
Road Pop-Over Elevation: 143.00 ft
Allowable HW Elevation: 142.76 ft (Edge of Pavement)

Pipe Type: RCP
Number of pipes: 1
Outfall: Wetland
Flow Direction: East
Manning's roughness: 0.012 (FDOT Drainage Design Guide Table B-1)
Entrance Coefficient (ke): 0.2 (Table C.2. Entrance Loss Coefficients FHWA Hydraulic design Series 5)

FLOW RATES (Q), Q = VA

Q (25 yr) = 42.4 cfs
Q (50 yr) = 50.2 cfs
Q (100 yr) = 59.4 cfs
Q (500 yr) = 100.9 cfs

TAILWATER

Tailwater from existing conditions.

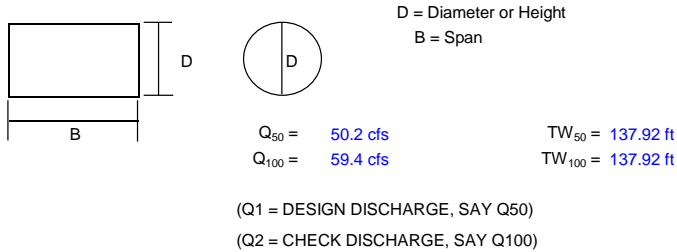
TW (25 yr) = 137.92 ft
TW (50 yr) = 137.92 ft
TW (100 yr) = 137.92 ft
TW (500 yr) = 137.92 ft

Subject: FPID 440274-1-22-01, SR 659 Combee Road
Proposed Cross Drain Headwater Analysis

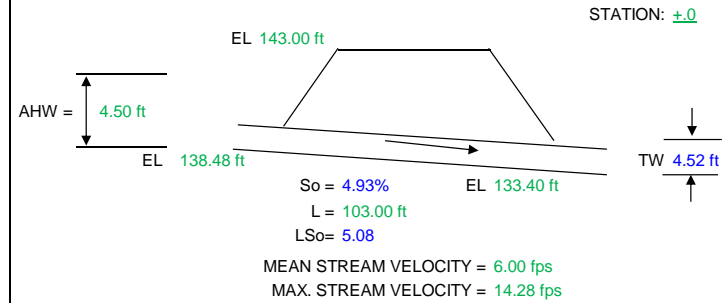
WORKSHEET FOR CULVERT CAPACITY CALCULATIONS
FIGURE 8-2 (FDOT DRAINAGE MANUAL VOL. 2)

PROJECT: FPID 440274-1-22-01, SR 659 Combee Road
Proposed Cross Drain Headwater Analysis

HYDROLOGIC AND CHANNEL INFORMATION



SKETCH



CULVERT DESCRIPTION (ENTRANCE TYPE)	Q (CFS) (PER PIPE)	SIZE (FT)		HEADWATER COMPUTATIONS											CON-TROLLING HW	OUTLET VELOCITY (FPS)	PEAK STAGE (FT)	PEAK STAGE (M)
				INLET CONTROL			OUTLET CONTROL $HW = H + DTW - LS_o$											
				D	B	Q/B	HW/D ₍₃₎	HW	k_e	$H_{(1)}$	$dc_{(2)}$	$(dc+D)/2$	TW	DTW				
25	42.4	3.0	N/A	N/A	1.10	3.30	0.2	1.02	2.10	2.55	4.52	4.52	5.08	0.46	3.30	6.00	141.78	43.21
50	50.2	3.0	N/A	N/A	1.30	3.90	0.2	1.43	2.30	2.65	4.52	4.52	5.08	0.87	3.90	7.10	142.38	43.40
100	59.4	3.0	N/A	N/A	1.50	4.50	0.2	2.01	2.50	2.75	4.52	4.52	5.08	1.45	4.50	8.40	142.98	43.58
500	100.9	3.0	N/A	N/A	2.80	8.40	0.2	5.80	3.00	3.00	4.52	4.52	5.08	5.24	8.40	14.28	146.88	44.77

SUMMARY & RECOMMENDATIONS:

- H @ Outlet Control = $(1 + k_e + (29 \cdot n^2 \cdot L) / R^{1.33}) \cdot ((Q/A)^2 / (2 \cdot g))$ Eq. 3.5 FHWA Hydraulic Design Series 5
- Critical Depth (dc) was found using the FHWA Hydraulic Design Series 5 charts. Note that dc cannot exceed D.
- HW/D for all storm events was found using the FHWA Hydraulic Design Series 5.

Designed by: 0 _____

Checked by: JR _____

Designed By: GLSP
 Date: 2/18/2019
 Checked By: TAP
 Date: 2/21/2019

Subject: FPID 440274-1-22-01, SR 659 Combee Road
Proposed Cross Drain Headwater Analysis

***ONLY ENTER dc VALUES HERE. DO NOT ENTER IN CHART ABOVE. CHART USES THESE VALUES TO CALCULATE dc FOR CIRCULAR PIPE.**
 Verify that existing flow below is same as existing flow for project cross drain. Change all values in table if flows do not match.

Figures Start on PDF pg. 218 for the FHWA Hydraulic Design Series 5

Q - 2-ft	HW/D	n = 0.012	1	1.75	2	2.25	2.5	2.75	3	3.5	4
25	1.10	42.4 cfs							1.10		
50	1.30	50.2 cfs							1.30		
100	1.50	59.4 cfs							1.50		
500	2.80	100.9 cfs							2.80		

Figures Start on PDF pg. 218 for the FHWA Hydraulic Design Series 5

Q - 2-ft	dc	n = 0.012	1	1.75	2	2.25	2.5	2.75	3	3.5	4
25	2.10	42.4 cfs							2.10		
50	2.30	50.2 cfs							2.30		
100	2.50	59.4 cfs							2.50		
500	3.00	100.9 cfs							3.00		

APPENDIX B

Correspondence

Gretchen Suárez-Peña

From: Corcoran, Brian <BrianCorcoran@polk-county.net>
Sent: Tuesday, February 12, 2019 11:19 AM
To: Gretchen Suárez-Peña
Subject: RE: Floodplain Management _Combee Road

CAUTION: This email originated from outside the organization. Use caution with links and attachments.

Gretchen

Nice talking to you this morning, per our conversation based upon the un-numbered A flood zone located to the east of Crystal Lake Drive N if a copy of the modeling and resulting BFE could be provided to the county when the study is completed that would be great.

Thanks

Brian Corcoran CFM
Floodplain Manager
Polk County Board of County Commissioners
330 W. Church St. Drawer GM03
P.O. Box 9005
Bartow, FL 33831-9005

briancorcoran@polk-county.net
Phone (863) 534-6765
Fax (863) 534-7646

From: Gretchen Suárez-Peña <Gretchen.Suarez-Pena@patelgreene.com>
Sent: Tuesday, February 12, 2019 9:22 AM
To: Corcoran, Brian <BrianCorcoran@polk-county.net>
Cc: Irvén, Phil <PhillIrvén@polk-county.net>; Matt Dockins <mdockins@rkk.com>; Garau, Michael <Michael.Garau@kimley-horn.com>; Timothy Polk <Tim.Polk@patelgreene.com>
Subject: [EXTERNAL]: RE: Floodplain Management _Combee Road

Hi Brian,

I tried calling you today and last week to speak about the Combee Road project. It seems we are playing a little bit of phone tag. Please feel free to call me. My contact information is below. I'll be in the office today until 2pm.

Thanks,

Gretchen L. Suárez-Peña, PE
Senior Drainage Engineer

Patel, Greene & Associates, PLLC (PGA)
215 East Main Street | Bartow, FL 33830
Office: [1-863-533-7317](tel:1-863-533-7317) Ext. 202 | Cell: [1-863-670-6380](tel:1-863-670-6380) | Email: gretchen@patelgreene.com

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From: Gretchen Suárez-Peña
Sent: Tuesday, February 5, 2019 1:21 PM
To: 'BrianCorcoran@polk-county.net' <BrianCorcoran@polk-county.net>
Cc: Irven, Phil <Phillrven@polk-county.net>; 'Matt Dockins' <mdockins@rkk.com>; 'Garau, Michael' <Michael.Garau@kimley-horn.com>; Timothy Polk <Tim.Polk@patelgreene.com>
Subject: Floodplain Management _ Combee Road

Hi Brian,

I am the drainage engineer on record for a Project Development and Engineering Study of Combee Road. The study evaluates the proposed widening of SR 659 (Combee Road) from US 98 to North Crystal Lake Drive in Polk County. As part of the Location Hydraulics Report, we want to document coordination with the Polk County Floodplain Management to ensure that the project is consistent with any floodplain plans and to have you provide any floodplain concerns for the area.

At this time, the FDOT is proposing to widen Combee Road using a three-lane typical section consisting of a two-way left turn lane and one travel lane in each direction. The typical section includes seven-foot wide buffered bicycle lanes, curb and gutter, and six-foot wide sidewalks on both sides. Dedicated right turn lanes will be provided at the intersections of US 98, Commerce Point Drive, South Crystal Lake Drive, and North Crystal Lake Drive to help ease congestion.

The only designated FEMA floodplain in the area is located at and around Crystal Lake at the northern limits of the project (FIRM 12105C0320G, dated 12/22/2016). At this time, there are no significant encroachments into the base floodplain along the project or of Crystal Lake and the project will not affect any floodplain values.

Your response to this email with any comments or concerns would be greatly appreciated.

Kind regards,

Gretchen L. Suárez-Peña, PE
Senior Drainage Engineer

Patel, Greene & Associates, PLLC (PGA)
215 East Main Street | [Bartow, FL 33830](#)
Office: [1-863-533-7317](tel:1-863-533-7317) Ext. 202 | Cell: 1-863-670-6380 | Email: gretchen@patelgreene.com

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