SR 400 (I-4) Project Development and Environment (PD&E) Study
FM No.: 432100-1-22-01

Location Hydraulic Report

Segment 2: State Road 400 (SR 400)/Interstate 4 (I-4) from West of SR 528 (Beachline Expressway) to West of SR 435 (Kirkman Road)

Orange County (75280), Florida

August, 2016

HNTB Corporation
610 Crescent Executive Court
Suite 400
Lake Mary, FL 32746

Professional Engineer Certificate

I hereby certify that I am a registered professional engineer in the State of Florida practicing with HNTB Corporation, Inc., a corporation authorized to operate as an engineering business, EB#6500, by the State of Florida, Department of Professional Regulation, Board of Professional Engineers, and that I have reviewed or approved the evaluation, findings, opinions, conclusions, or technical advice hereby reported for SR 400 (I-4) Project Development and Environment Study for the Florida Department of Transportation in Orange County, Florida.

This Location Hydraulic Report (LHR) includes a summary of data collection efforts, floodplain impact estimates, limited cross drain evaluations, and an overall drainage review prepared for the conceptual analyses for the State Road 400 (SR 400)/Interstate 4 (I-4), from West of SR 528 (Beachline Expressway) to West of SR 435 (Kirkman Road) in Orange County.

I acknowledge that the procedures and references used to develop the results contained in this report are standard to the professional practice of transportation engineering and planning as applied through professional judgments and experience. This document is for planning purposes only and is not to replace any effort required for final design.

SIGNATURE: ______________________________________

NAME: Sanam Rai, P.E.

FIRM: HNTB Corporation

P.E. No.: 69089

DATE: August 2016

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

1.0 Introduction

I-4 is an integral part of Central Florida's transportation system. The Interstate carries the greatest number of people and vehicles of any transportation facility in the region and serves many of the area's primary activity centers. When the Interstate opened in February 1965, it was designed to serve intrastate and interstate travel by providing a critical link between the east and west coasts of Central Florida. Although this role continues to be a crucial transportation function of I-4, the highway has evolved to one that serves many shorter trips. Today, the highway serves as the primary link between hotel/motel complexes and tourist attractions such as Walt Disney World, Universal Studios, Sea World, the International Drive Resort Area and downtown Orlando. In addition, since I-4 is the only north-south limited access facility that is centrally located between the predominant employment centers and the major suburbs to the north, it has become the primary commuting corridor in the Central Florida metropolitan area.

Tremendous growth in Central Florida over the past decades has made it difficult for the transportation system to accommodate travel demand. A significant amount of this growth is occurring within close proximity to I-4. In recent years, congestion on I-4 has extended well beyond normal peak hours and major crashes have closed the highway, resulting in traffic congestion throughout the metropolitan area. Congestion and delays on I-4 and the parallel arterial highways are now considered to be major transportation problems facing the region. The congestion on I-4 is further evidenced by the less than desirable levels of service on the Interstate as well as the crossroads.

Projections of future population and employment in the region indicate that travel demand will continue to increase well into the future. The ability to accommodate the new travel patterns resulting from growth must be provided to sustain the region's economy. Without the improvements, extremely congested conditions are expected to occur for extended periods of time in both the morning and evening peak periods. Due to these congested conditions, user travel times will continue to increase, the movement of goods through the urban area will be slower, and the deliveries of goods within the urban area will be forced to other times throughout the day.

The need for improvements to I-4 is illustrated by the important transportation roles I-4 serves to the Central Florida region and the State of Florida. If no improvements are made to the Interstate, a loss in mobility for the area's residents, visitors, and employees can be expected, resulting in a severe threat to the continued viability of the economy and the quality of life.

This reevaluation project involves revising the original design concept showing two (2) High Occupancy Vehicle (HOV) lanes to four (4) Express Lanes as recommended in the Environmental Impact Statement (EIS) for I-4 from SR 528 to SR 472. The Express Lanes are tolled lanes and will extend the full length of the project. The access to/from the tolled lanes will be evaluated as part of this effort to determine if changes are needed from the previously approved concept for access to/from the HOV Lanes. The original I-4 PD&E Studies involved physical separation between the HOV lanes and the general use lanes on I-4. Additionally, a demand management tool was proposed during the EIS phase of the project to control the use of the lanes by requiring a minimum number of occupants per vehicle in order to maintain an acceptable level of service (Level of Service D).

This reevaluation addresses revising the demand management tool to convert the HOV lanes to tolled Express Lanes. A variable pricing tolling plan is proposed. The tolls will vary by time of day and day of week to maintain acceptable levels of service in the Express Lanes. The tolls will be collected electronically through existing E-Pass, SunPass and other systems currently in place in the Orlando metropolitan area. The conversion to Express Lanes will maintain the same right of way limits as documented previously and will not change the impacts to the social, natural or physical environment.

A Systems Access Modification Report (SAMR) update is also being performed concurrent with the reevaluation and is expected to be completed by April 2015.

The primary objective of this Location Hydraulic Report (LHR) is to evaluate the hydraulic conditions along this proposed corridor in the existing and proposed conditions. This evaluation shall be accomplished by assessing and quantifying all floodplain impacts and providing recommendations to offset any impacts. The results of this evaluation will provide FDOT with the information necessary to reach a decision on the type, design, and location of improvements that are required for the widening of SR 400 (I-4).

This report has been prepared in accordance with the requirements set forth in Executive Order 11988, "Floodplain Management", US DOT Order 5650.2, "Floodplain Management and Protection", and Federal-Aid Policy Guide 23 CFR 650A. The intent of these regulations is to avoid or minimize roadway encroachments within the 100-year (base) floodplain, where practicable, and to avoid supporting land use development, which is incompatible with floodplain values. This report provides preliminary information on designated floodplains, cross culverts and potential floodplain impacts of the project on these areas.

General information regarding basin delineation, cross culvert location and culvert parameters used in the preparation of this report include the following:

- Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) for Orange County No. 12095C0405F AND 12095C0415F (Figure 6)
- US Department of Agriculture (USDA) Soils Conservation Service (SCS) Soils Survey for Orange County (Figure 2)
- US Geological Survey (USGS) Quadrangle Map (Figure 3)
- Florida Department of Transportation (FDOT) PD&E Manual, Part 2, Chapter 24 (revised January 2008)
- FDOT Drainage Manual (2015)
- 2014 SFWMD Basis of Review for Environmental Resource (ERP BOR)
- Existing Construction Plans
- Various Existing Permits
- Site Investigation

2.0 Project Description and Purpose

The Florida Department of Transportation (FDOT) is proposing to reconstruct and widen I-4 as part of the I-4 Ultimate concept. This involves the build-out of I-4 to its ultimate condition through Central Florida, including segments in Polk, Osceola, Orange, Seminole, and Volusia Counties. The concept design proposes the addition of two (2) new express lanes in each direction giving it a total of ten (10) dedicated lanes. The study area in this section from south of SR 528 (Beachline Expressway) to SR 435 (Kirkman Road) includes the interchanges at SR 528, Sand Lake Road, and at Universal Boulevard, and provides for the required stormwater treatment with seventeen (17) existing and proposed pond sites along the corridor (See Figure 1: Project Location Map). The typical section is in the process of being developed, though all efforts are being made to ensure that the design will be contained within the existing right-of-way with the exception of the pond sites. This alignment serves as the basis for the development of the proposed improvements outlined in the Location Hydraulic Report.

2.1 Proposed Recommended Typical Section

The proposed roadway is intended to be an urban principal arterial interstate. The proposed improvements to I-4 include widening the existing six lane divided rural highway to a ten lane barrier separated highway. The existing roadway typical section has three 12-foot travel lanes with 10-foot shoulders in each direction. The existing right-of-way width varies but is typically 300 feet. Two mainline typical sections are proposed for I-4 Segment 2. The typical section from the begin project limits east of Central Florida Parkway to SR 528 includes a 44-foot rail envelope in the median within a minimum 300 foot right of way (6+4 with rail envelope). The typical section from SR 528 to west of SR 435 does not include the rail corridor and also has a proposed minimum 300 foot right of way (6+4 without rail envelope). Both typical sections have a design speed of 70 miles per hour (mph) and will include three 12-foot general use lanes with a 10-foot inside shoulder and a 12-foot outside shoulder (10-foot paved) and two 12-foot express lanes with a 4-foot inside shoulder and a 10-foot outside shoulder, in each direction. A barrier wall between adjacent shoulders will separate the express lanes from the general use lanes. Additionally, up to three auxiliary lanes in either direction of travel will be provided in some areas. Figure 1.2 and Figure 1.3 illustrate the proposed mainline typical sections for I-4 Segment 2.

While the overall typical section remains consistent throughout Segment 2, there are some areas along the I-4 BtU corridor that will have special sections. Special cross sections were developed to meet the needs of the project due to right of way constraints, existing utility easements or other design considerations along the corridor. These special sections may include C-D roads, braided ramp systems, elevated express lanes or elevated general use lanes. Additionally, the median width may vary in certain locations to accommodate changes in the horizontal alignment due to crossroad support structures or other design features. The special sections within the Segment 2 corridor include a C-D system between Central Florida Parkway and SR 528; the eastbound C-D Road is at grade and the westbound C-D Road is elevated. The eastbound C-D Road extends approximately 1.9 miles between SR 528 in Segment 2 and the Daryl Carter Parkway interchange located within Segment 1 of the I-4 BtU corridor. The westbound C-D Road extends approximately 5.9 miles between SR 528 in Segment 2 and the Osceola Parkway interchange located within Segment 1 of the I-4 BtU corridor.

3.0 Design Criteria

The design of stormwater management facilities for this project is governed by the rules and criteria set forth by the South Florida Water Management District (SFWMD) and the FDOT. These criteria were drawn from the 2014 SFWMD Basis of Review for Environmental Resource (ERP BOR) and the 2015 FDOT Drainage Manual.

3.1 Culvert Design

- All cross drains, if applicable, shall be designed to have sufficient hydraulic capacity to convey the 50-year (Design Frequency) storm event. All culverts shall be analyzed for the base flood (100-year).

- Backwater shall not significantly change land use values unless flood rights are purchased.
- The headwater for design frequency conditions shall be kept at or below the travel lanes.
- The highest tailwater elevation, which can be reasonably expected to occur coincident with the design storm event, shall be used (typically, crown of pipe is used).
- The minimum culvert size is 18" or its equivalent size.
- The design of all cross culverts shall comply with the guidelines set forth in the FDOT Drainage Manual, Chapter 4.

3.2 Floodplains/Floodways

- The proposed project may not cause a net reduction in flood storage within the 10-year floodplain.
- Structures shall cause no more than a one-tenth (0.1) of a foot increase in the 100-year flood elevation 500-feet upstream.
- Proposed construction shall not cause a reduction in flood conveyance capabilities.
- Best Management Practices (BMP's) shall be employed to minimize velocity to avoid undue erosion.
- The design of encroachments shall be consistent with standards established by FEMA.

The above criteria were collected from applicable portions of:

- FDOT Drainage Handbook – Culvert Design (January 2004)
- FDOT Drainage Manual (2015)
- FHWA Code of Federal Regulation 23 CFR 650A

Figure 1: Project Location Map

4.0 Site Conditions

This project lies within the jurisdiction of the South Florida Water Management District (SFWMD). Wetlands, wildlife, soils conditions, land use, cross culverts, and floodplains describe the site conditions present within the limits of this study. Involvement within wetlands and impact of wildlife are specifically addressed in two separate reports, "*Wetlands Evaluation Report*" and "*Endangered Species Biological Assessment*" prepared as part of this PD&E Study.

4.1 Soils

The Soil Survey of Orange County, Florida, published by the United States Department of Agriculture (USDA) Soil Conservation Service (SCS) has been reviewed for the project vicinity. There are eleven (11) different soil types located in the project area. Table 1 lists these soil types and their hydric properties. The Soil Survey Map for the project is illustrated in Figure 2.

Table 1: SCS Soil Survey Information

Soil Type	Hydrologic Soil Group
Archbold fine sands	A
Basinger fine sands	A/D
Candler-Apopka fine sands	A
Immokalee fine sands	B/D
Pomello fine sand	A
Smyrna fine sand	A/D
St. Johns fine sand	B/D
St. Lucie fine sand	A
Sanibel Muck	A/D
Smyrna-Urban land complex	A/D
Urban Land	N/A

Based on a review of the Orange County, Florida, United States Geographical Survey (USGS) quadrangle map, the existing ground surface elevations along the project alignment vary approximately from +114 to +139 feet NAVD. A reproduction of the USGS quadrangle map for the project vicinity is shown in Figure 3.

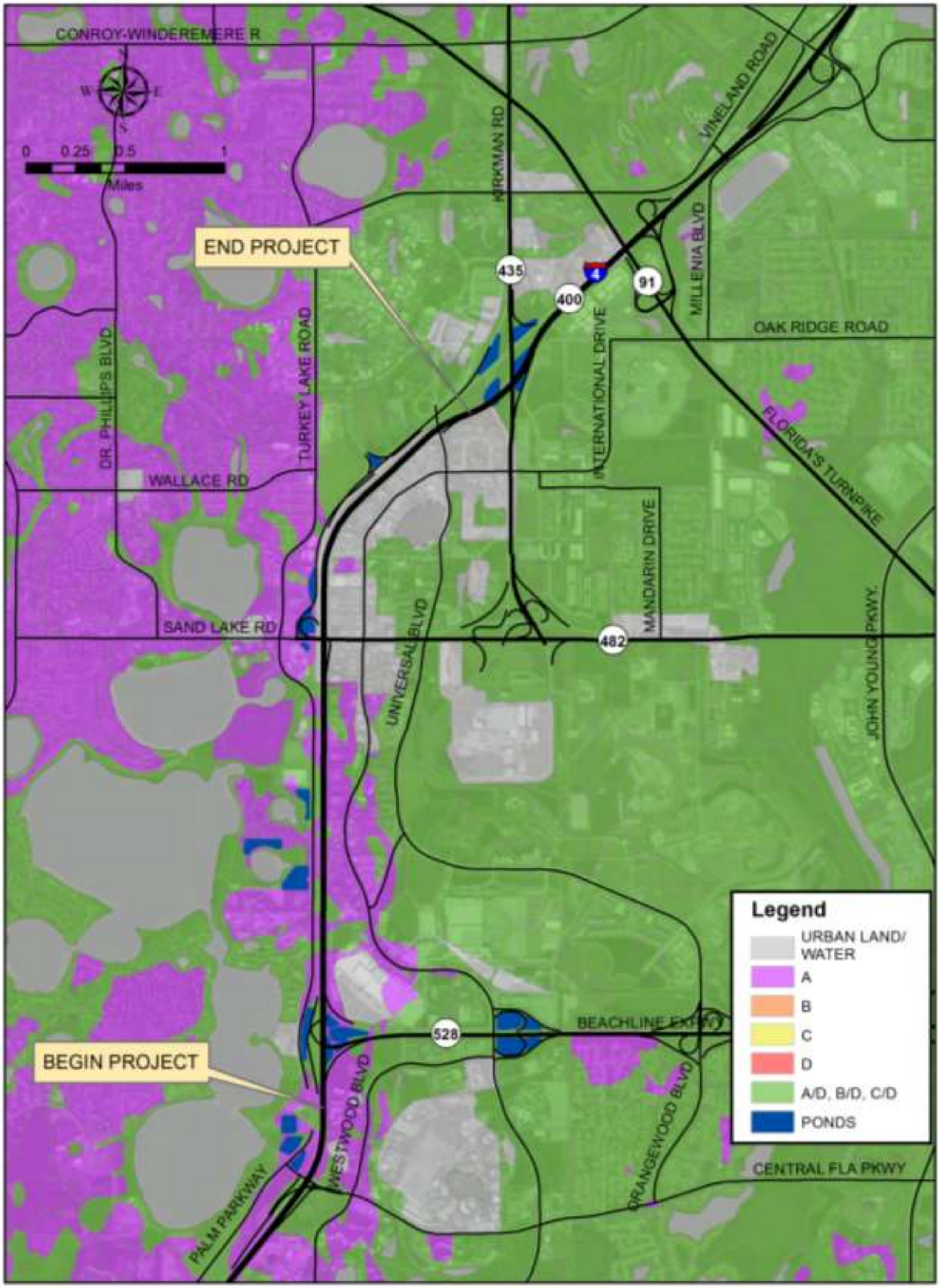


Figure 2: Soil Survey Map

Figure 3: USGS Quadrangle Map

4.2 Land Use

4.2.1 Existing Land Use

Existing land use information within the SR 400 (I-4) PD&E Study is based on the existing land use map. The existing land uses are agricultural, acreage not zoned for agriculture, residential, retail/office, public/semi-public, vacant nonresidential and vacant residential. The majority of existing land in the study area is zoned for retail office use. Figure 4 illustrates the existing land use within the project area.

4.2.2 Future Land Use

Future land uses include commercial, high density residential, institutional, planned development and mixed use. The majority of future land use in the study area is zoned for mixed use. The widening of I-4 will not alter the existing or future land uses in the area. The future land uses are illustrated in Figure 5.

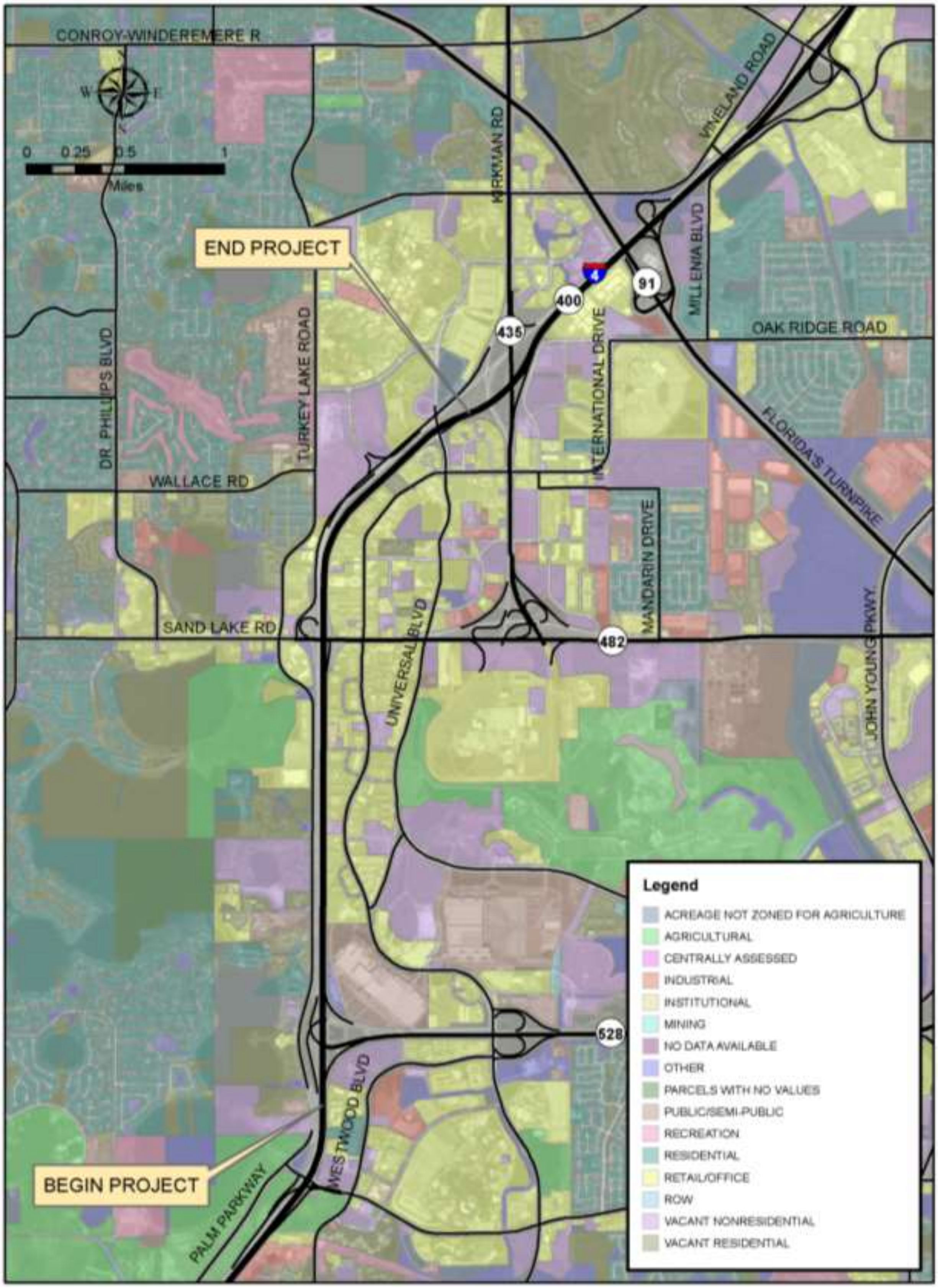


Figure 4: Existing Land Use Map

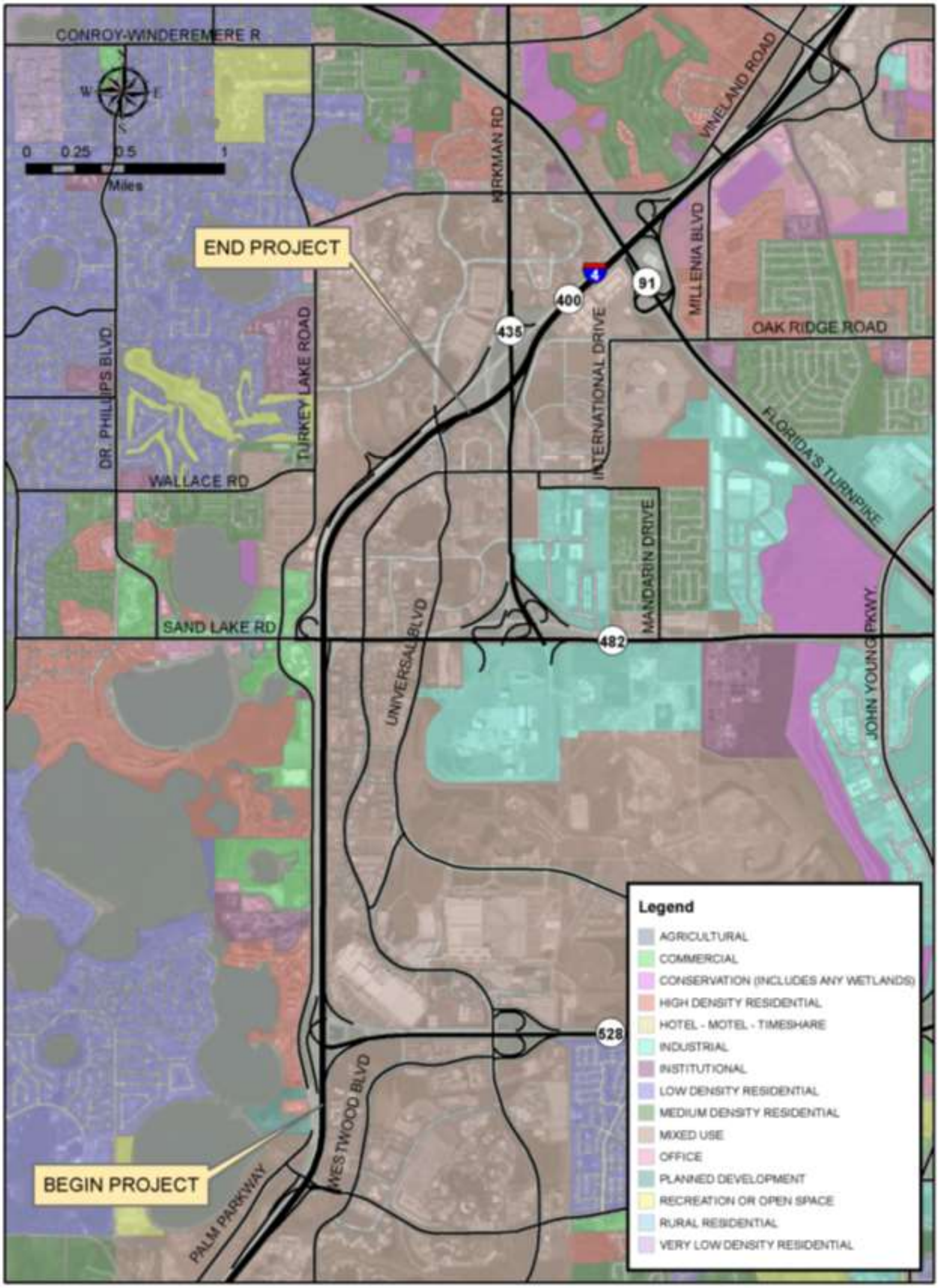


Figure 5: Future Land Use Map

4.3 Cross Drains

4.3.1 Existing Conditions

There are three (3) existing structures which act as cross drains within the study area. Table 2 depicts the existing cross drain data obtained from the Straight Line Diagram of Road Inventory (Appendix A) pertinent to the project study area, as well as, original construction plans. In the case where original construction plans were not found, cross drain invert elevations were obtained from the original PD&E study. Therefore, field verification is needed to determine the upstream and downstream flow elevations for the cross drain located at Milepost 7.409. During the design phase, field verification will be necessary to determine the actual pipe lengths as well.

Table 2: Existing Cross Drains

Milepost	Station	Description from Original Construction Plans						
		Count	Span (in)	Rise (in)	Type	Length (Ft)	Elevation (Ft NAVD)	
							Upstream	Downstream
7.409	1434+46	1	42	42	RCP	230	110.49*	110.12*
8.028	1467+13	1	36	36	RCP	245	116.61	115.91
8.545	1494+90	1	30	30	RCP	228	130.81	129.11

Abbreviations: RCP – Reinforced Concrete Pipe, *Field Verify

4.3.2 Proposed Conditions

Through hydraulic analysis, it was determined that all three (3) cross drains, Milepost 7.409, Milepost 8.028 and Milepost 8.545 need to be upsized. Table 3 depicts the results of the hydraulic analysis.

Table 3: Proposed Cross Drains

Milepost	Station	Description from Original Construction Plans						
		Count	Span (in)	Rise (in)	Type	Length (Ft)	Elevation (Ft NAVD)	
							Upstream	Downstream
7.409	1434+46	1	48	48	RCP	318	110.20	110.00
8.028	1467+13	1	42	42	RCP	290	116.20	115.30
8.545	1494+90	1	36	36	RCP	285	129.30	129.10

Abbreviations: RCP – Reinforced Concrete Pipe

4.4 Bridge Structures

4.4.1 Existing Condition

There are four (4) existing bridges located within the project corridor. The first two (2) bridges are located at the interchange of SR 528 and I-4. These bridges lie within the exit ramps that cross I-4. The remaining two (2) bridges are located at Station 1480+50.00, which cross over Sand Lake

Road. Table 4 depicts the attributes of the existing bridges. Structure conditions and year of construction was provided from the original I-4 PD&E Study.

Table 4: Existing Bridges

Structure No.	Milepost	Station	Description	Width (Ft)	Structure Type
750180	6.209	1371+00	SR 528 WB over I-4	31	UP
750087	6.340	1378+50	SR 528 EB over I-4	42	UP
750335	8.251	1480+50	I-4 WB over SR 482	163	BR
750336	8.251	1480+50	I-4 EB over SR 482	163	BR

Abbreviations: UP – UP (travels under facility), BR – Bridge (travels over facility)

4.4.2 Proposed Condition

In the proposed condition, the existing bridges will be either widened or replaced to accommodate the widening of the I-4.

4.5 Floodplain/Floodways

The Federal Emergency Management Agency (FEMA) has developed Flood Insurance Rate Maps (FIRM) for Orange County. According to FEMA Map Nos. 12095C0405F AND 12095C0415F, none of the roadway or the existing ponds within this segment are located in the 100-year floodplain. The proposed ponds 200-A, 200-B, 205-A and 205-B are adjacent to the 100-year floodplain, however, there is no impact to the floodplain. There are no regulatory floodways within the project corridor.

The Geographical Information System (GIS) and FEMA FIRM data identified two floodplain zones present within the project study area. These zones are identified as follows:

- Zone A – Area of 1% annual chance of flood (100-year flood), no base flood elevation determined; and
- Zone AE – Area of 1% annual chance of flood (100-year flood), base elevation determined.

The locations of the FEMA floodplains and the community panels referenced are shown on Figure 6.

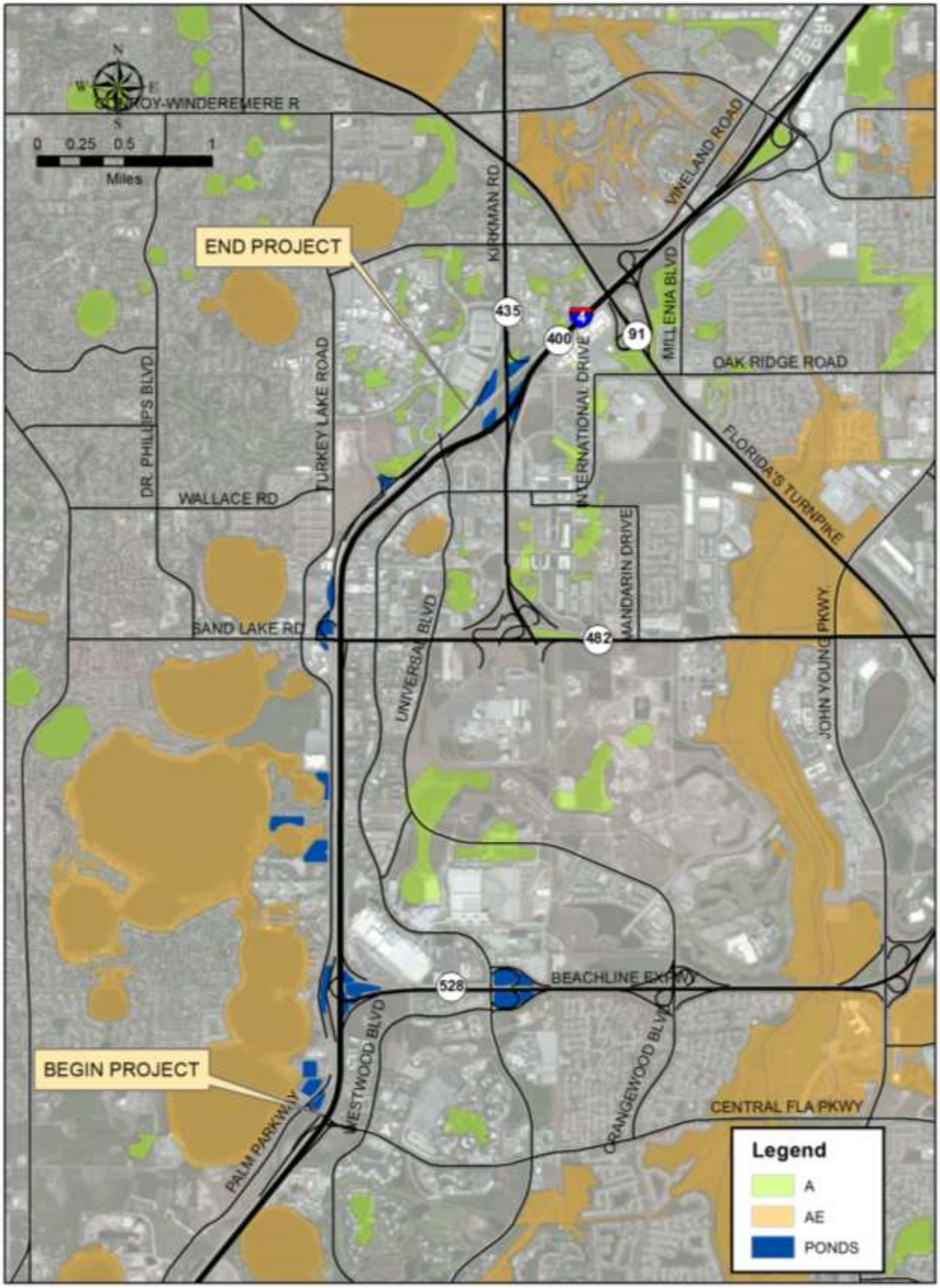


Figure 6: FEMA Flood Insurance Map

5.0 Recommendations and Conclusions

5.1 Cross Drains

There are three (3) cross drains within the study area. The existing cross drains have been evaluated for headwater impacts to determine if replacement is necessary. Through hydraulic analysis, it was determined that all three (3) cross drains need to be upsized.

5.2 Bridge Structures

There are four (4) existing bridges which will require widening. Scour analysis will not be needed during the design and construction phase, since the bridges span over I-4 and Sand Lake Road, and not water bodies.

5.3 Floodplains and Floodways

Floodplains are sparsely present adjacent to some proposed ponds within the study limits; however, no floodways are located within the project area. The floodplains that are present alongside of the ponds are associated lakes or conveyance to those lakes. There will be no impacts to the existing floodplains or regulatory floodways as a result of this project.

5.4 Project Classification

In accordance with FDOT's PD&E Manual, Part 2, Chapter 24, Section 24-2.1 "Floodplain" Statements, the proposed corridor has been evaluated to determine the impact of the proposed hydraulic modifications. Hydraulic improvements are grouped into six categories based upon the type of the hydraulic improvements and estimated floodplain impact. The proposed project can be best described as a project which will not involve any work below the 100 year flood elevation. "*Although this involves work within the horizontal limits of the 100-year floodplain, no work is being performed below the 100-year flood elevation and, as a result, this project does not encroach upon the base floodplain".*

5.5 Project Summary

The proposed reconstruction and widening of SR 400 (I-4) involves adding two new lanes in each direction and providing stormwater management systems. There are three (3) existing culverts which will necessitate culvert replacements. This has been determined by hydraulic analysis. There are four (4) bridges within the corridor. The bridges will need to be widened to meet the proposed geometry. The proposed alignment does not impact the 100-year floodplain, nor do any proposed pond sites. By complying with regulatory criteria, the implementation of this project will not adversely affect the area adjacent to the corridor and meets the expectations of the stakeholders.

APPENDIX A –

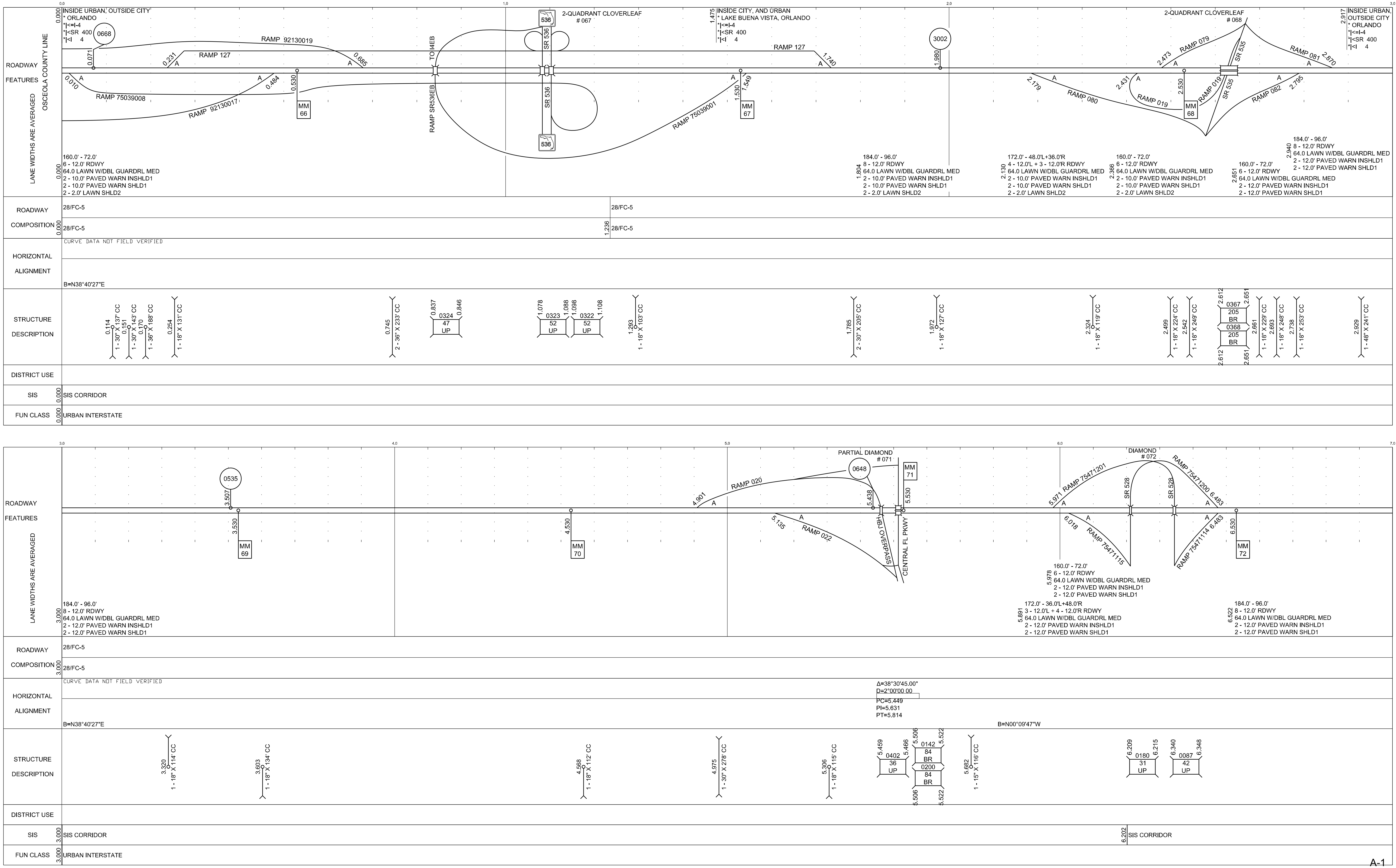
STRAIGHT LINE DIAGRAMS

	5 YR INV	SLD REV	BMP	INTERIM REVISIONS EMP	INV	SLD REV
DATE	06/23/2011	08/17/2011	000.000	024.673	01/17/2013 EN	03/13/2013 MR
BY	EN/KA	URS				

FLORIDA DEPARTMENT OF TRANSPORTATION

STRAIGHT LINE DIAGRAM OF ROAD INVENTORY

SECTION STATUS	INT. or US ROUTE NO.	STATE ROAD NO.	COUNTY	DISTRICT	ROADWAY ID	SHEET NO:
02	I 4	SR 400	ORANGE	05	75280000	1 OF 5



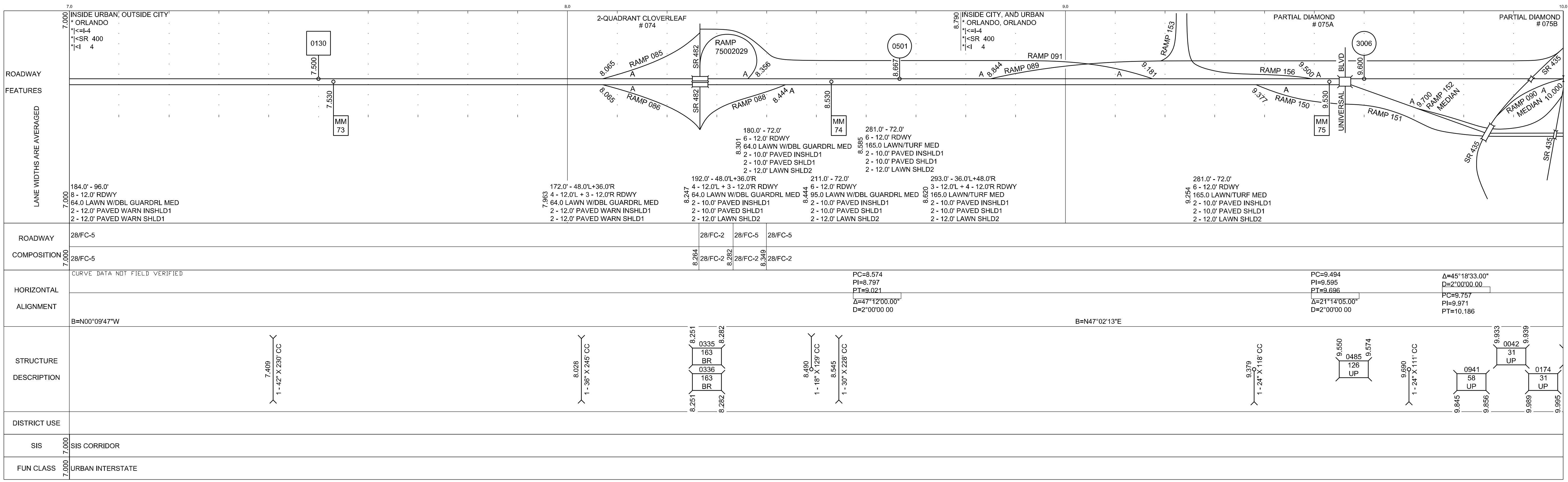
Created at: 03/04/2013 11:18

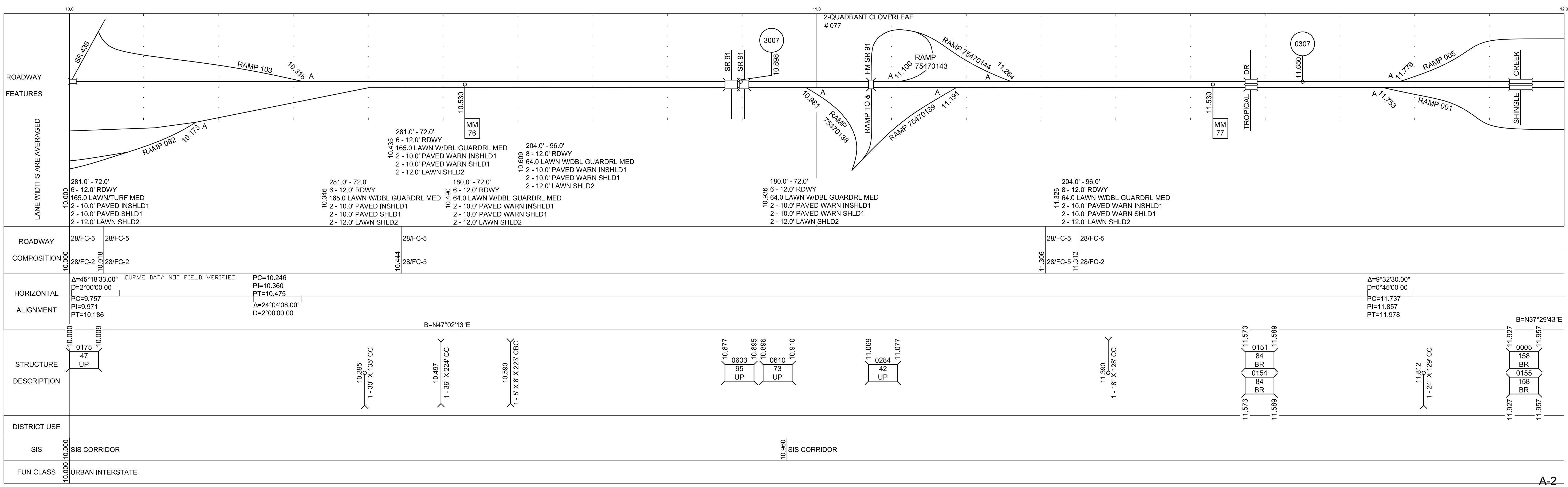
	5 YR INV	SLD REV	BMP	INTERIM REVISIONS EMP	INV	SLD REV
DATE	06/23/2011	08/17/2011	000.000	024.673	01/17/2013 EN	03/14/2013 MR
BY	EN/KA	URS				

FLORIDA DEPARTMENT OF TRANSPORTATION

STRAIGHT LINE DIAGRAM OF ROAD INVENTORY

SECTION STATUS	INT. or US ROUTE NO.	STATE ROAD NO.	COUNTY	DISTRICT	ROADWAY ID	SHEET NO:
02	I 4	SR 400	ORANGE	05	75280000	2 OF 5





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APPENDIX B –

CROSS DRAIN CALCULATIONS

CROSS DRAIN ANALYSIS - EXISTING CONDITION

HNTB Corporation
610 Crescent Executive Court, Suite 400
Lake Mary, FL 32746

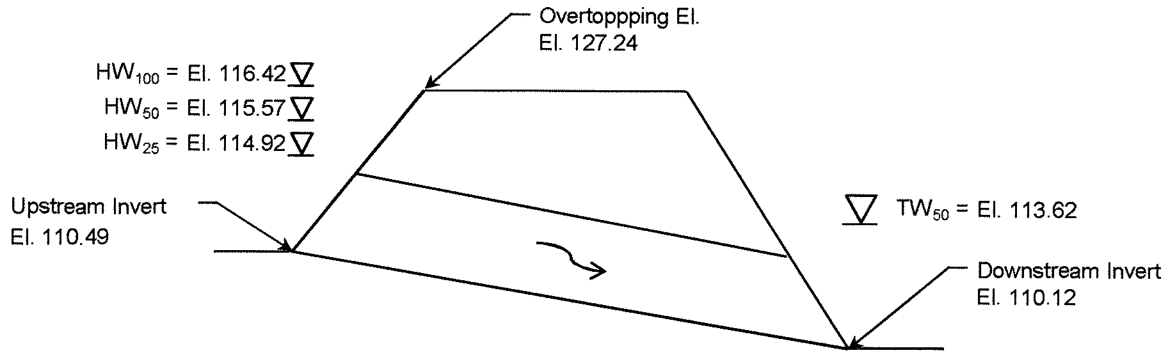
		DATE
made by:	LDP	25-Sep-13
checked by:	HJJ	25-Sep-13
HNTB job #:	59219	

PROJECT: **I-4 PD&E - Segment 2**

LOCATION: **MP 7.409**

Cross Drain Characteristics:

Number of Barrels:	1	
Cross Drain Shape:	Round	
Manning's "n":	0.012	
Entrance Loss Coef.:	0.20	
Span (B):	3.5 ft	
Height (D):	3.5 ft	
Length (L):	230 ft	
Slope (So):	0.002 ft/ft	
Upstream Invert:	110.49	
Downstream Invert:	110.12	
Overtopping El.:	127.24	
Tailwater El.:	113.62	(Based on crown of pipe)
Description:	42" Pipe	



$Q_{25} = V*A = 6 \text{ fps} * (\pi D^2/4) =$ 57.7 cfs
$Q_{100} = 1.4 * Q_{25} =$ 80.8 cfs

Culvert Description	# of Barrels	Q (cfs)	Size		Headwater Computation													Con. HW	Outlet Velocity	Comments
					Inlet Control			Outlet Control HW = H + DTW - LSo												
			D	B	Q/B	HW/D*	HW	Ke	H**	d_c***	$(d_c+D)/2$	TW	DTW	LSo	HW					
42" Pipe 25 Yr	1	57.7	3.5 ft	3.5 ft	16.49	1.10	3.85	0.20	1.30	2.40	2.95	3.50	3.5	0.37	4.43			4.43	6.00	
42" Pipe 50 Yr	1	69.0	3.5 ft	3.5 ft	19.71	1.25	4.38	0.20	1.95	2.55	3.025	3.50	3.5	0.37	5.08			5.08	7.17	
42" Pipe 100 Yr	1	80.8	3.5 ft	3.5 ft	23.09	1.52	5.32	0.20	2.80	2.85	3.175	3.50	3.5	0.37	5.93			5.93	8.40	

* From Chart 1 of HDS-5
** From Chart 5 of HDS-5
*** From Chart 4 of HDS-5

CROSS DRAIN ANALYSIS - PROPOSED CONDITION

HNTB Corporation
610 Crescent Executive Court, Suite 400
Lake Mary, FL 32746

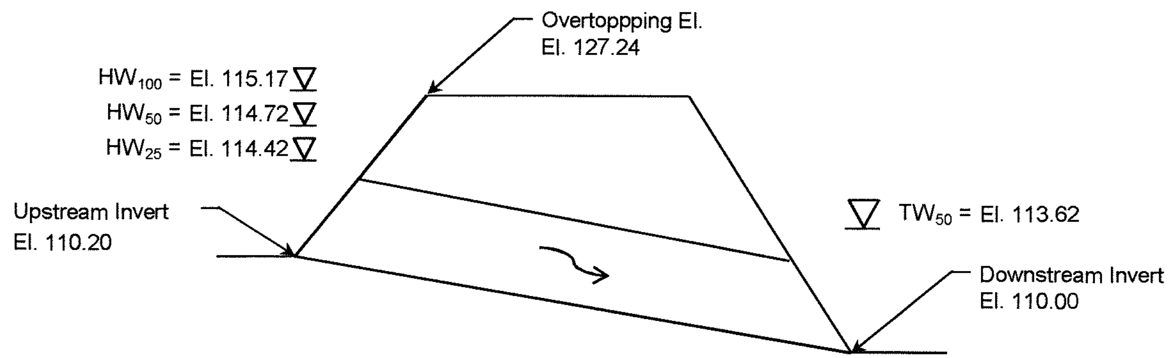
		DATE
made by:	LDP	25-Sep-13
checked by:	HJJ	25-Sep-13
HNTB job #:	59219	

PROJECT: **I-4 PD&E - Segment 2**

LOCATION: **MP 7.409**

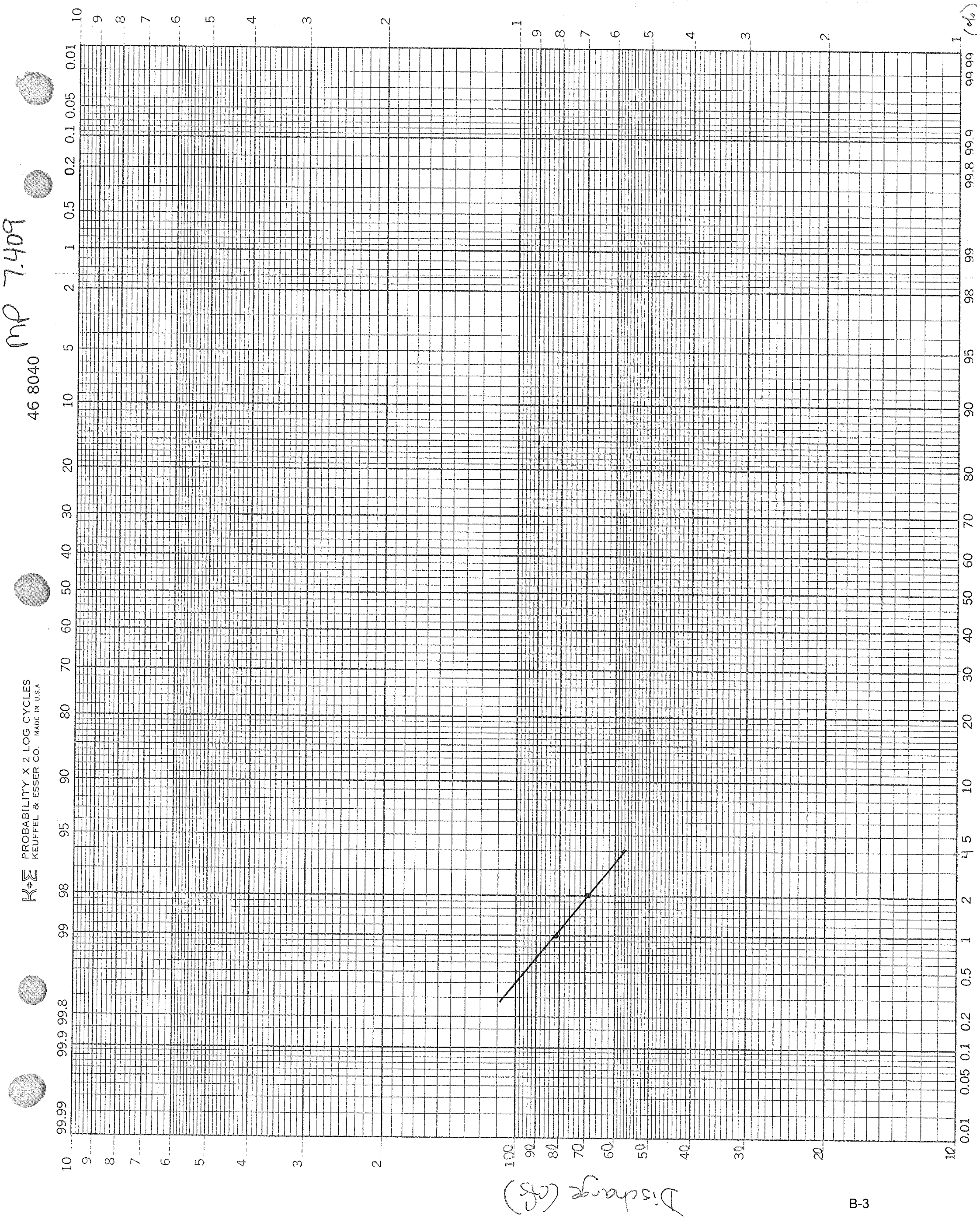
Cross Drain Characteristics:

Number of Barrels:	1
Cross Drain Shape:	Round
Manning's "n":	0.012
Entrance Loss Coef.:	0.20
Span (B):	4.0 ft
Height (D):	4.0 ft
Length (L):	316 ft
Slope (So):	0.001 ft/ft
Upstream Invert:	110.20
Downstream Invert:	110.00
Overtopping El.:	127.24
Tailwater El.:	113.62
Description:	48" Pipe



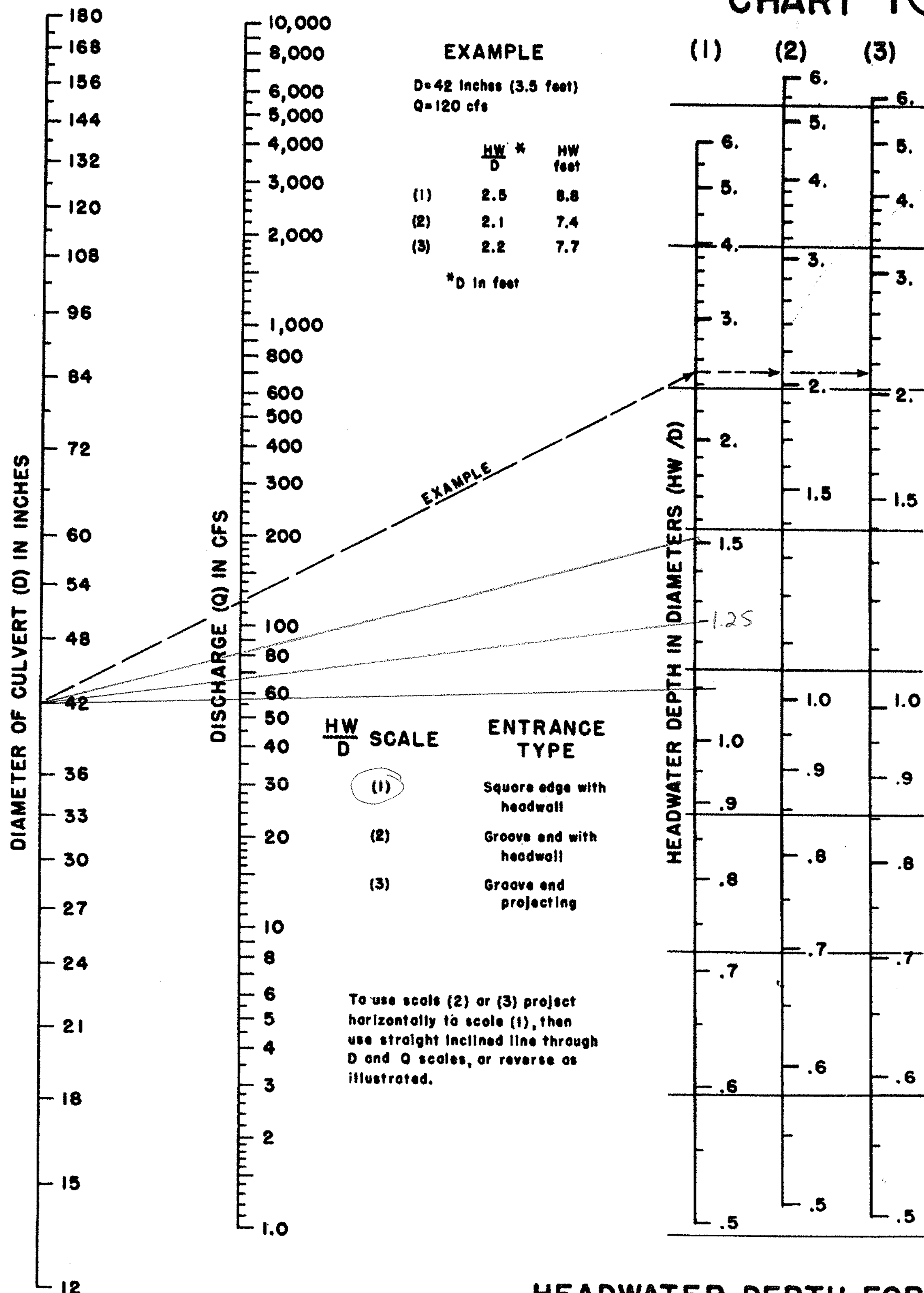
Culvert Description	# of Barrels	Q (cfs)	Size		Headwater Computation											Con. HW	Outlet Velocity	Comments
					Inlet Control			Outlet Control HW = H + DTW - LSo										
			D	B	Q/B	HW/D*	HW	Ke	H**	d_c***	$(d_c+D)/2$	TW	DTW	LSo	HW			
48" Pipe 25 Yr	1	57.7	4.0 ft	4.0 ft	14.43	0.85	3.40	0.20	0.80	2.30	3.15	3.62	3.62	0.2	4.22	4.22	4.59	
48" Pipe 50 Yr	1	69.0	4.0 ft	4.0 ft	17.25	0.97	3.88	0.20	1.10	2.55	3.275	3.62	3.62	0.2	4.52	4.52	5.49	
48" Pipe 100 Yr	1	80.8	4.0 ft	4.0 ft	20.20	1.18	4.72	0.20	1.55	2.70	3.35	3.62	3.62	0.2	4.97	4.97	6.43	

* From Chart 1 of HDS-5
** From Chart 5 of HDS-5
*** From Chart 4 of HDS-5


K+E PROBABILITY X 2 LOG CYCLES
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 8040
MP 7.409
Discharge (cfs)
(%)

MP 7.409 (EX)

CHART 10



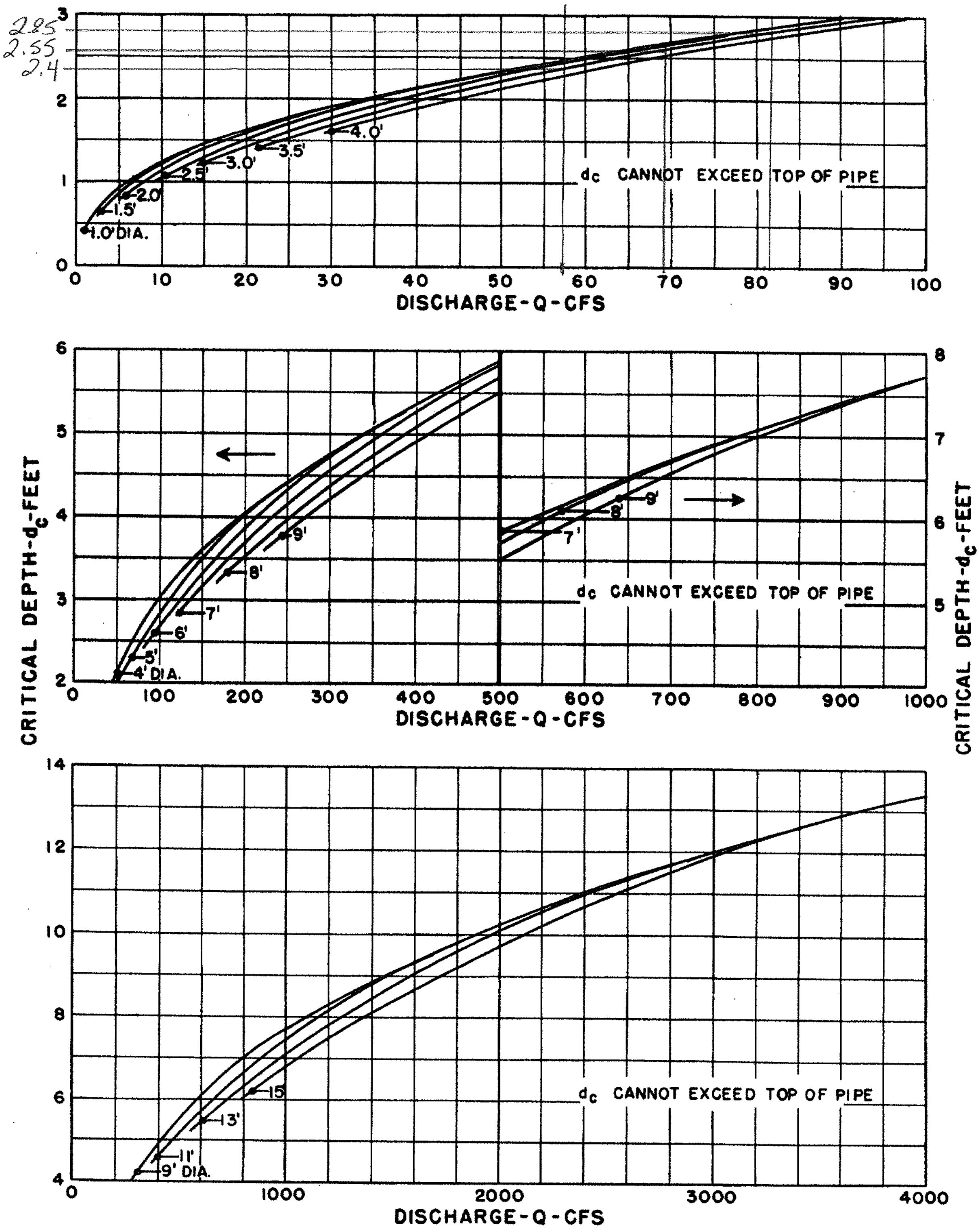
HEADWATER SCALES 2&3
REVISED MAY 1964

BUREAU OF PUBLIC ROADS JAN. 1963

HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

MP 7.409 (EX)

CHART 4

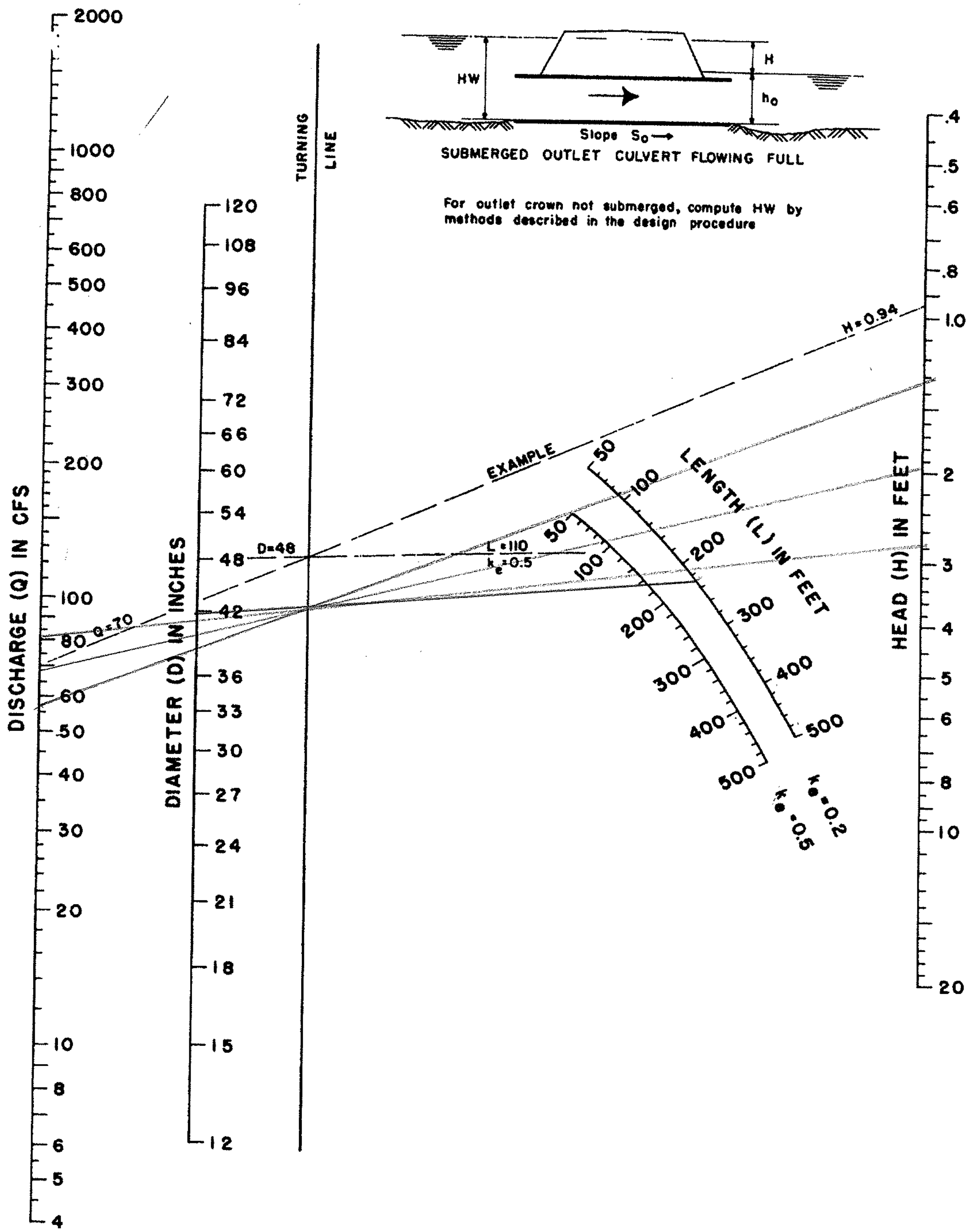


BUREAU OF PUBLIC ROADS
JAN. 1964

CRITICAL DEPTH
CIRCULAR PIPE

MP 7.409 (EX)

CHART 5

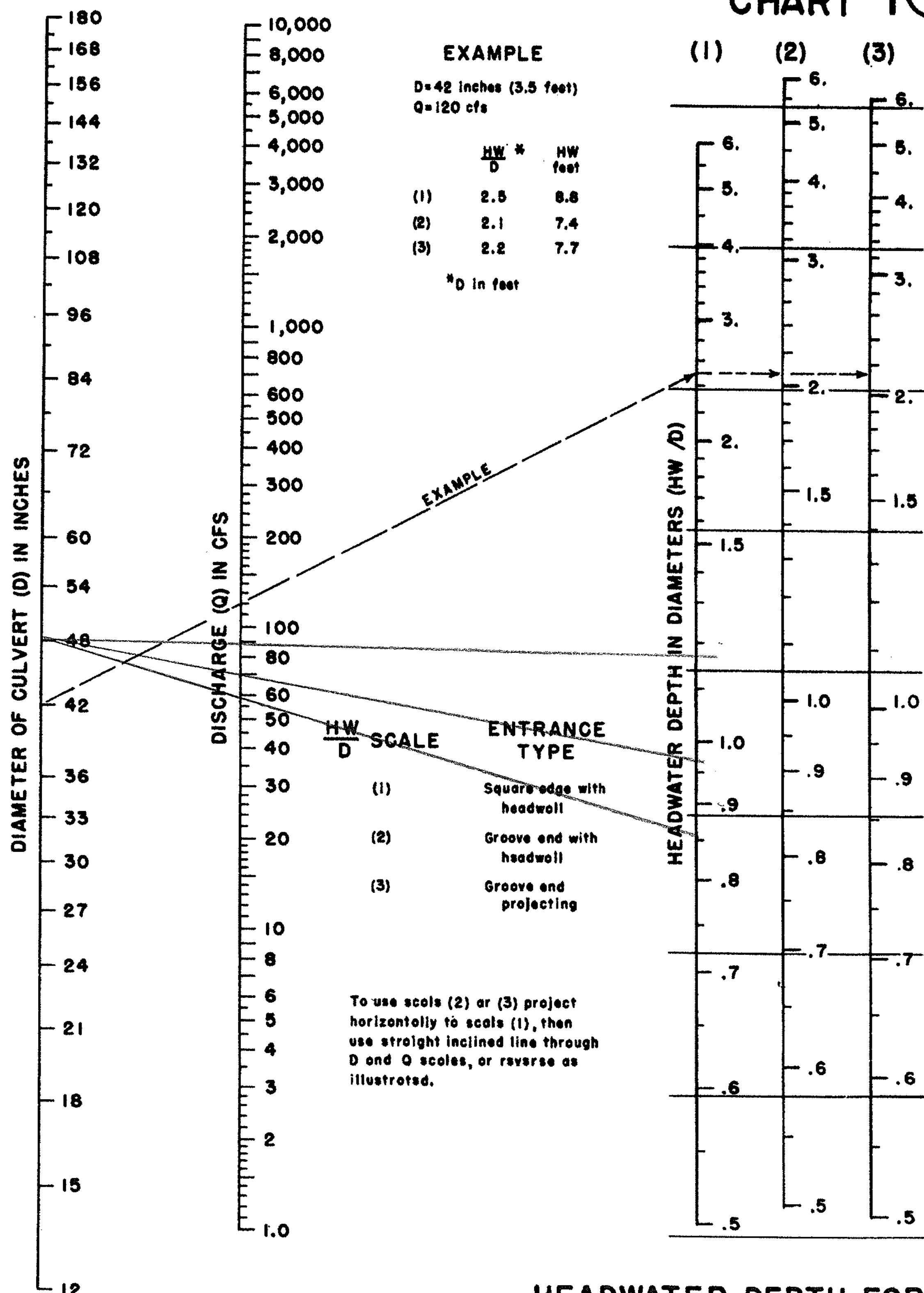


HEAD FOR CONCRETE PIPE CULVERTS FLOWING FULL
n = 0.012

BUREAU OF PUBLIC ROADS JAN. 1963

MP 7.409 (PR)

CHART 10



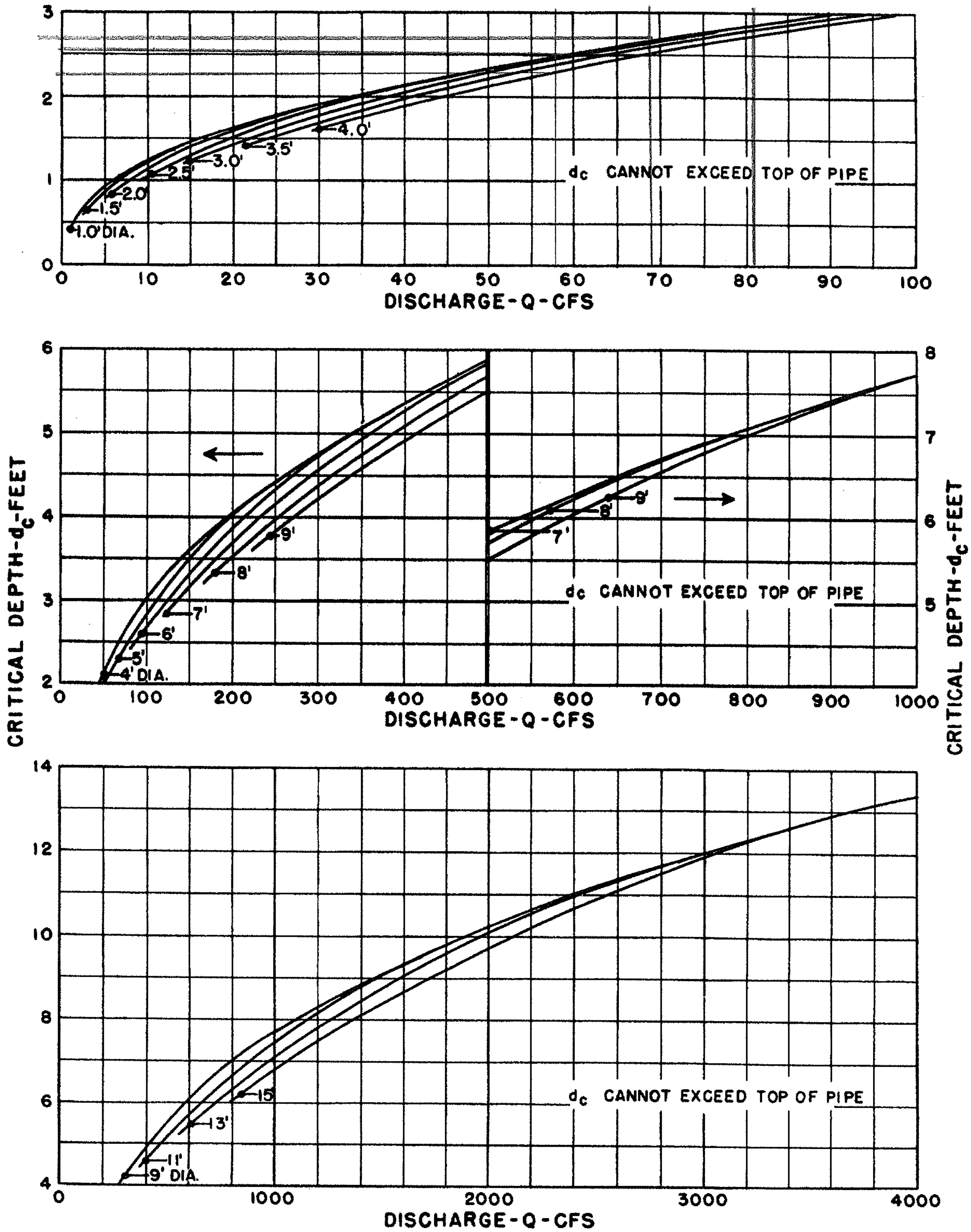
HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

HEADWATER SCALES 2&3
REVISED MAY 1964

BUREAU OF PUBLIC ROADS JAN. 1963

MP 7.409 (PR)

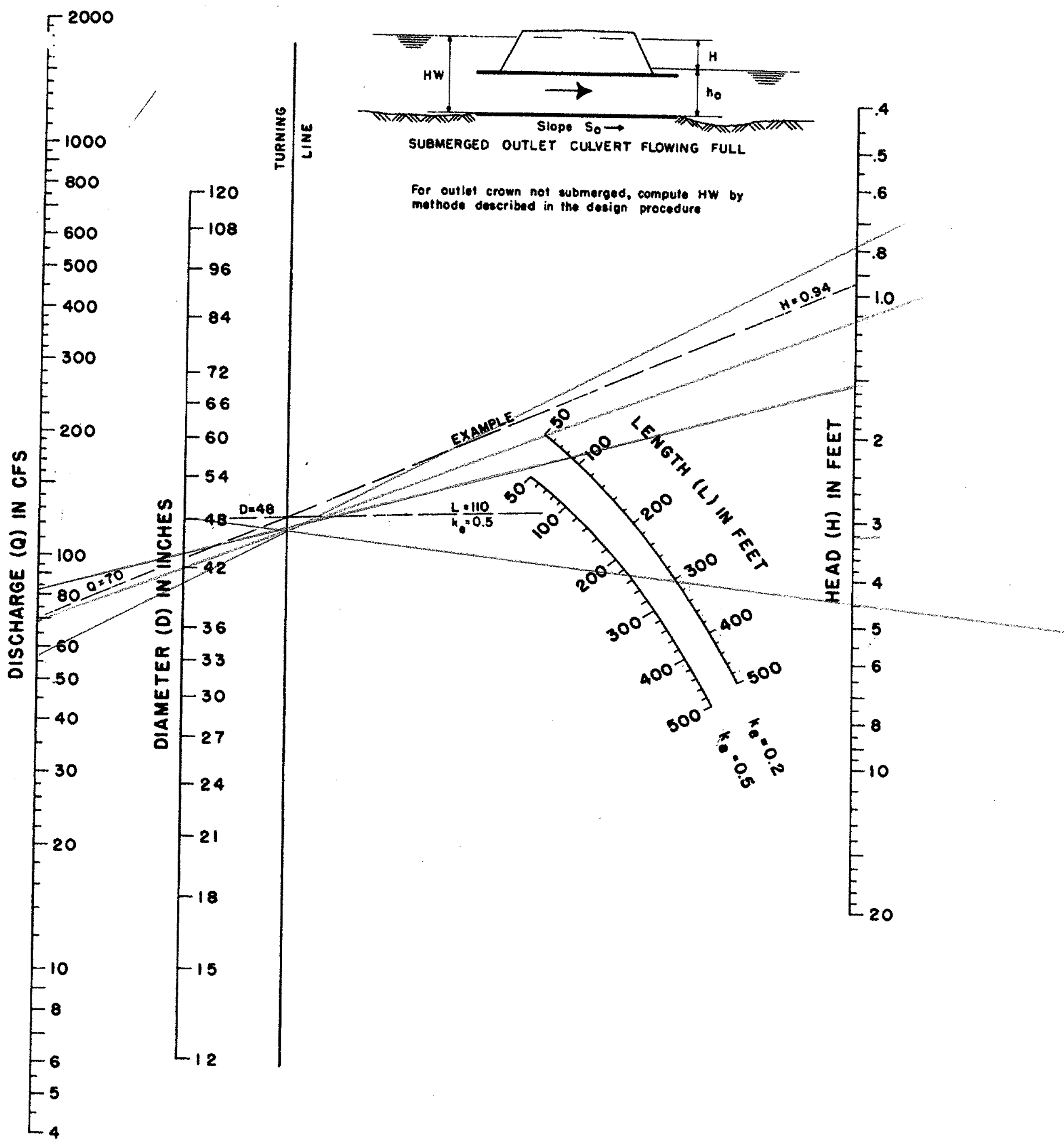
CHART 4



BUREAU OF PUBLIC ROADS
JAN. 1964

CRITICAL DEPTH
CIRCULAR PIPE

CHART 5



HEAD FOR CONCRETE PIPE CULVERTS FLOWING FULL
n = 0.012

BUREAU OF PUBLIC ROADS JAN. 1963

CROSS DRAIN ANALYSIS - EXISTING CONDITION

HNTB Corporation
610 Crescent Executive Court, Suite 400
Lake Mary, FL 32746

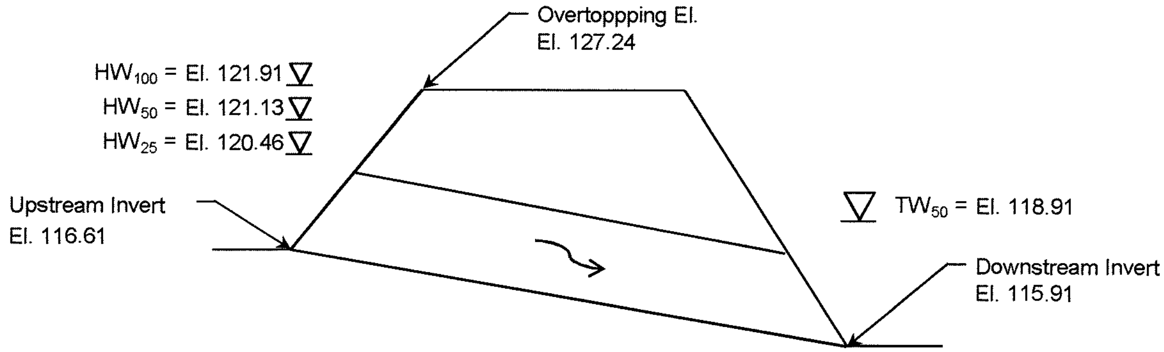
		DATE
made by:	LDP	25-Sep-13
checked by:	HJJ	25-Sep-13
HNTB job #:	59219	

PROJECT: **I-4 PD&E - Segment 2**

LOCATION: **MP 8.028**

Cross Drain Characteristics:

Number of Barrels:	1
Cross Drain Shape:	Round
Manning's "n":	0.012
Entrance Loss Coef.:	0.20
Span (B):	3.0 ft
Height (D):	3.0 ft
Length (L):	245 ft
Slope (So):	0.003 ft/ft
Upstream Invert:	116.61
Downstream Invert:	115.91
Overtopping El.:	127.24
Tailwater El.:	118.91 (Based on crown of pipe)
Description:	36" Pipe



$Q_{25} = V*A = 6\text{ fps} * (\pi D^2/4) =$ 42.4 cfs
$Q_{100} = 1.4 * Q_{25} =$ 59.4 cfs

Culvert Description	# of Barrels	Q (cfs)	Size		Headwater Computation											Con. HW	Outlet Velocity	Comments
					Inlet Control			Outlet Control HW = H + DTW - LSo										
			D	B	Q/B	HW/D*	HW	Ke	H**	d_c***	$(d_c+D)/2$	TW	DTW	LSo	HW			
36" Pipe 25 Yr	1	42.4	3.0 ft	3.0 ft	14.14	1.15	3.45	0.20	1.55	2.10	2.55	3.00	3	0.7	3.85	3.85	6.00	
36" Pipe 50 Yr	1	51.0	3.0 ft	3.0 ft	17.00	1.40	4.20	0.20	2.22	2.30	2.65	3.00	3	0.7	4.52	4.52	7.22	
36" Pipe 100 Yr	1	59.4	3.0 ft	3.0 ft	19.79	1.60	4.80	0.20	3.00	2.45	2.725	3.00	3	0.7	5.30	5.30	8.40	

* From Chart 1 of HDS-5
** From Chart 5 of HDS-5
*** From Chart 4 of HDS-5

CROSS DRAIN ANALYSIS - PROPOSED CONDITION

HNTB Corporation
610 Crescent Executive Court, Suite 400
Lake Mary, FL 32746

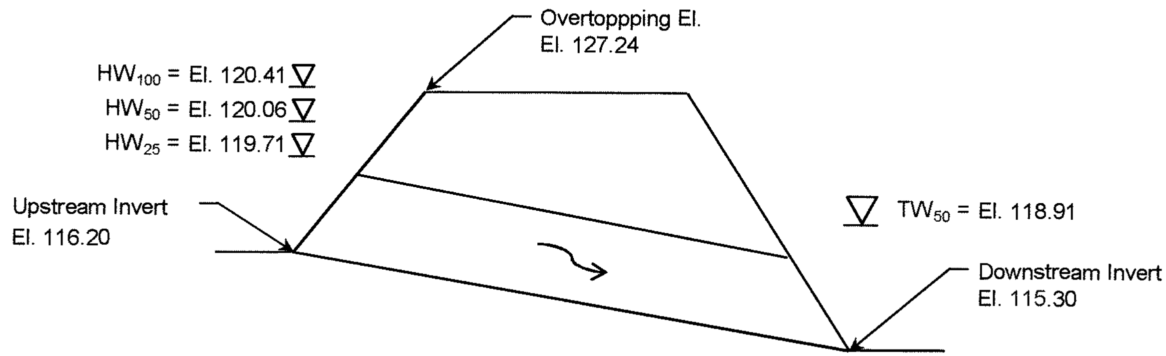
		DATE
made by:	LDP	25-Sep-13
checked by:	HJJ	25-Sep-13
HNTB job #:	59219	

PROJECT: **I-4 PD&E - Segment 2**

LOCATION: **MP 8.028**

Cross Drain Characteristics:

Number of Barrels:	1
Cross Drain Shape:	Round
Manning's "n":	0.012
Entrance Loss Coef.:	0.20
Span (B):	3.5 ft
Height (D):	3.5 ft
Length (L):	300 ft
Slope (So):	0.003 ft/ft
Upstream Invert:	116.20
Downstream Invert:	115.30
Overtopping El.:	127.24
Tailwater El.:	118.91
Description:	42" Pipe



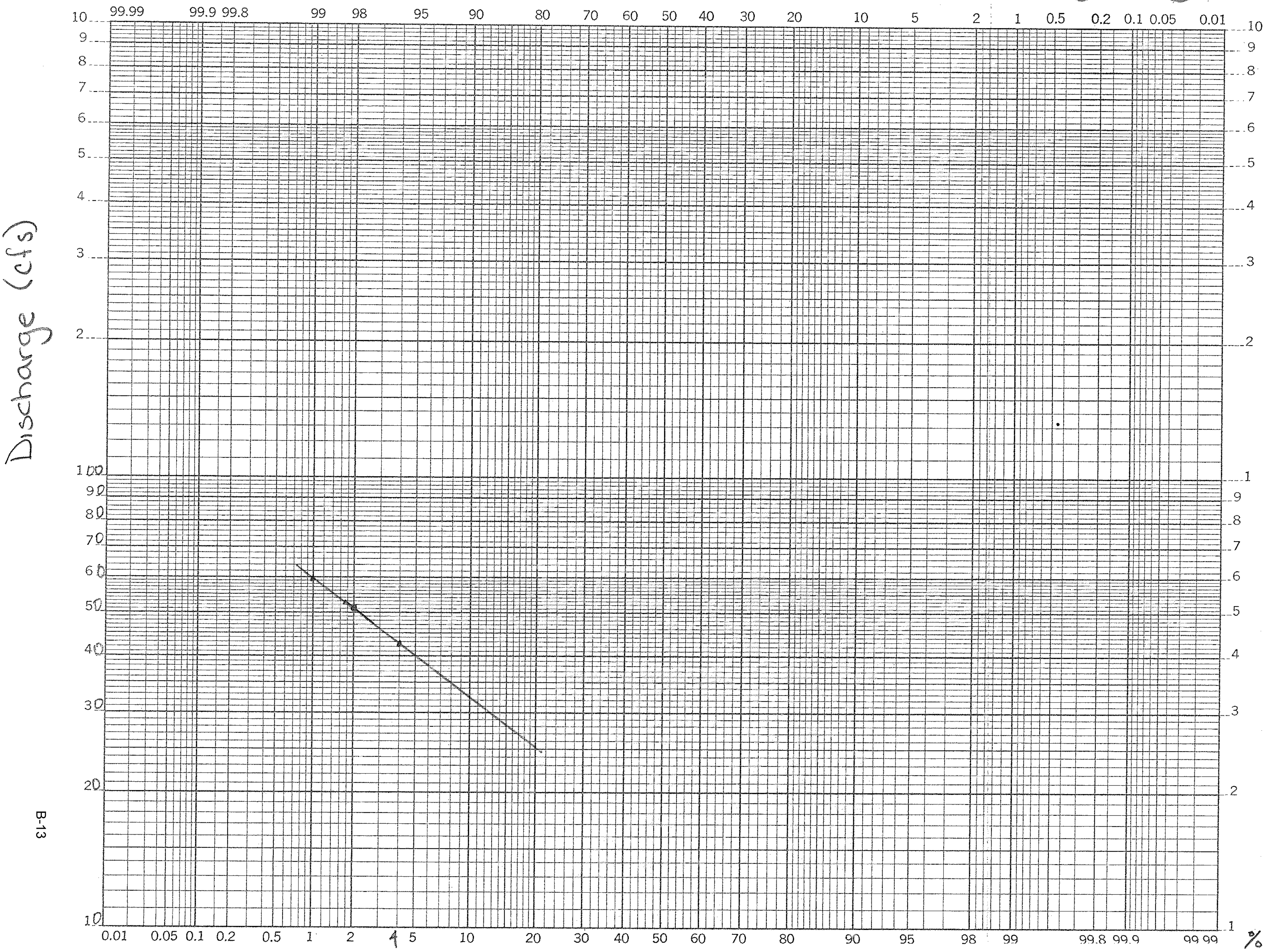
Culvert Description	# of Barrels	Q (cfs)	Size		Headwater Computation											Con. HW	Outlet Velocity	Comments
					Inlet Control			Outlet Control HW = H + DTW - LSo										
			D	B	Q/B	HW/D*	HW	Ke	H**	d_c***	$(d_c+D)/2$	TW	DTW	LSo	HW			
42" Pipe 25 Yr	1	42.4	3.5 ft	3.5 ft	12.12	0.88	3.08	0.20	0.80	2.00	2.75	3.61	3.61	0.9	3.51	3.51	4.41	
42" Pipe 50 Yr	1	51.0	3.5 ft	3.5 ft	14.57	1.05	3.68	0.20	1.15	2.25	2.875	3.61	3.61	0.9	3.86	3.86	5.30	
42" Pipe 100 Yr	1	59.4	3.5 ft	3.5 ft	16.96	1.15	4.03	0.20	1.50	2.40	2.95	3.61	3.61	0.9	4.21	4.21	6.17	

* From Chart 1 of HDS-5
** From Chart 5 of HDS-5
*** From Chart 4 of HDS-5

MP 8.028

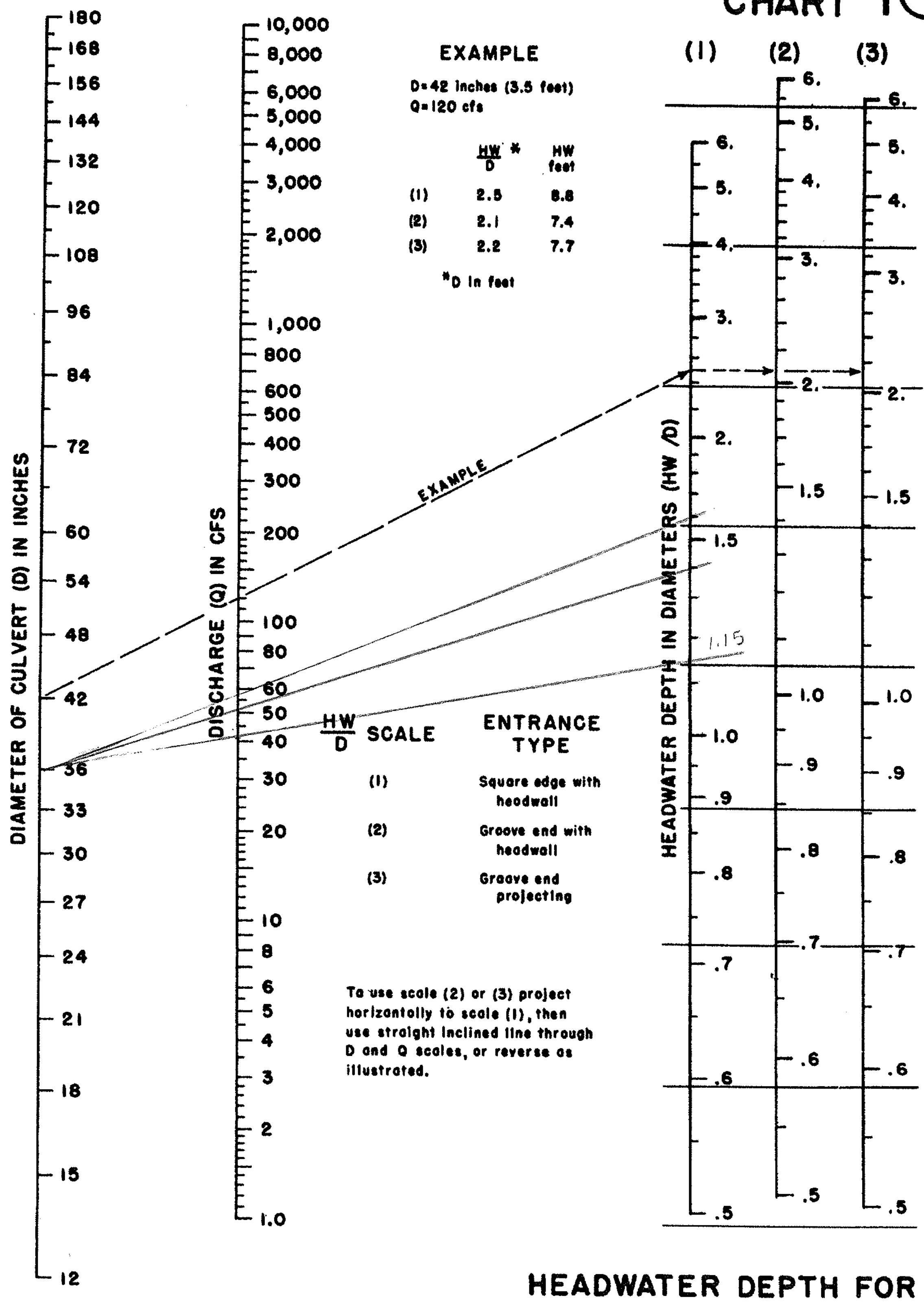
K+E PROBABILITY X 2 LOG CYCLES
KEUFFEL & ESSER CO. MADE IN U.S.A.

46 8040



MP 8.028 (Ex)

CHART 10



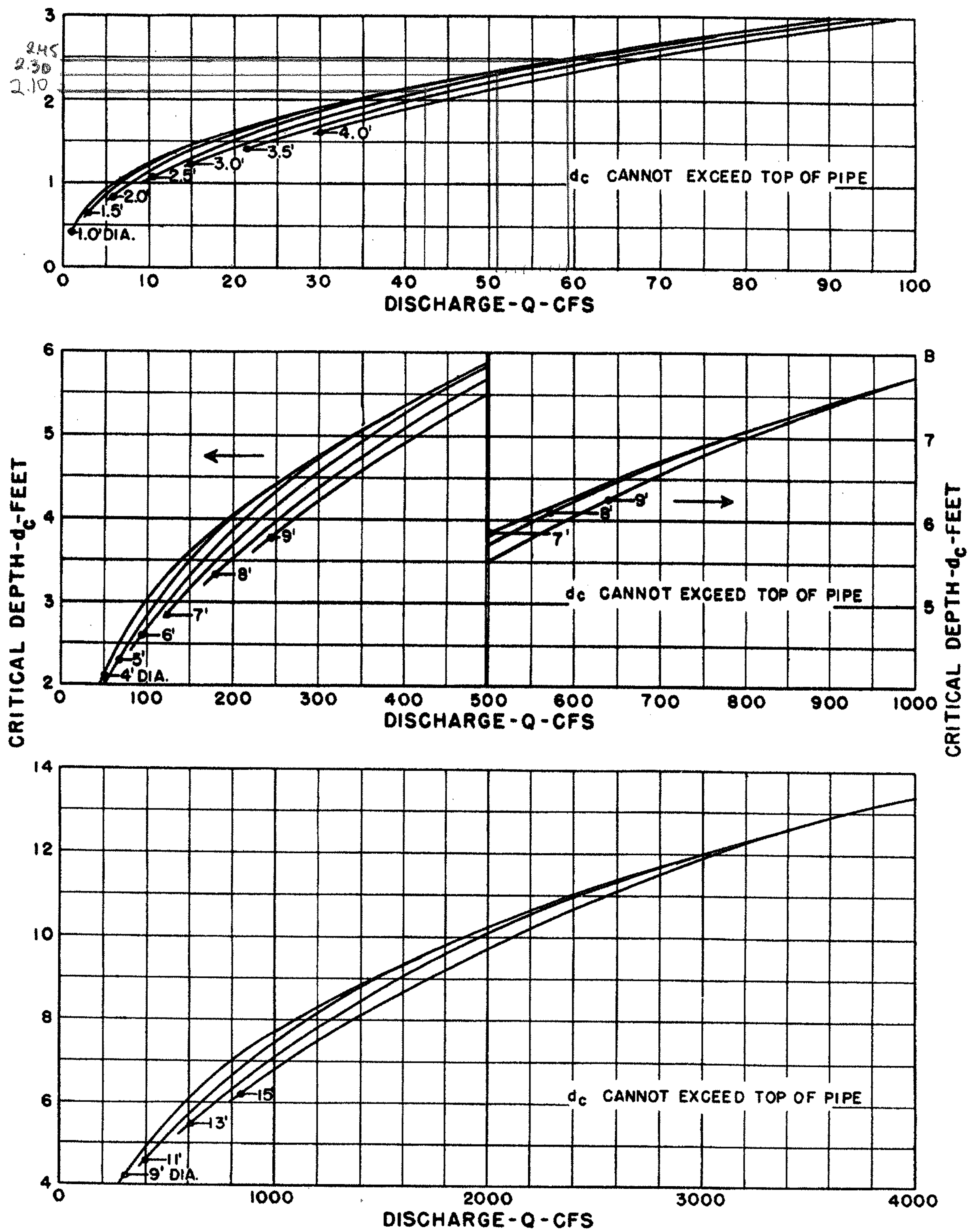
HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

HEADWATER SCALES 2&3
REVISED MAY 1964

BUREAU OF PUBLIC ROADS JAN. 1963

MP 8.028 (Ex)

CHART 4



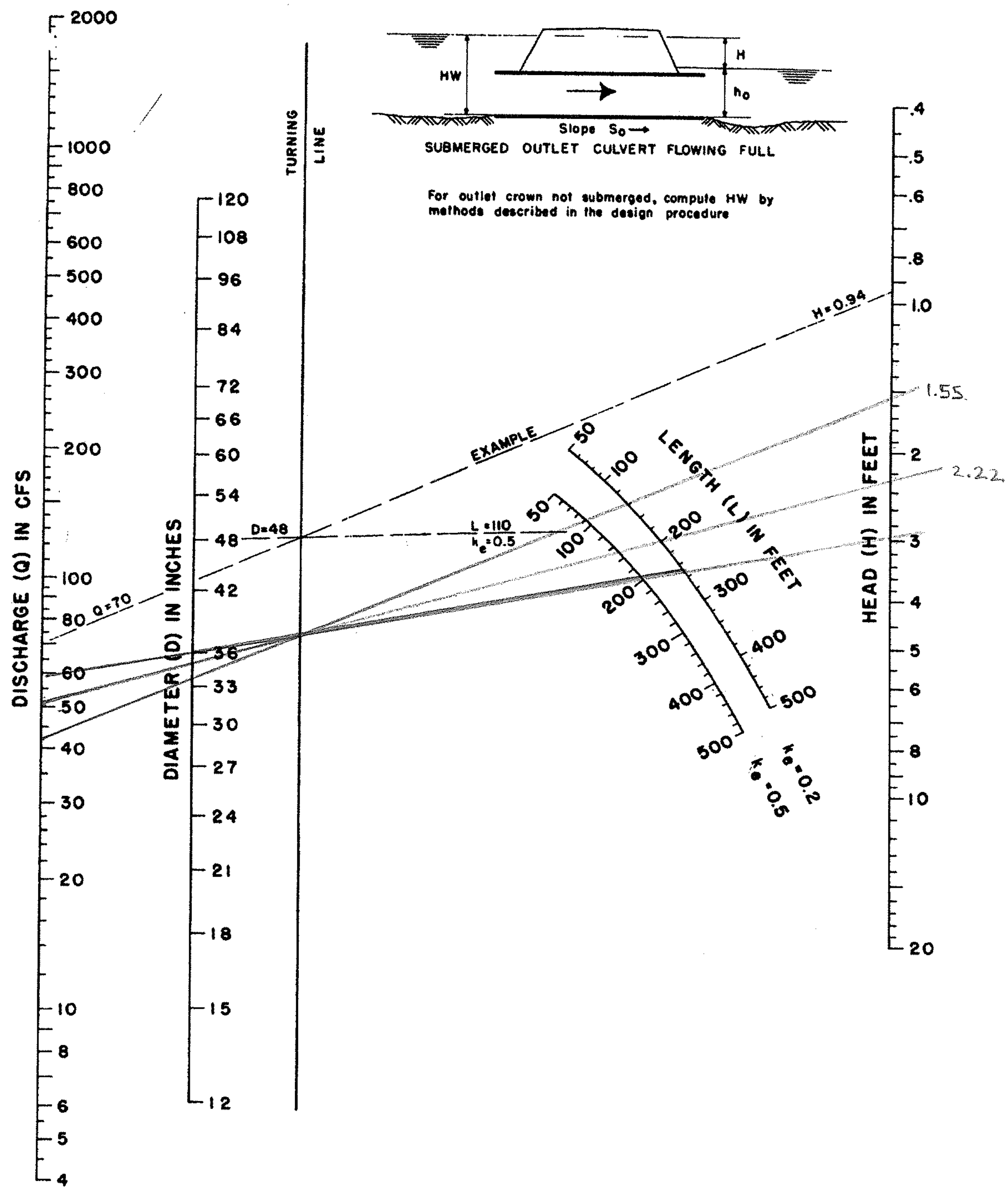
BUREAU OF PUBLIC ROADS

JAN. 1964

CRITICAL DEPTH
CIRCULAR PIPE

MP 8.028 (Ex)

CHART 5

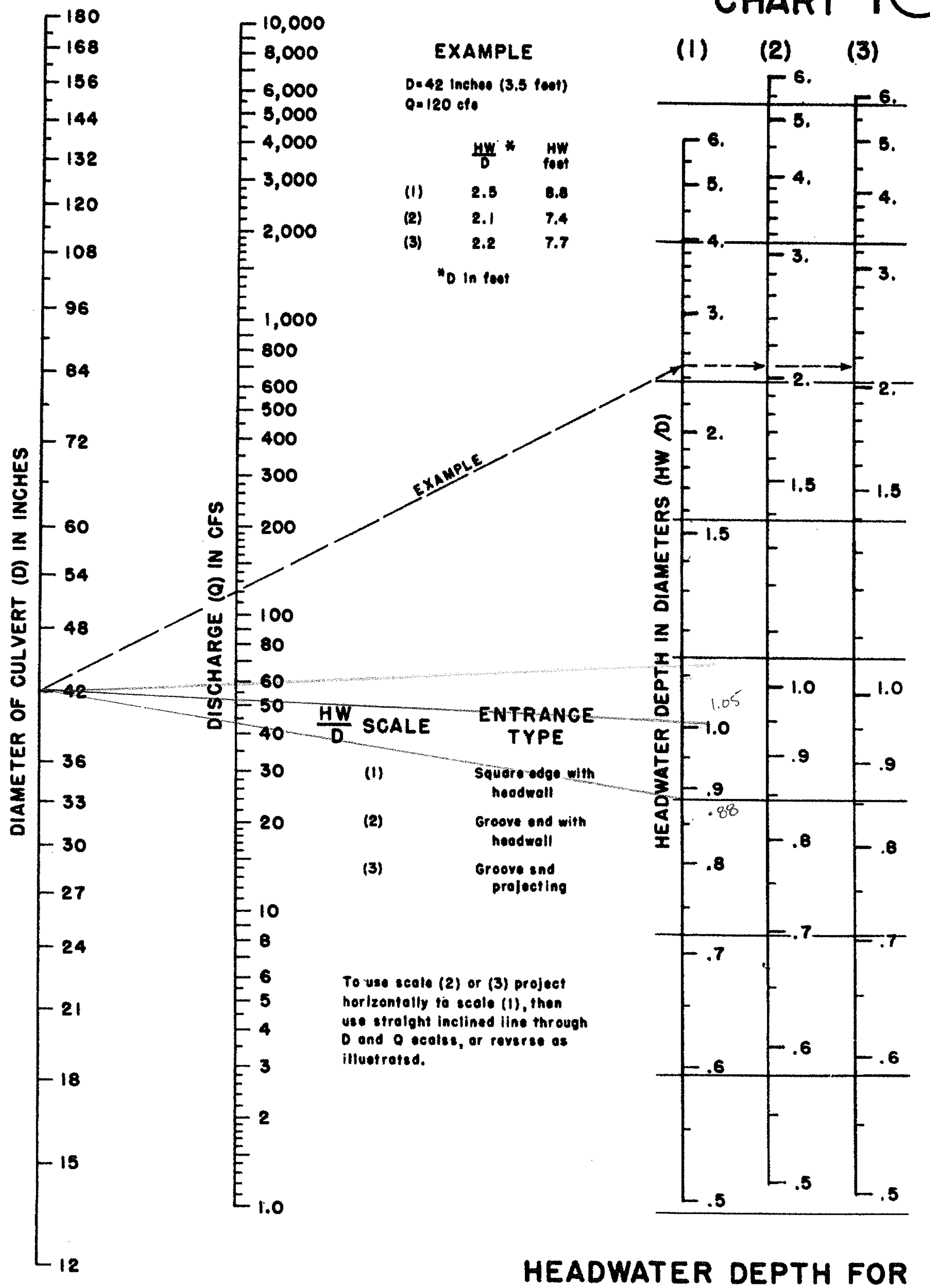


HEAD FOR CONCRETE PIPE CULVERTS FLOWING FULL
n = 0.012

BUREAU OF PUBLIC ROADS JAN. 1963

MP 8.028(PR)

CHART 10



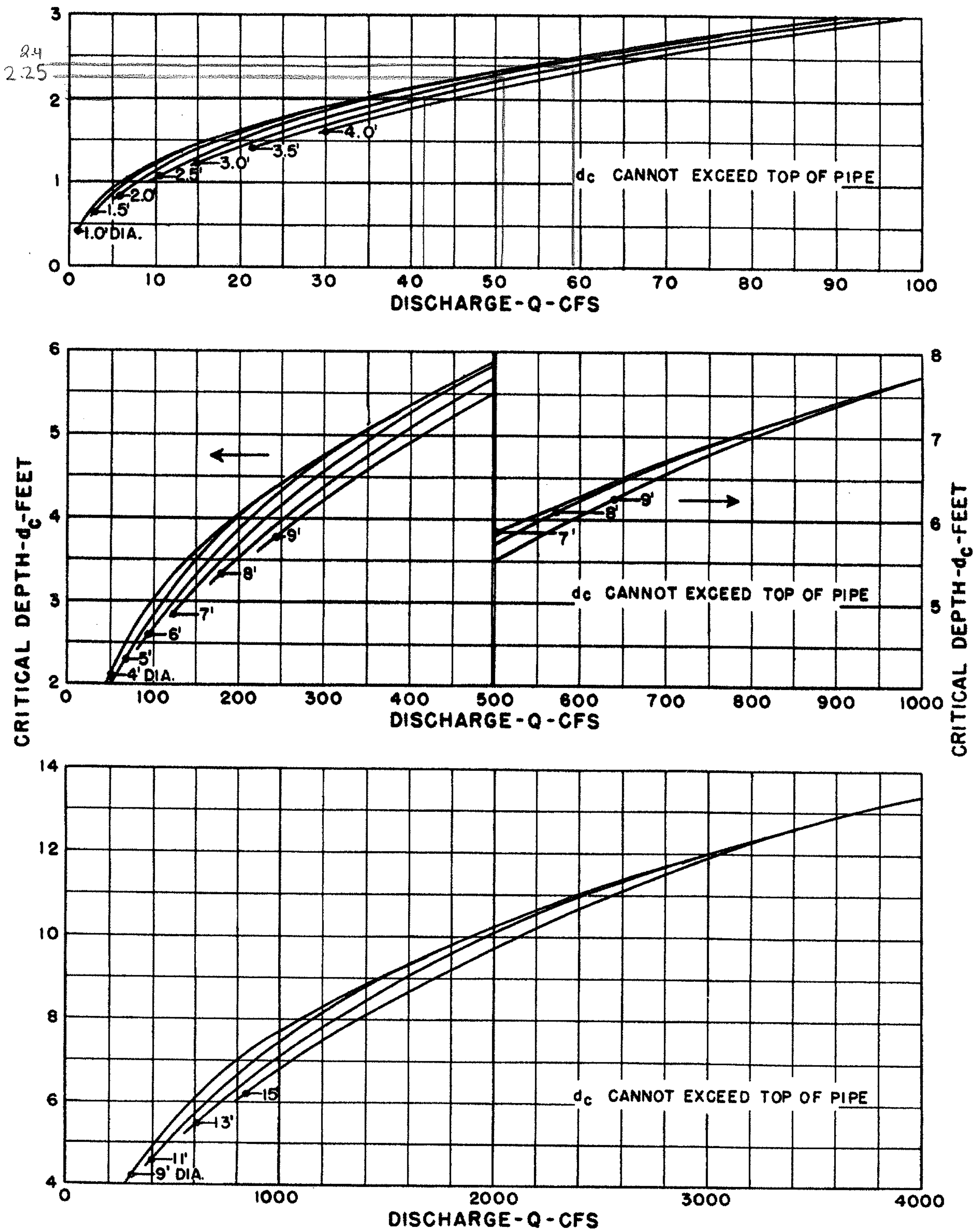
HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

HEADWATER SCALES 2&3
REVISED MAY 1964

BUREAU OF PUBLIC ROADS JAN. 1963

MP 8.028 (PR)

CHART 4

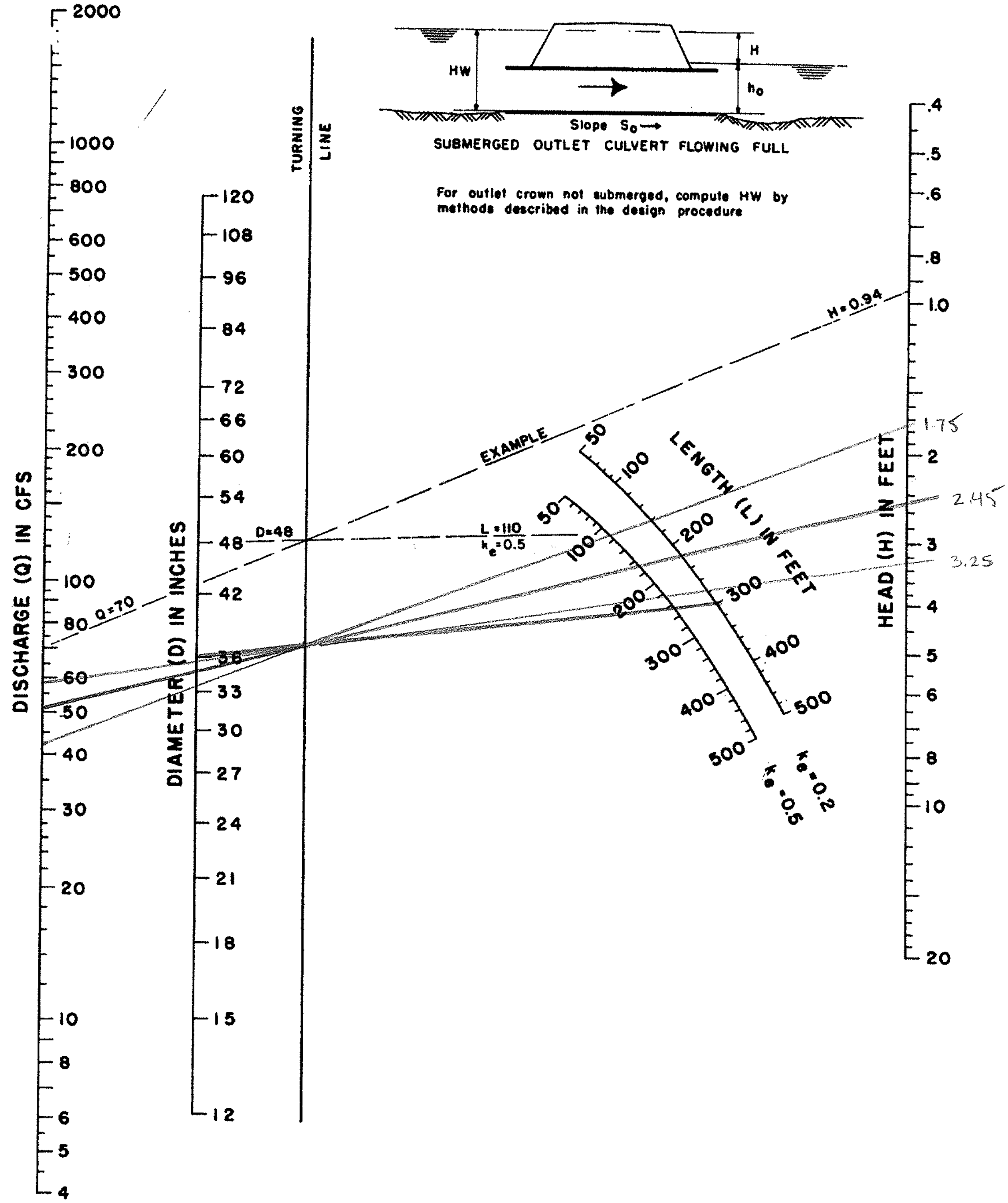


BUREAU OF PUBLIC ROADS
JAN. 1964

CRITICAL DEPTH
CIRCULAR PIPE

MP. 8.028 (PR)

CHART 5



HEAD FOR
CONCRETE PIPE CULVERTS
FLOWING FULL
n = 0.012

BUREAU OF PUBLIC ROADS JAN. 1963

CROSS DRAIN ANALYSIS - EXISTING CONDITION

HNTB Corporation
610 Crescent Executive Court, Suite 400
Lake Mary, FL 32746

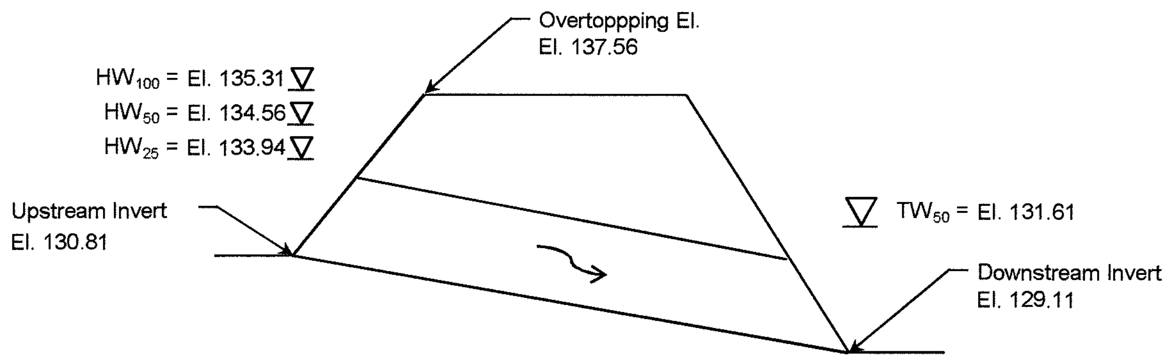
		DATE
made by:	LDP	25-Sep-13
checked by:	HJJ	25-Sep-13
HNTB job #:	59219	

PROJECT: **I-4 PD&E - Segment 2**

LOCATION: **MP 8.545**

Cross Drain Characteristics:

Number of Barrels:	1
Cross Drain Shape:	Round
Manning's "n":	0.012
Entrance Loss Coef.:	0.20
Span (B):	2.5 ft
Height (D):	2.5 ft
Length (L):	228 ft
Slope (So):	0.007 ft/ft
Upstream Invert:	130.81
Downstream Invert:	129.11
Overtopping El.:	137.56
Tailwater El.:	131.61 (Based on crown of pipe)
Description:	30" Pipe



$Q_{25} = V*A = 6\ \text{fps} * (\pi D^2/4) =$ 29.5 cfs
$Q_{100} = 1.4 * Q_{25} =$ 41.2 cfs

Culvert Description	# of Barrels	Q (cfs)	Size		Headwater Computation											Con. HW	Outlet Velocity	Comments
					Inlet Control			Outlet Control HW = H + DTW - LSo										
			D	B	Q/B	HW/D*	HW	Ke	H**	d_c***	$(d_c+D)/2$	TW	DTW	LSo	HW			
30" Pipe 25 Yr	1	29.5	2.5 ft	2.5 ft	11.78	1.25	3.13	0.20	1.80	1.90	2.2	2.50	2.5	1.7	2.60	3.13	6.00	
30" Pipe 50 Yr	1	35.2	2.5 ft	2.5 ft	14.08	1.50	3.75	0.20	2.40	2.00	2.25	2.50	2.5	1.7	3.20	3.75	7.17	
30" Pipe 100 Yr	1	41.2	2.5 ft	2.5 ft	16.49	1.80	4.50	0.20	3.40	2.20	2.35	2.50	2.5	1.7	4.20	4.50	8.40	

* From Chart 1 of HDS-5
** From Chart 5 of HDS-5
*** From Chart 4 of HDS-5

CROSS DRAIN ANALYSIS - PROPOSED CONDITION

HNTB Corporation
610 Crescent Executive Court, Suite 400
Lake Mary, FL 32746

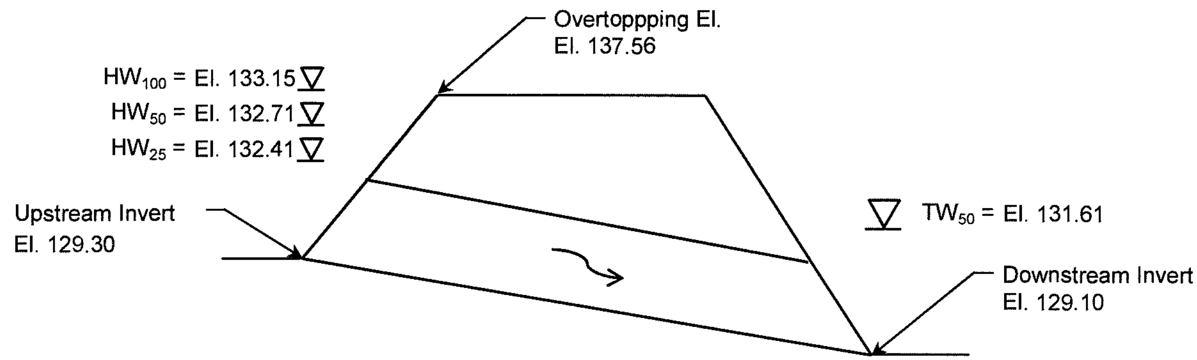
		DATE
made by:	LDP	25-Sep-13
checked by:	HJJ	25-Sep-13
HNTB job #:	59219	

PROJECT: **I-4 PD&E - Segment 2**

LOCATION: **MP 8.545**

Cross Drain Characteristics:

Number of Barrels:	1
Cross Drain Shape:	Round
Manning's "n":	0.012
Entrance Loss Coef.:	0.20
Span (B):	3.0 ft
Height (D):	3.0 ft
Length (L):	283 ft
Slope (So):	0.0007 ft/ft
Upstream Invert:	129.30
Downstream Invert:	129.10
Overtopping El.:	137.56
Tailwater El.:	131.61
Description:	36" Pipe



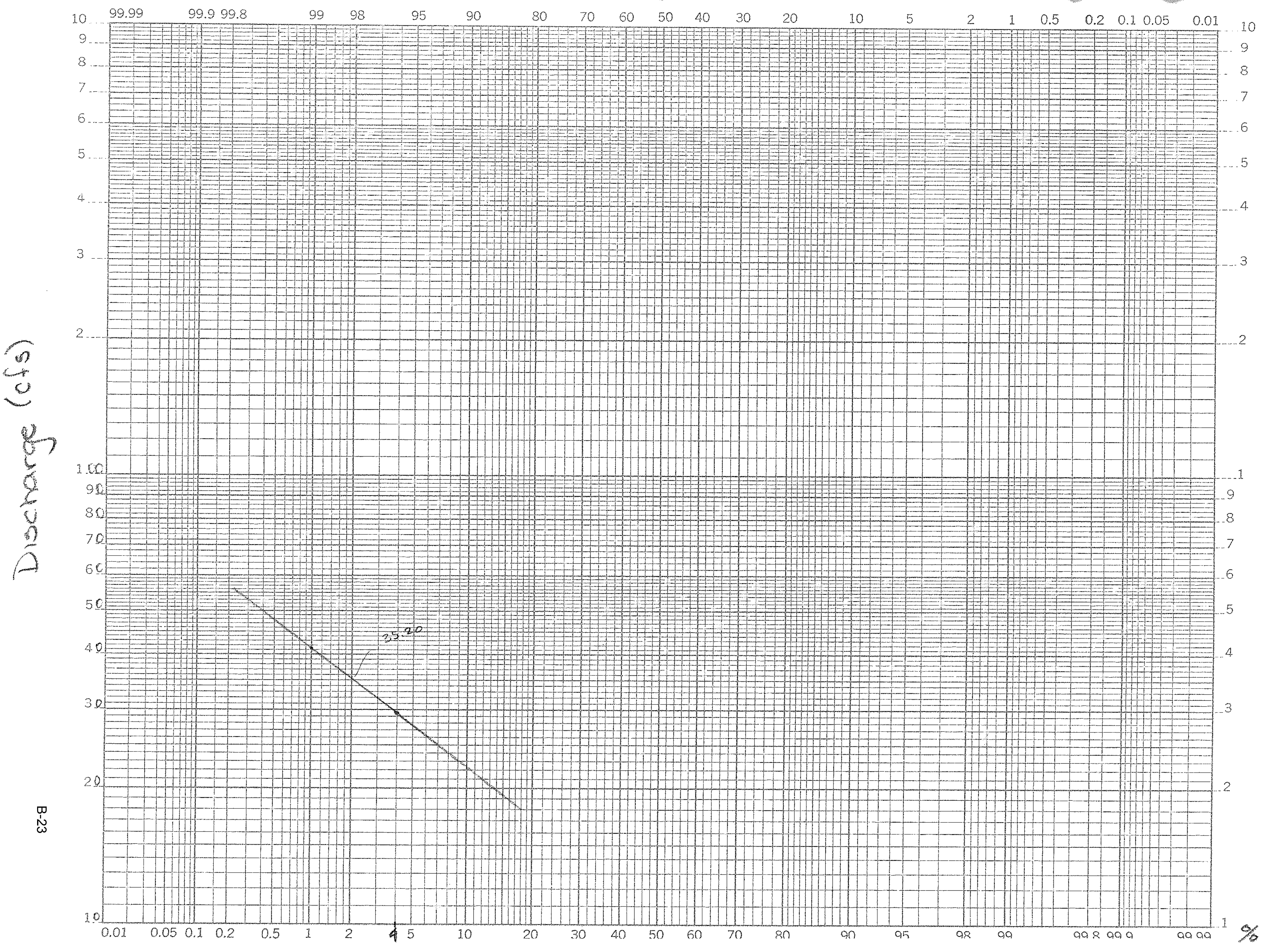
Culvert Description	# of Barrels	Q (cfs)	Size		Headwater Computation												Con. HW	Outlet Velocity	Comments
					Inlet Control			Outlet Control HW = H + DTW - LSo											
			D	B	Q/B	HW/D*	HW	Ke	H**	d_c***	$(d_c+D)/2$	TW	DTW	LSo	HW				
36" Pipe 25 Yr	1	29.5	3.0 ft	3.0 ft	9.82	0.88	2.64	0.20	0.80	1.80	2.4	2.51	2.51	0.2	3.11	3.11	4.17		
36" Pipe 50 Yr	1	35.2	3.0 ft	3.0 ft	11.73	1.00	3.00	0.20	1.10	1.90	2.45	2.51	2.51	0.2	3.41	3.41	4.98		
36" Pipe 100 Yr	1	41.2	3.0 ft	3.0 ft	13.74	1.12	3.36	0.20	1.50	2.10	2.55	2.51	2.55	0.2	3.85	3.85	5.83		

* From Chart 1 of HDS-5
** From Chart 5 of HDS-5
*** From Chart 4 of HDS-5

MP 8.545

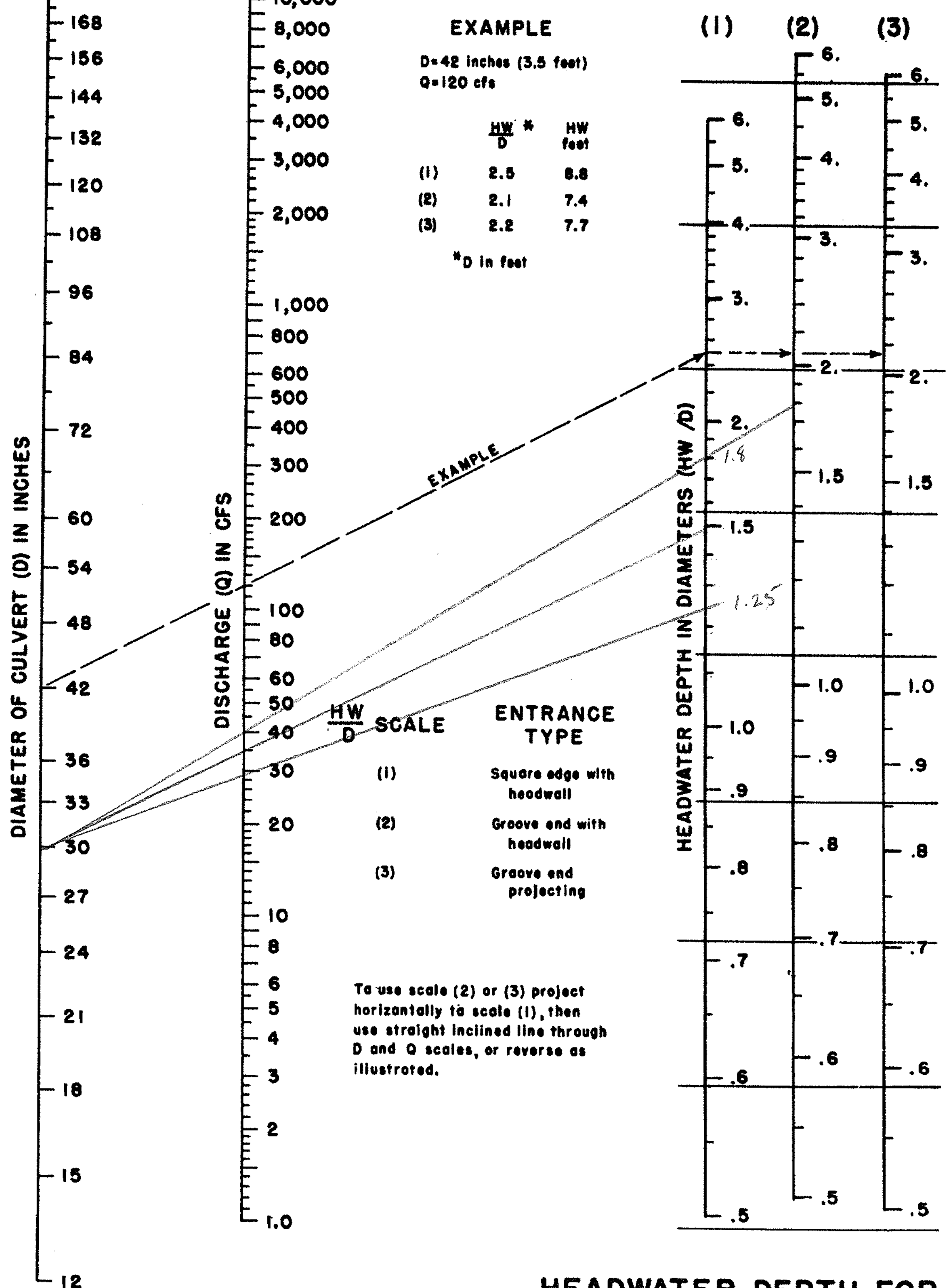
K+E PROBABILITY X 2 LOG CYCLES
KEUFFEL & ESSER CO. MADE IN U.S.A

46 8040



MP 8.545 (Ex)

CHART 10



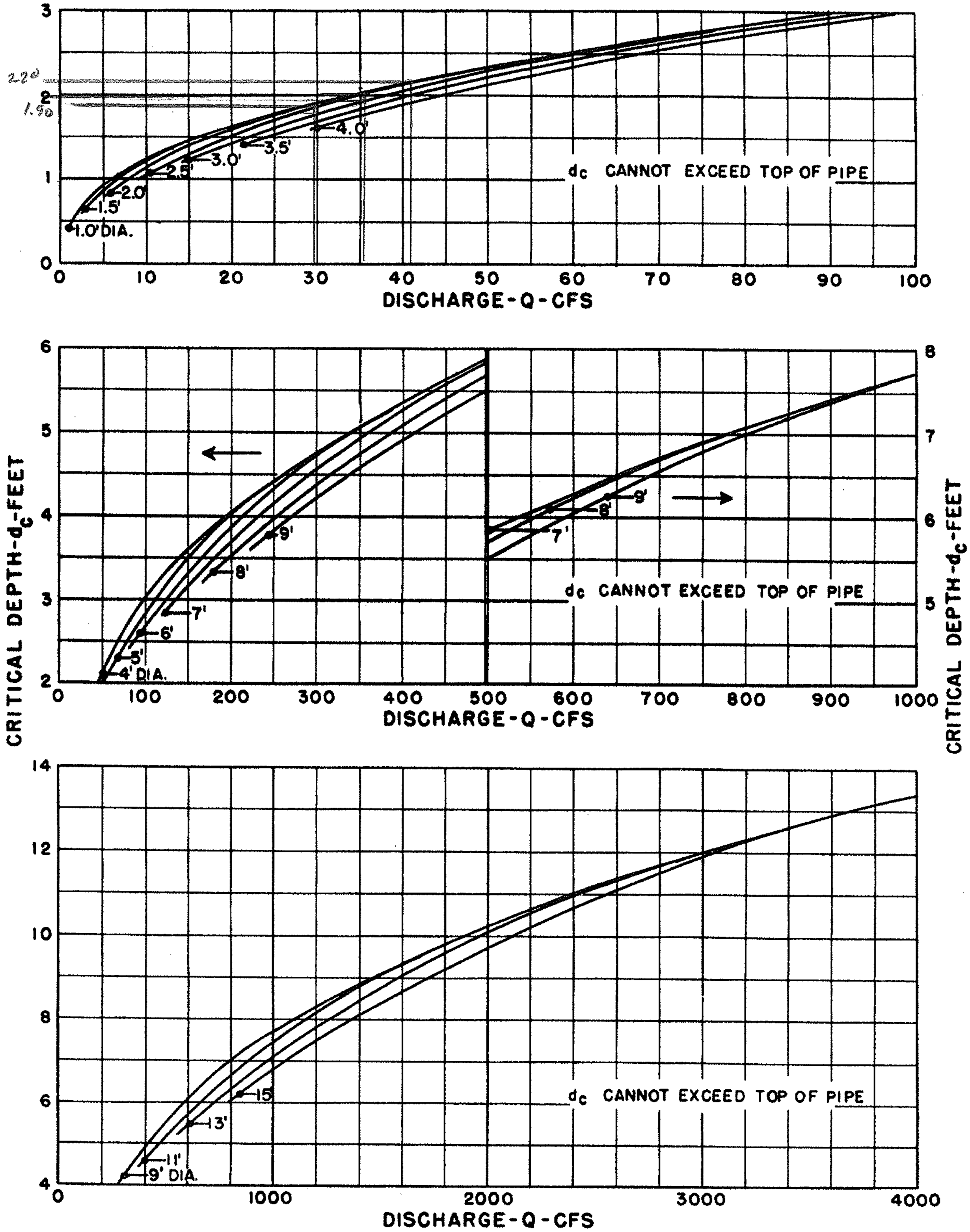
HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

HEADWATER SCALES 2&3
REVISED MAY 1964

BUREAU OF PUBLIC ROADS JAN. 1963

MP 8.545 (Ex)

CHART 4



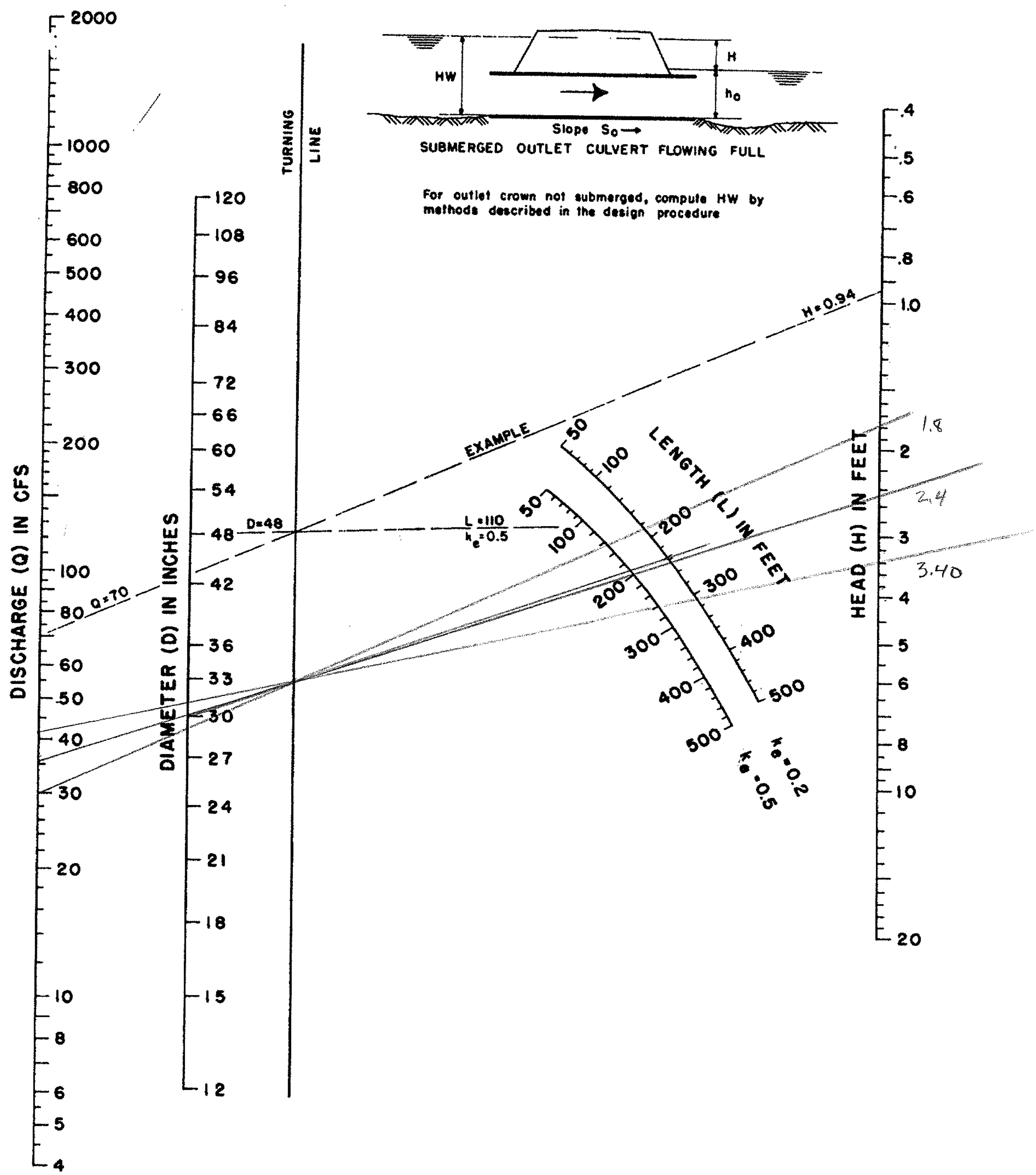
BUREAU OF PUBLIC ROADS

JAN. 1964

CRITICAL DEPTH
CIRCULAR PIPE

MP 8.545(Ex)

CHART 5

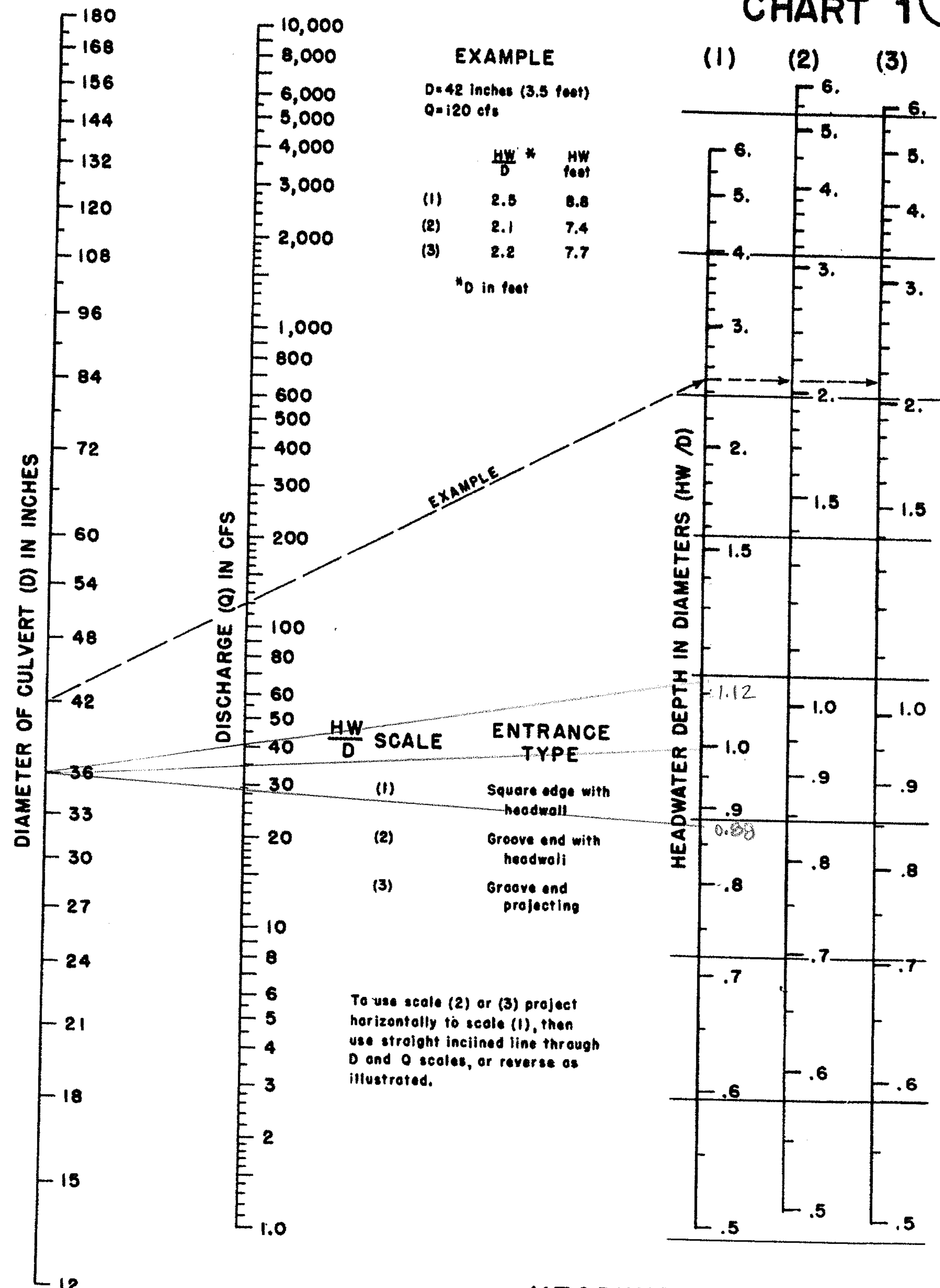


BUREAU OF PUBLIC ROADS JAN. 1963

HEAD FOR CONCRETE PIPE CULVERTS FLOWING FULL n = 0.012

MP 8.545(PR)

CHART 1



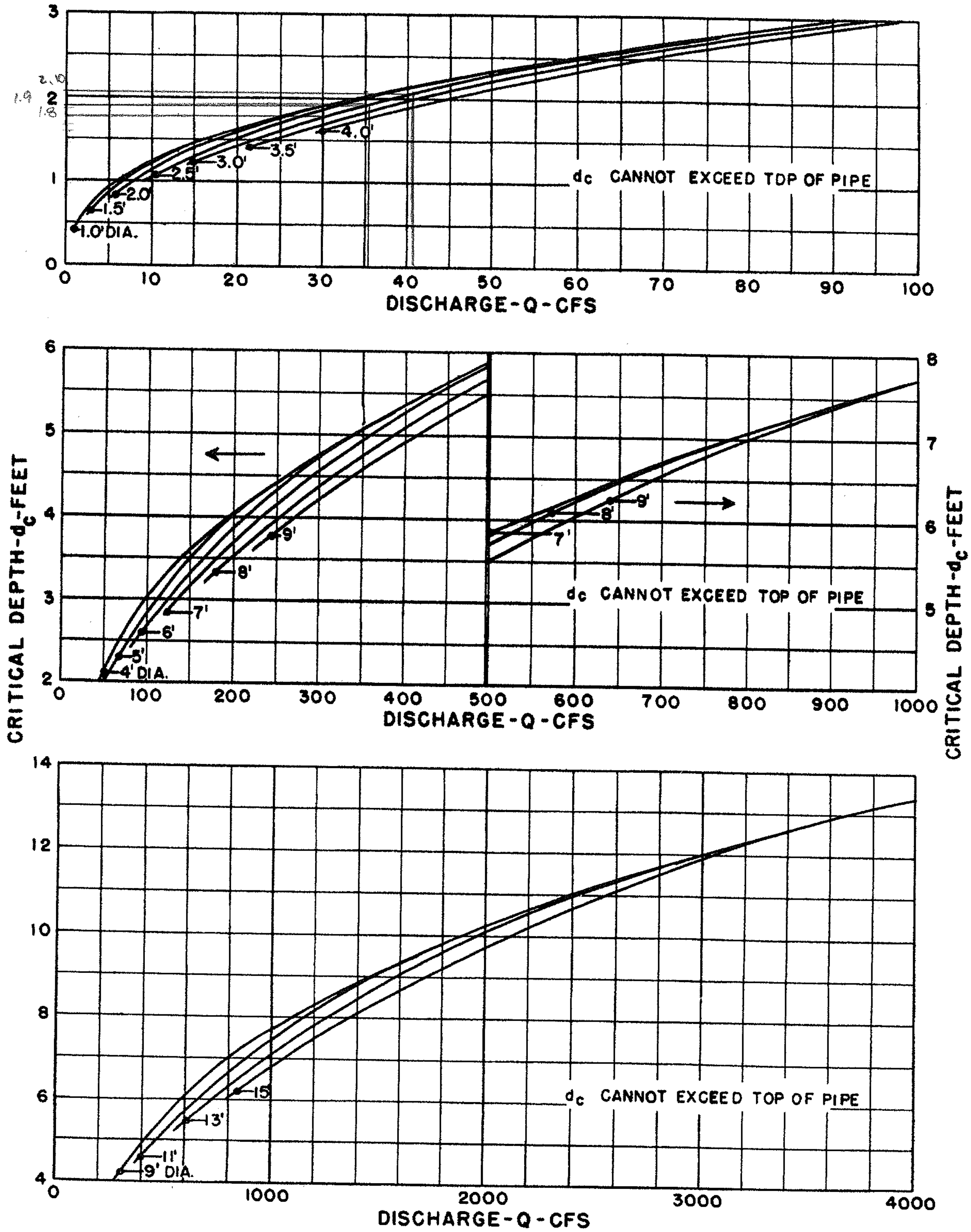
HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

HEADWATER SCALES 2&3
REVISED MAY 1964

BUREAU OF PUBLIC ROADS JAN. 1963

MP 8.545 (PR)

CHART 4



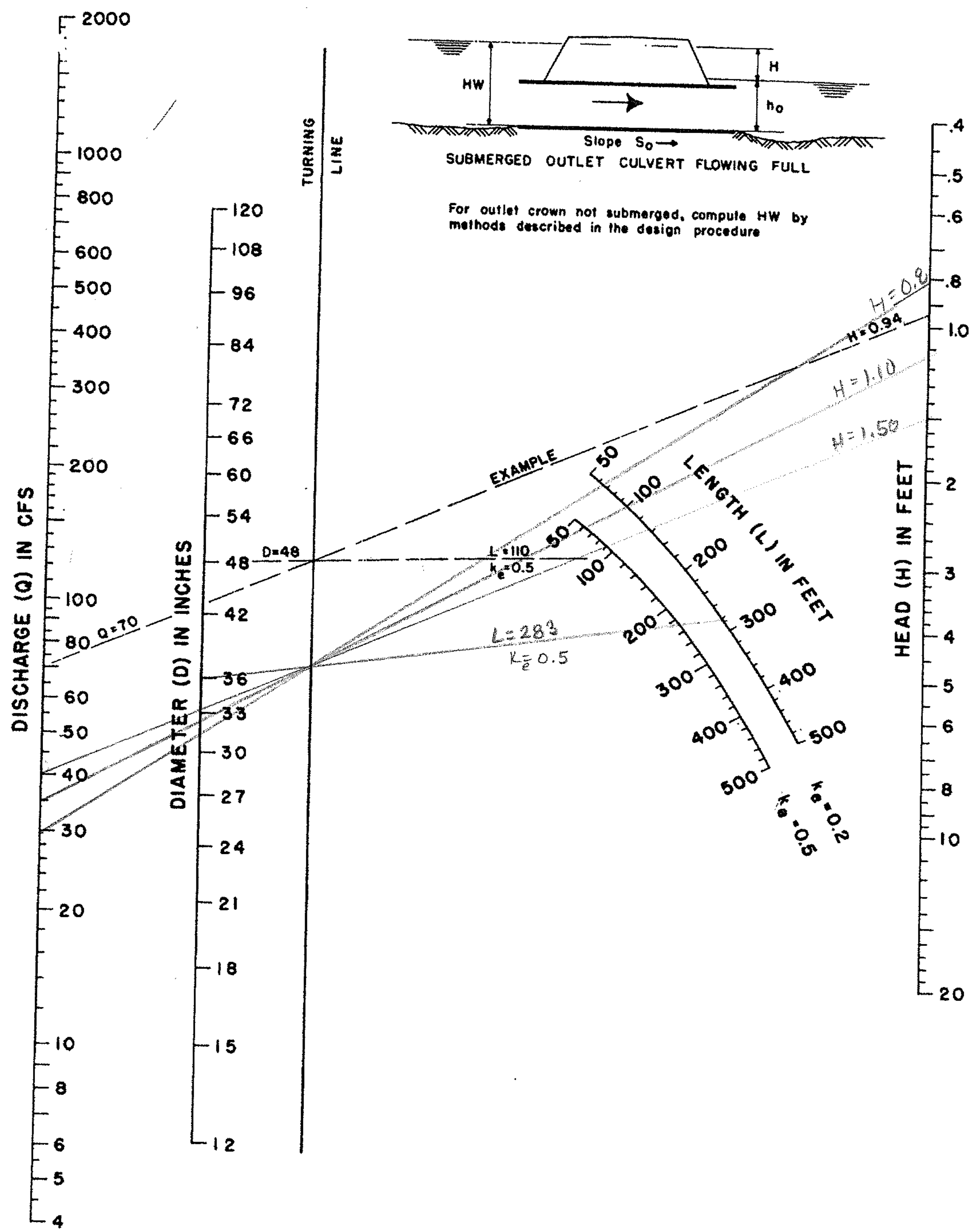
BUREAU OF PUBLIC ROADS

JAN. 1964

CRITICAL DEPTH
CIRCULAR PIPE

MP 8.545 (PR)

CHART 5



HEAD FOR CONCRETE PIPE CULVERTS FLOWING FULL

n = 0.012

BUREAU OF PUBLIC ROADS JAN. 1963