

## APPENDIX A - CULVERT PERFORMANCE CHARTS

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These charts provide nomographs to determine inlet and outlet control headwater depths for common culvert shapes. Nomographs for additional culvert shapes are in FHWA Hydraulic Design Series No. 5 “Hydraulic Design of Highway Culverts.”

***Note:** The outlet control nomographs provide accurate estimates of headwater depths if there is full flow in the culvert barrel and a submerged outlet. The nomographs may slightly overestimate headwater depths if the barrel flows partially full.*

### INDEX TO CULVERT PERFORMANCE CHARTS

Chart	Shape	Material	Control	Comments
1	Circular	Concrete	Inlet	Inlet projecting or in headwall
2	Circular	Concrete	Inlet	Prefabricated concrete end section
3	Circular	Metal	Inlet	Corrugated or structural plate pipe with inlet projecting, mitered, or in headwall. <b>(Use Scale 2 for ODOT sloped end with or without slope paving.)</b>
4	Circular	Metal	Inlet	Safety end section with bars <b>(Use for concrete or metal barrel.)</b>
5	Circular	Metal	Inlet	Prefabricated metal end section
6	Circular	Metal	Inlet	Reinforced concrete beveled ring around inlet
7	Circular	Concrete	Outlet	
8	Circular	Metal	Outlet	Corrugated metal pipe

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**INDEX TO CULVERT PERFORMANCE CHARTS, CONTD.**


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Chart	Shape	Material	Control	Comments
9	Circular	Metal	Outlet	Structural plate pipe
10	Box	Concrete	Inlet	Top edge square with wingwalls
11	Box	Concrete	Inlet	Top edge beveled with wingwalls ( <b>Use Scale 2 for box culvert shown on ODOT Standard Drawing BR 800.</b> )
12	Box	Concrete	Outlet	
13	Pipe-Arch	Metal	Inlet	Corrugated pipe-arch with inlet projecting, mitered, or in headwall ( <b>Use Scale 2 for ODOT sloped end with or without slope paving.</b> )
14	Pipe-Arch	Metal	Inlet	Structural plate pipe-arch with inlet projecting, or in headwall with or without beveled edge and 18-inch corner radius
15	Pipe-Arch	Metal	Inlet	Structural plate pipe-arch with inlet projecting, or in headwall with or without beveled edge and 31-inch corner radius
16	Pipe-Arch	Metal	Outlet	Corrugated metal
17	Pipe-Arch	Metal	Outlet	Structural plate with 18-inch corner radius
18	Arch	Metal	Inlet	Structural plate arch with inlet projecting, mitered, or in headwall with $0.3 \leq \text{Rise/Span} < 0.4$

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**INDEX TO CULVERT PERFORMANCE CHARTS, CONTD.**

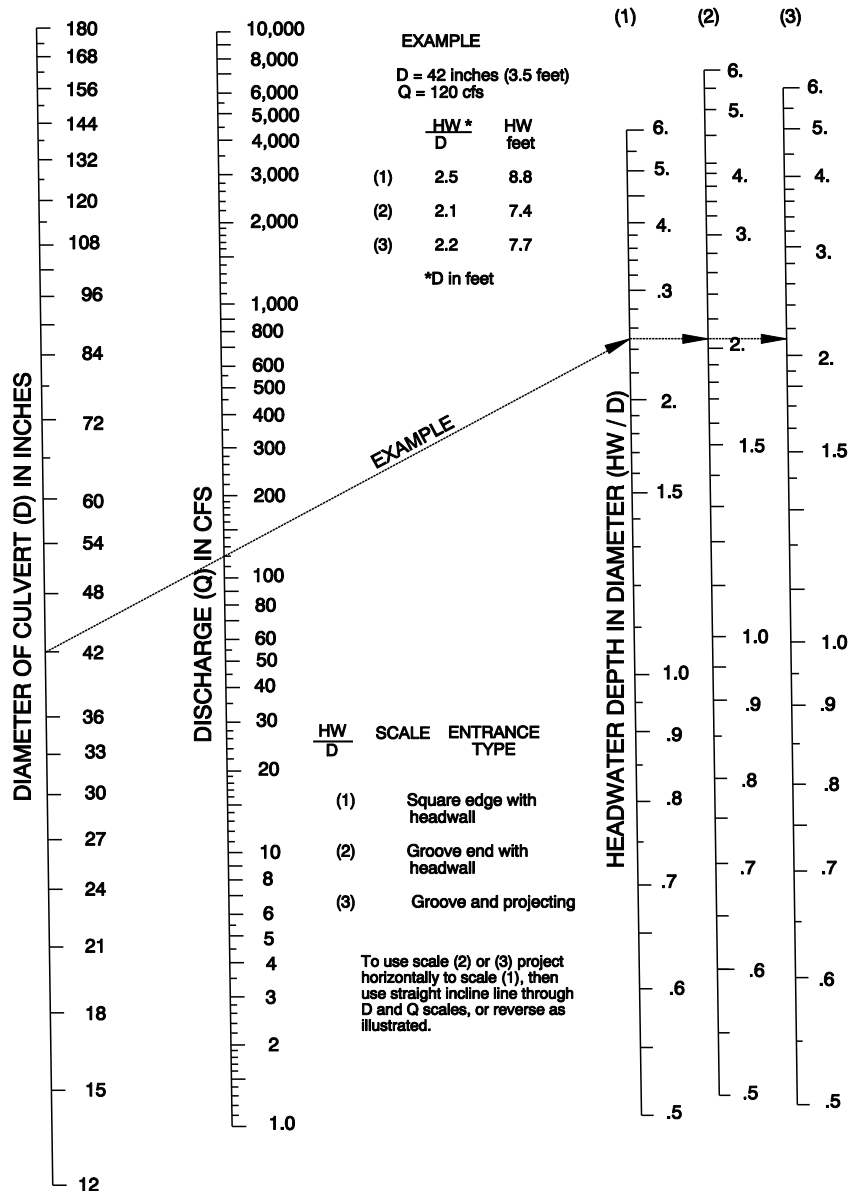

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Chart	Shape	Material	Control	Comments
19	Arch	Metal	Inlet	Structural plate arch with inlet projecting, mitered, or in headwall with $0.4 \leq \text{Rise/Span} < 0.5$
20	Arch	Metal	Inlet	Structural plate arch with inlet projecting, mitered, or in headwall with $0.5 \leq \text{Rise/Span}$
21	Arch	Metal	Outlet	Structural plate arch with earth bottom and $0.3 \leq \text{Rise/Span} < 0.4$
22	Arch	Metal	Outlet	Structural plate arch with earth bottom and $0.4 \leq \text{Rise/Span} < 0.5$
23	Arch	Metal	Outlet	Structural plate arch with earth bottom and $0.5 < \text{Rise/Span}$

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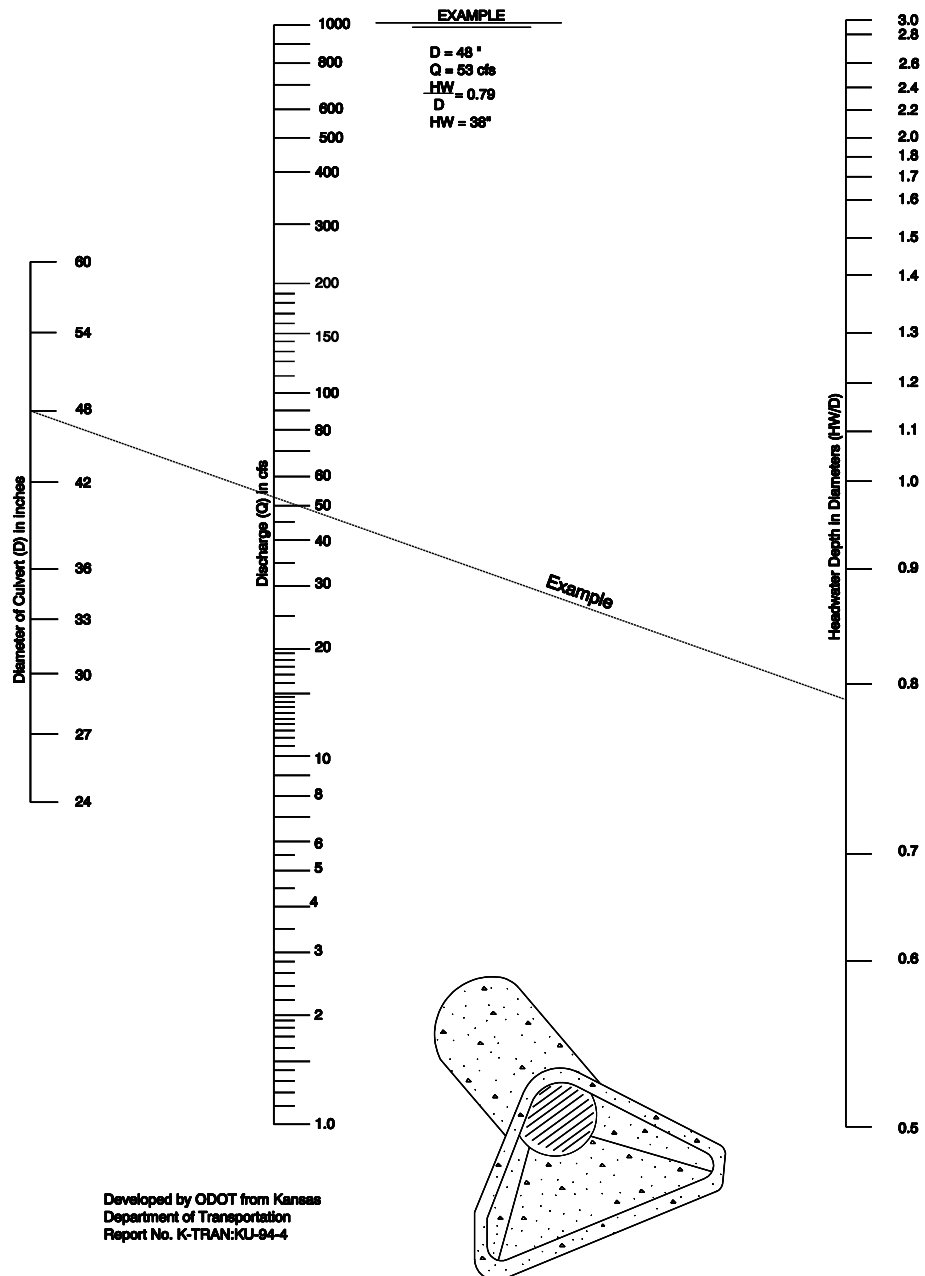
# CHART 1

## HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL



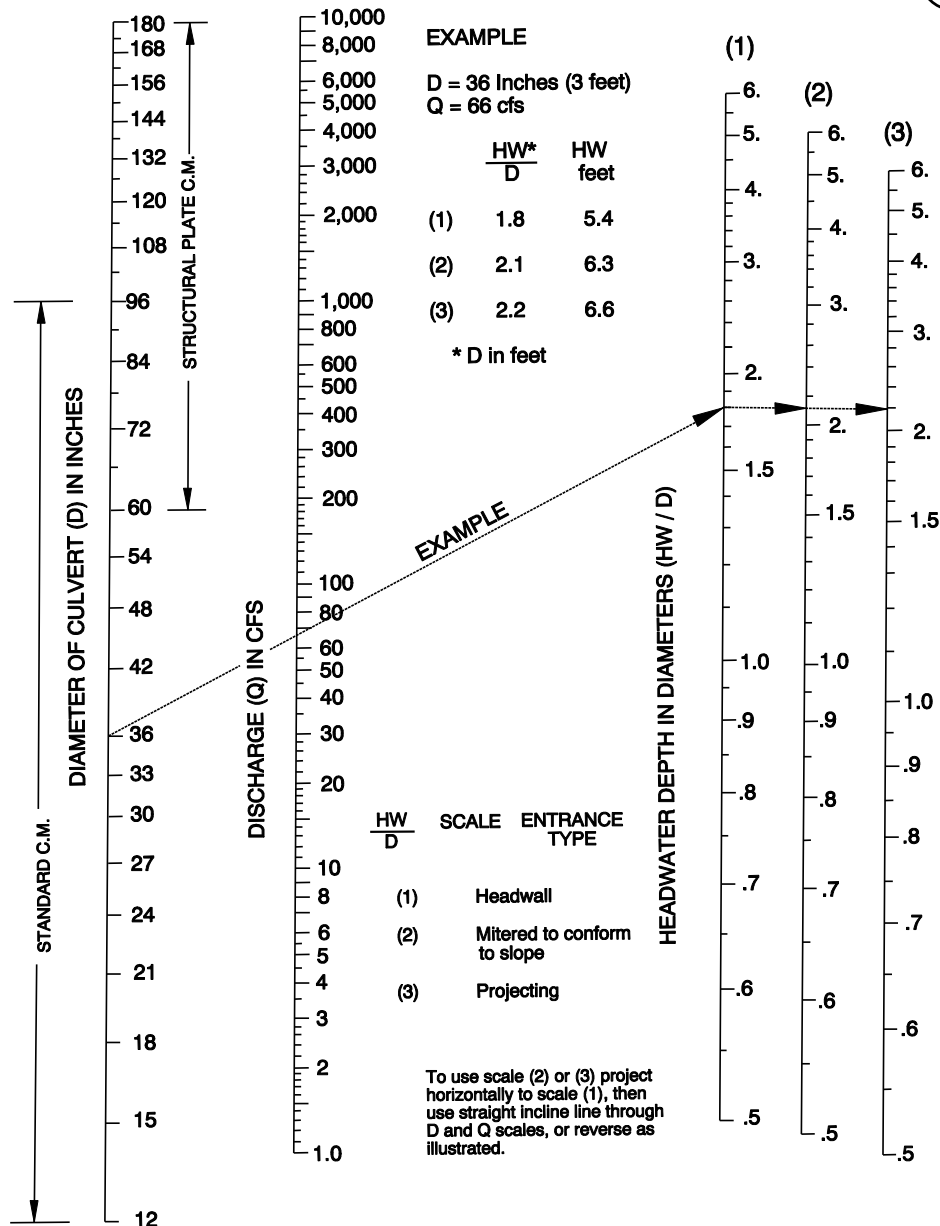
## CHART 2

### HEADWATER DEPTH FOR PREFABRICATED CONCRETE END SECTION IN INLET CONTROL



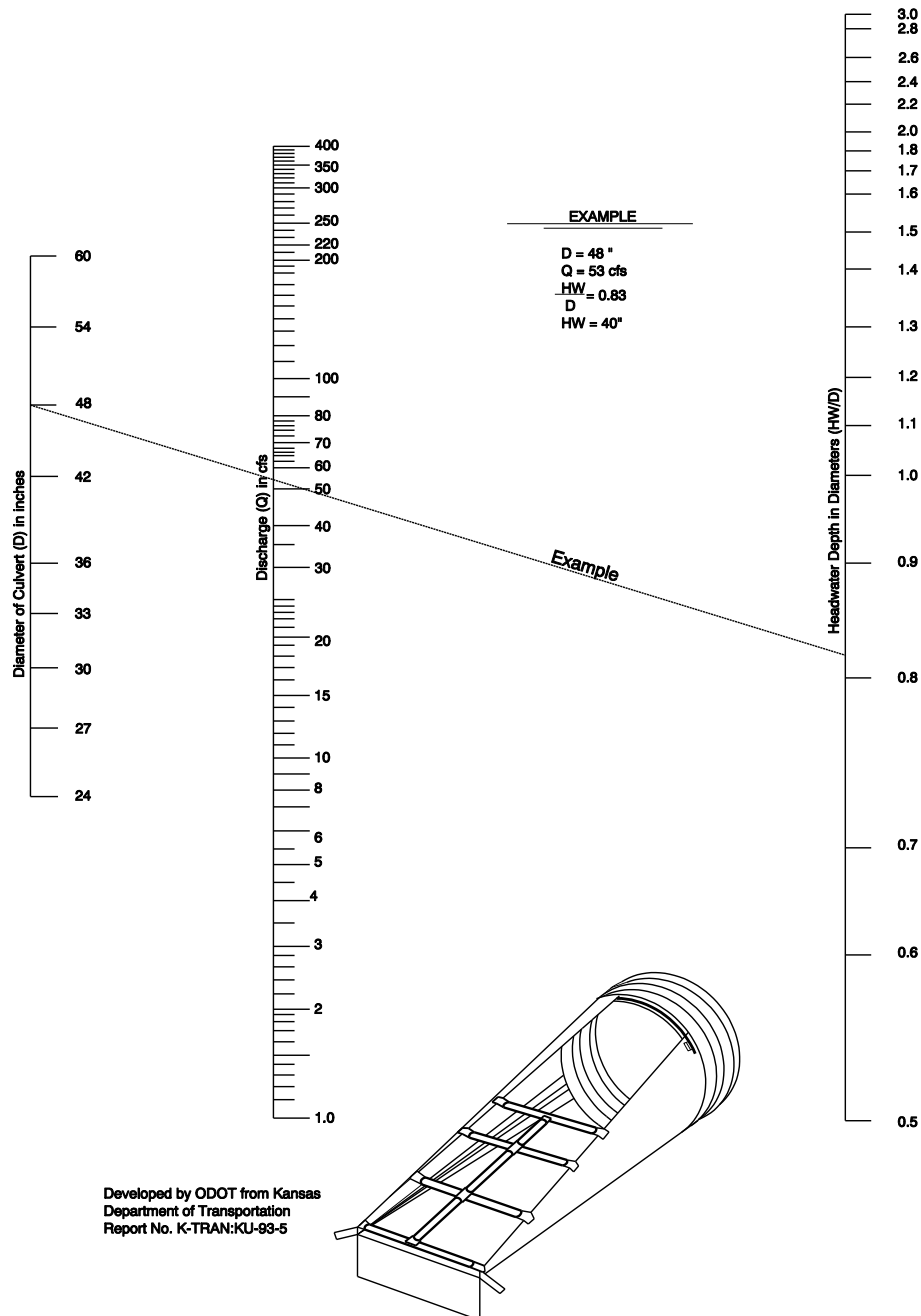
# CHART 3

## HEADWATER DEPTH FOR C.M. CULVERTS WITH INLET CONTROL

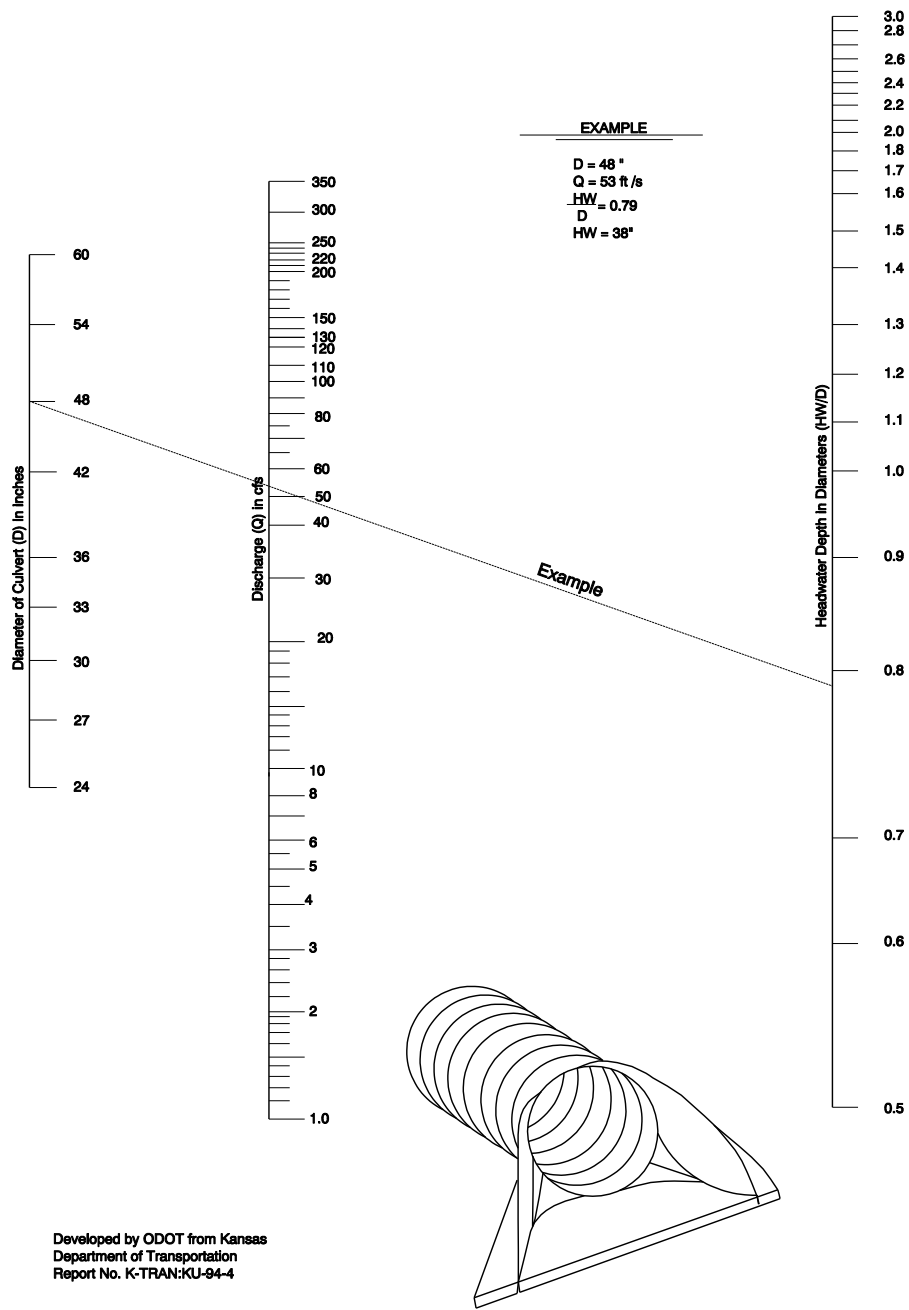




# **CHART 4** **HEADWATER DEPTH FOR** **SAFETY END SECTIONS** **WITH SAFETY BARS IN** **INLET CONTROL**

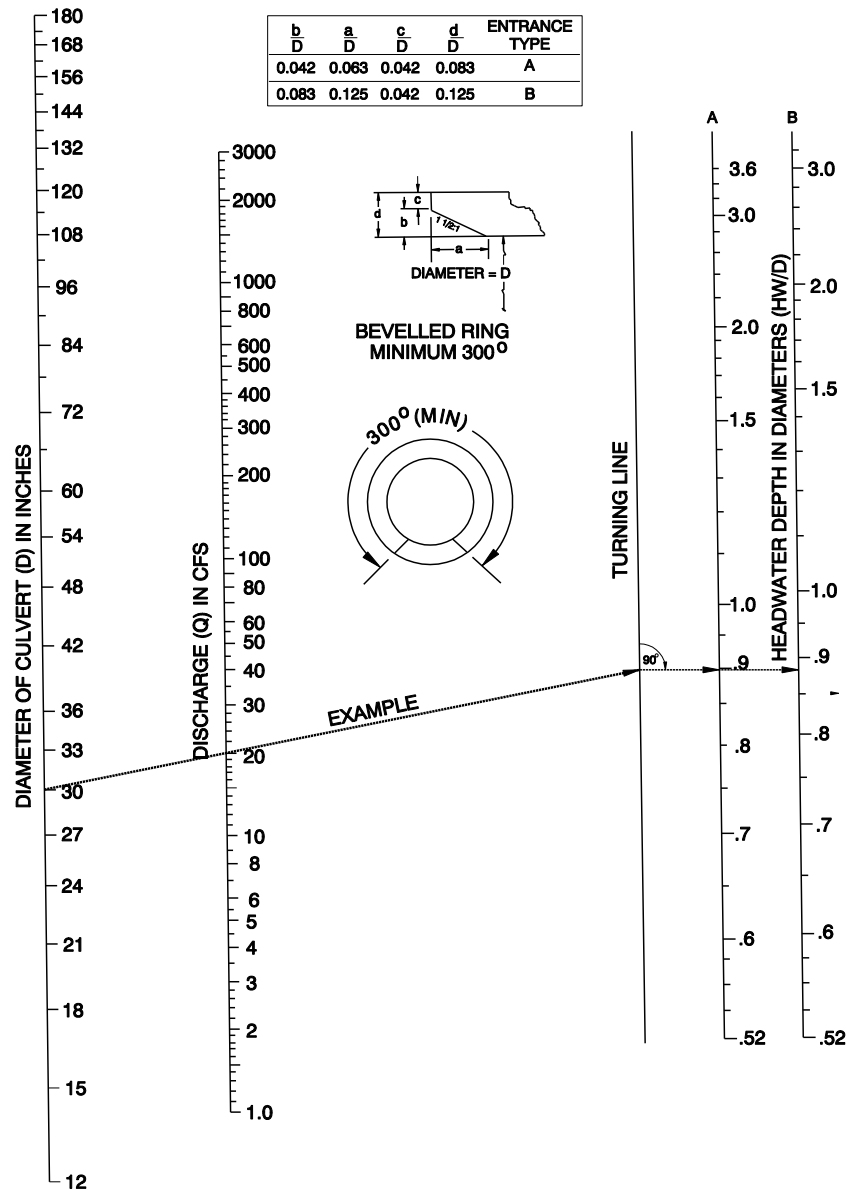


# **CHART 5** **HEADWATER DEPTH FOR** **PREFABRICATED METAL** **END SECTIONS IN INLET CONTROL**



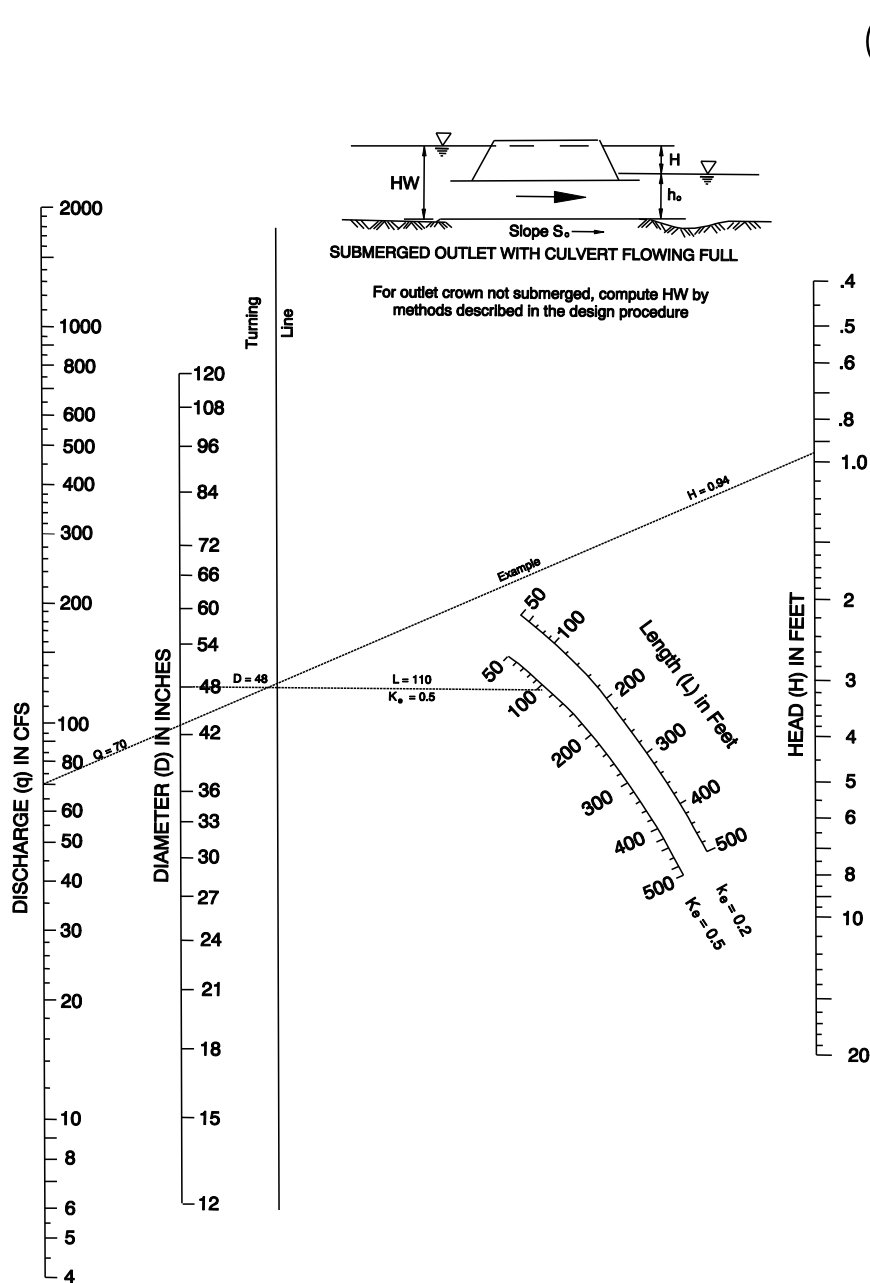
## CHART 6

### HEADWATER DEPTH FOR CIRCULAR PIPE CULVERTS WITH BEVELED RING INLET CONTROL



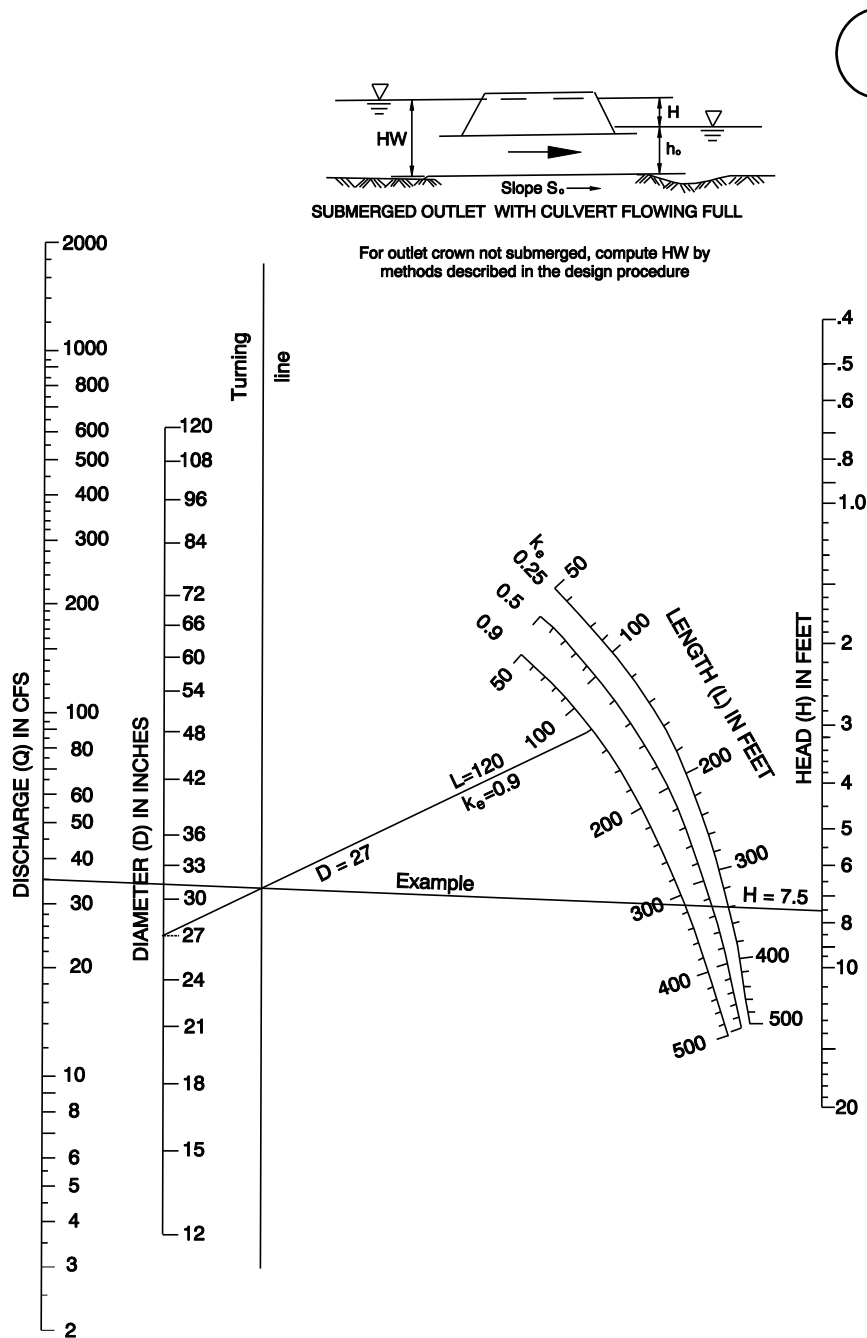
# CHART 7

## HEAD FOR CONCRETE PIPE CULVERTS FLOWING FULL IN OUTLET CONTROL $n = 0.012$

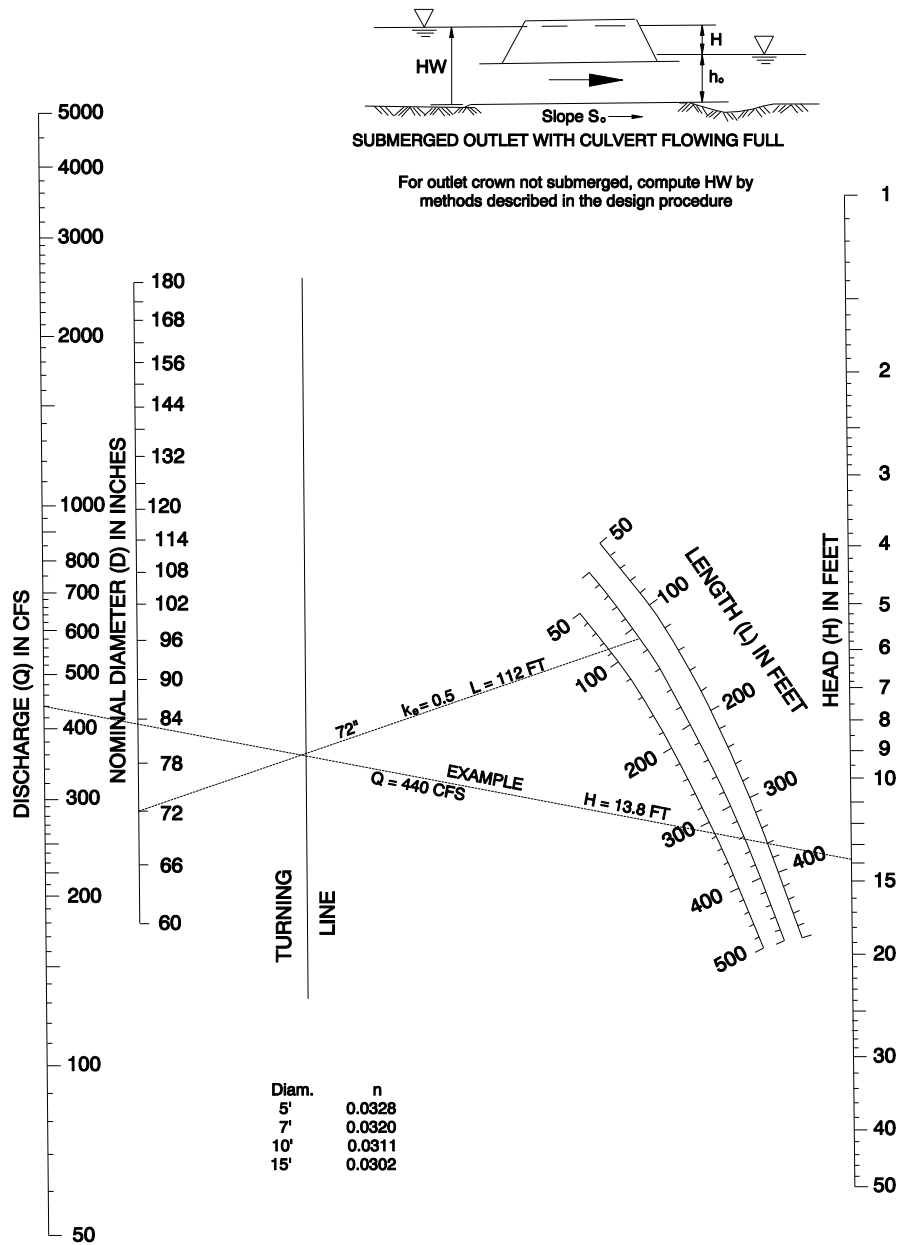


**CHART 8**

**HEAD FOR STANDARD**  
**C.M. PIPE CULVERTS**  
**FLOWING FULL IN OUTLET CONTROL**  
 $n = 0.024$

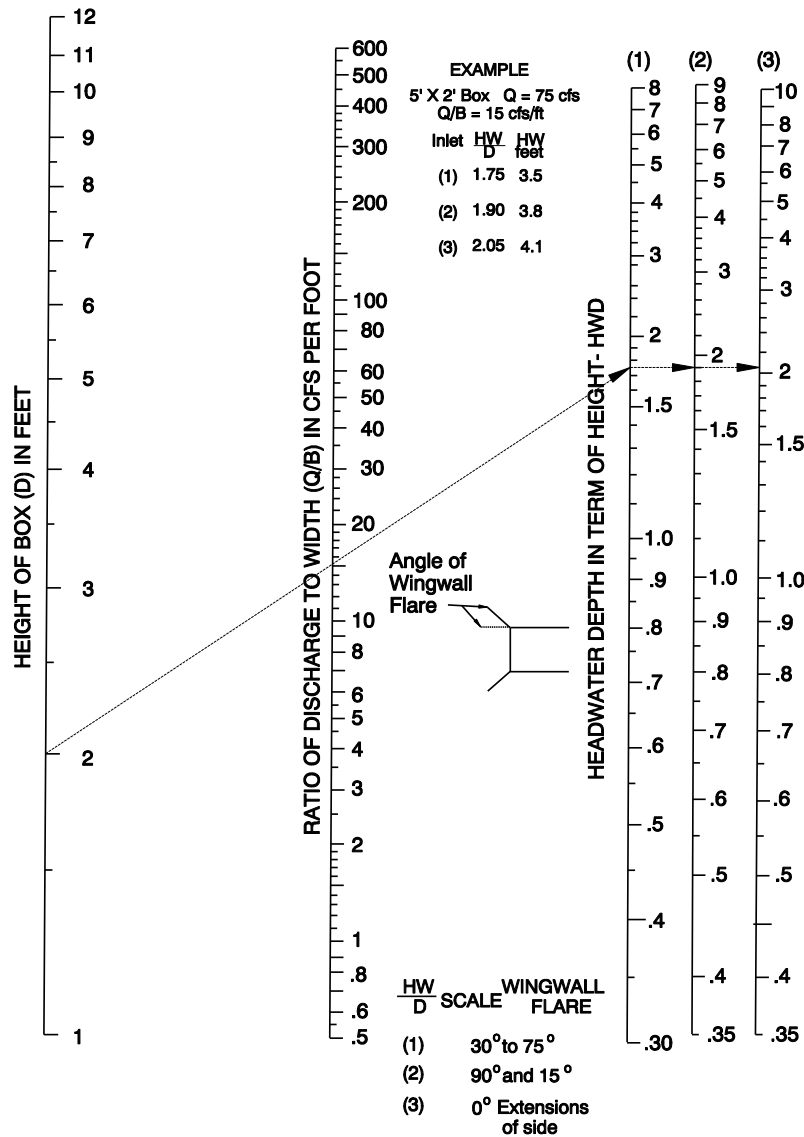


# **CHART 9** **HEAD FOR** **STRUCTURAL PLATE** **CORR. METAL PIPE CULVERTS** **FLOWING FULL IN OUTLET CONTROL** **$N = 0.0328$ TO $0.0302$**



# CHART 10

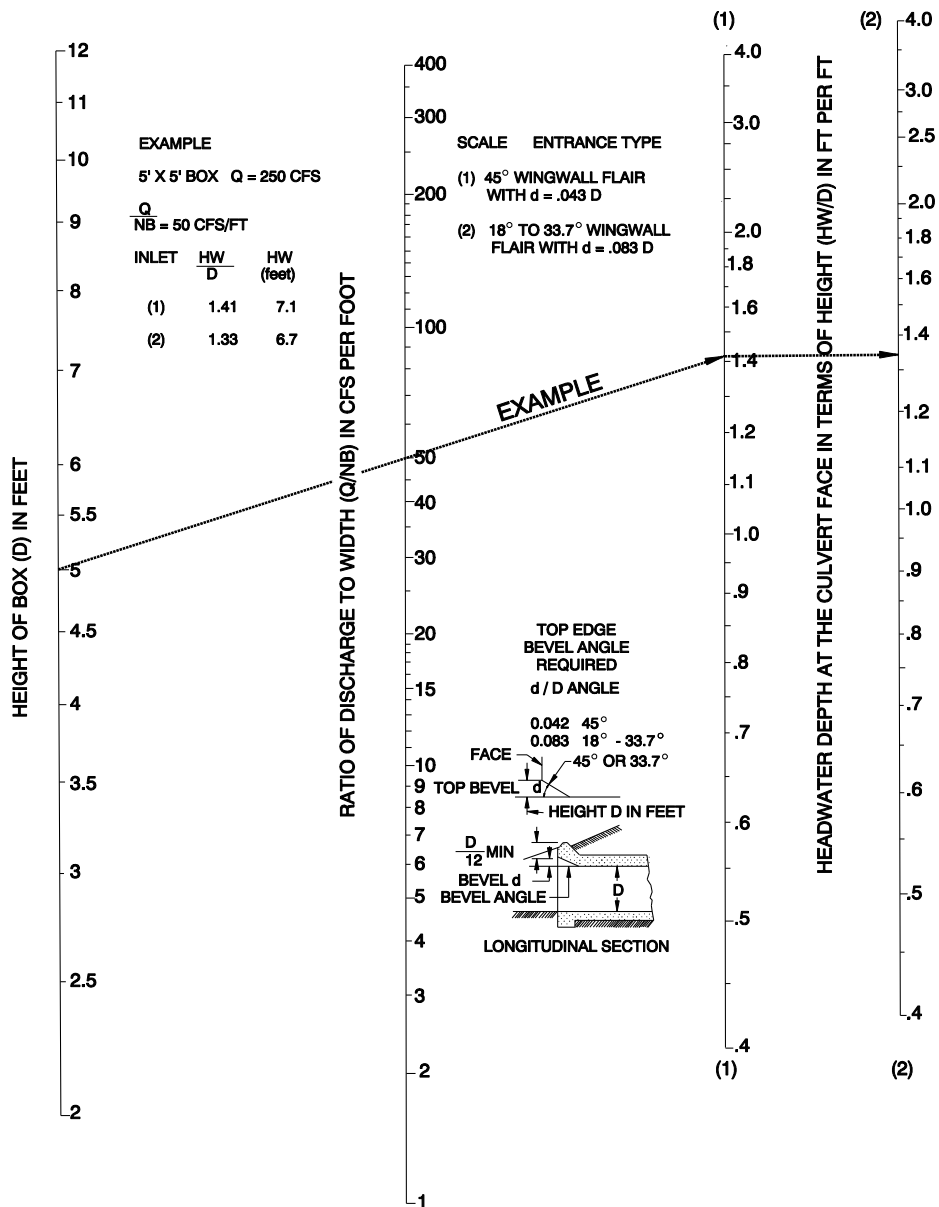
## HEADWATER DEPTH FOR BOX CULVERTS WITH INLET CONTROL



To use scale (2) (3) project horizontally to (1) then use straight inclined line through D and Q scales, or reverse as illustrated.

# CHART 11

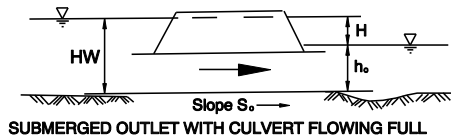
## HEADWATER DEPTH FOR RECTANGULAR BOX CULVERTS WITH INLET CONTROL FLARED WINGWALLS 18° TO 33.7° AND 45° WITH BEVELED EDGE AT TOP OF INLET



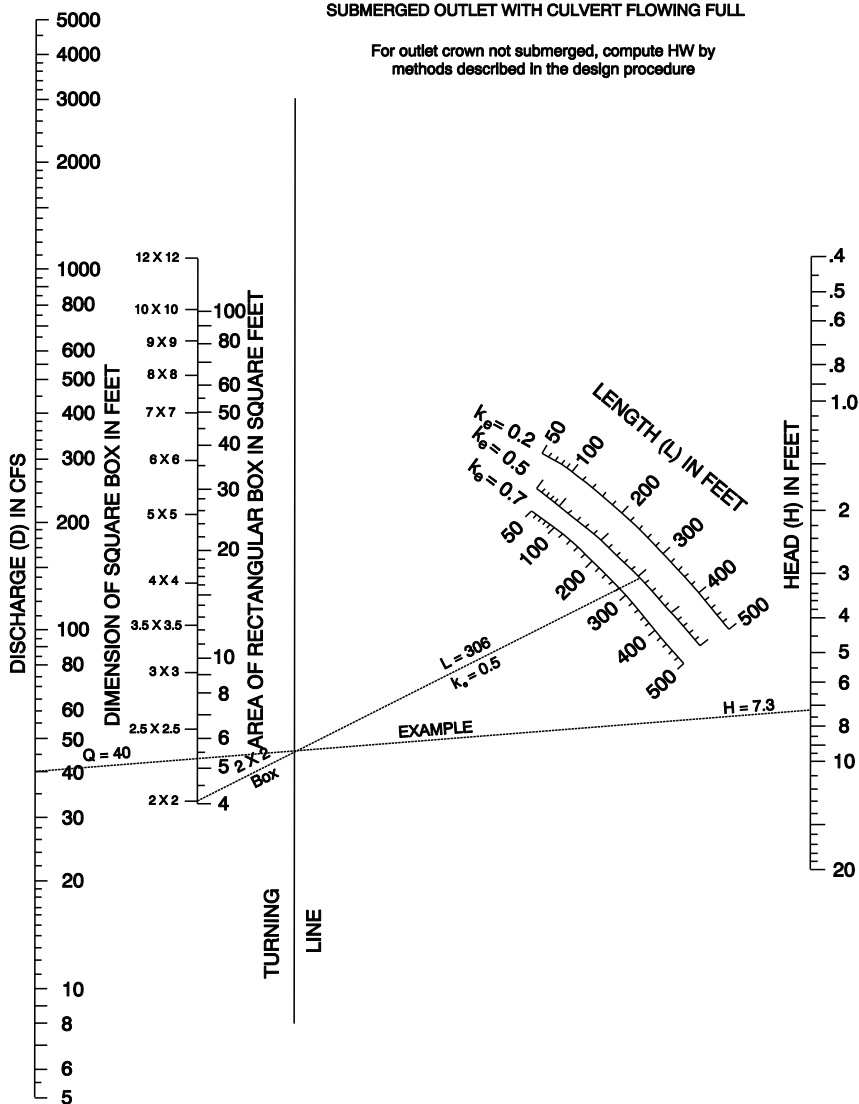


# CHART 12

## HEAD FOR CONCRETE BOX CULVERTS FLOWING FULL IN OUTLET CONTROL $n = 0.012$

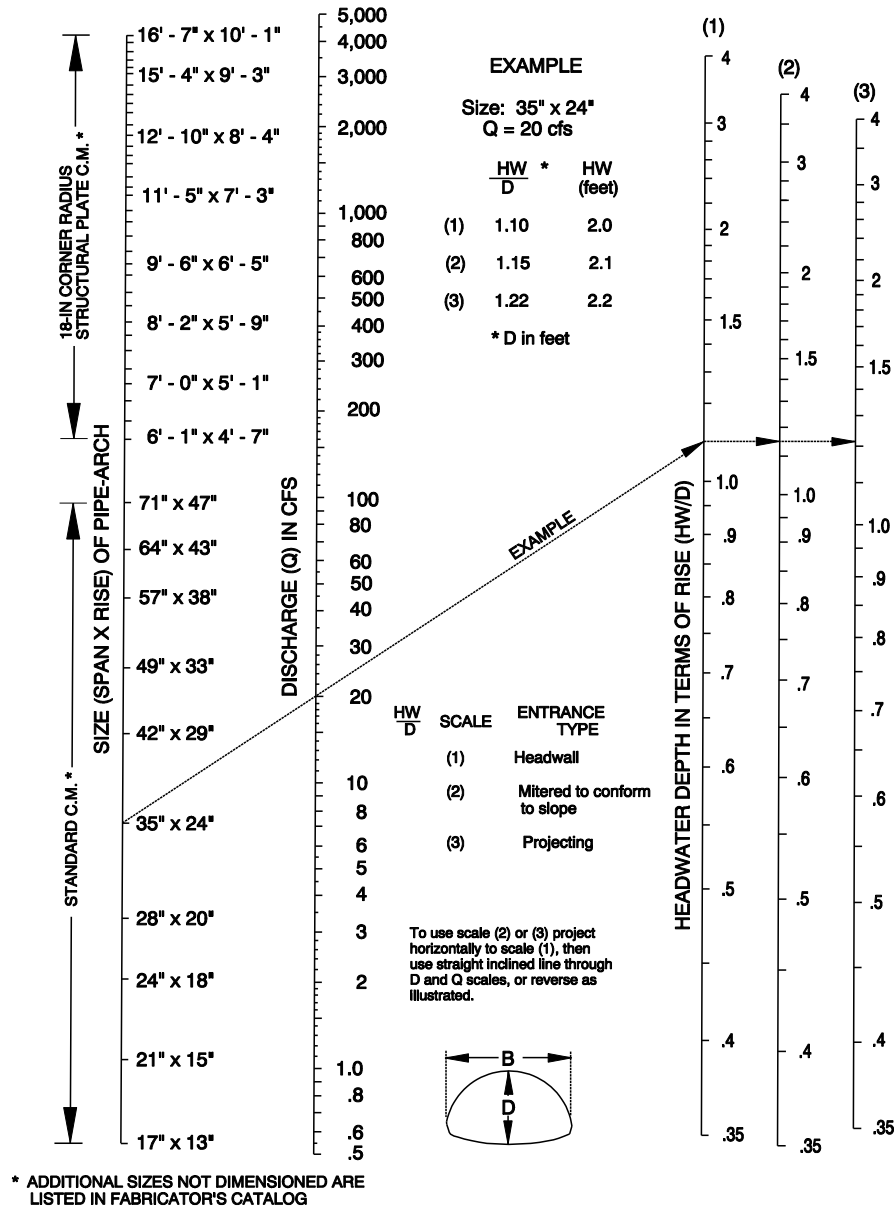


For outlet crown not submerged, compute HW by methods described in the design procedure



# CHART 13

## HEADWATER DEPTH FOR C.M. PIPE-ARCH CULVERTS WITH INLET CONTROL



## CHART 14

### HEADWATER DEPTH FOR STRUCTURAL PLATE PIPE-ARCH CULVERTS WITH INLET CONTROL

EXAMPLE  
SIZE 12.9' X 8.3' Q = 1000 CFS

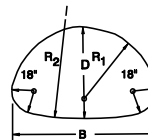
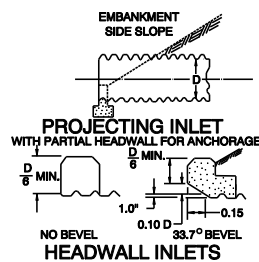
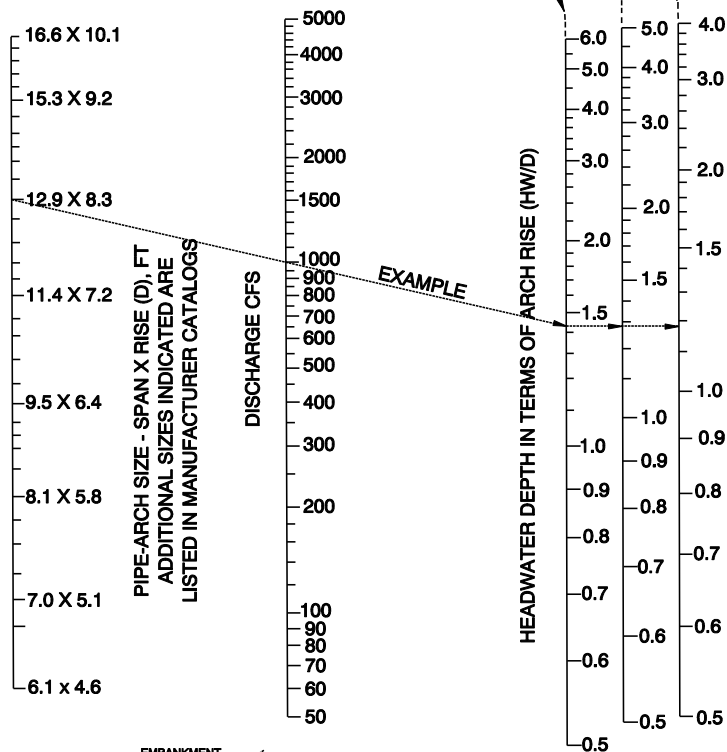
	PROJECT	HEADWALL NO BEV/BEVEL	
HW/D	1.42	1.27	1.17
HW/r	11.8	10.5	9.7

TYPE OF INLET  
90° HEADWALL:

33.7° X 0.10 D BEVEL

NO BEVEL

PROJECTING



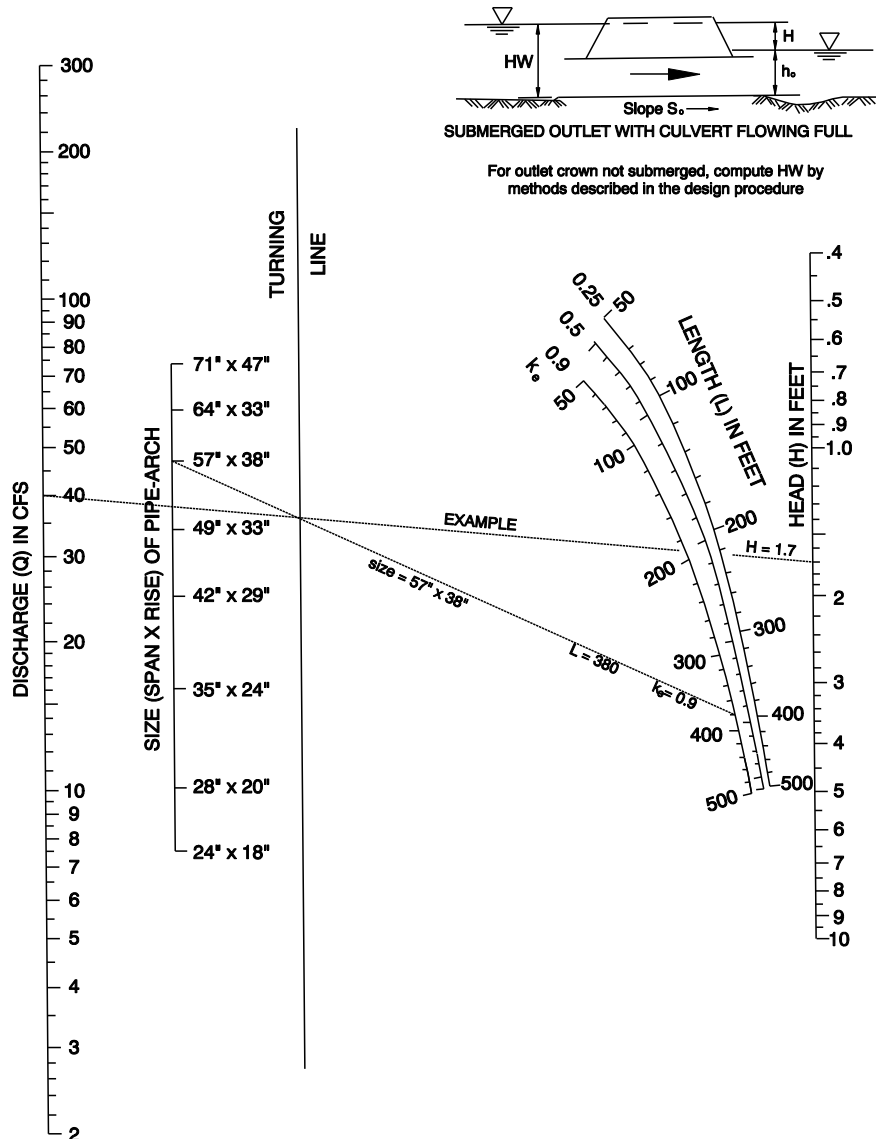
18-IN. RADIUS CORNER PLATE  
PROJECTING OR HEADWALL INLET  
HEADWALL WITH OR WITHOUT EDGE BEVEL



# CHART 16

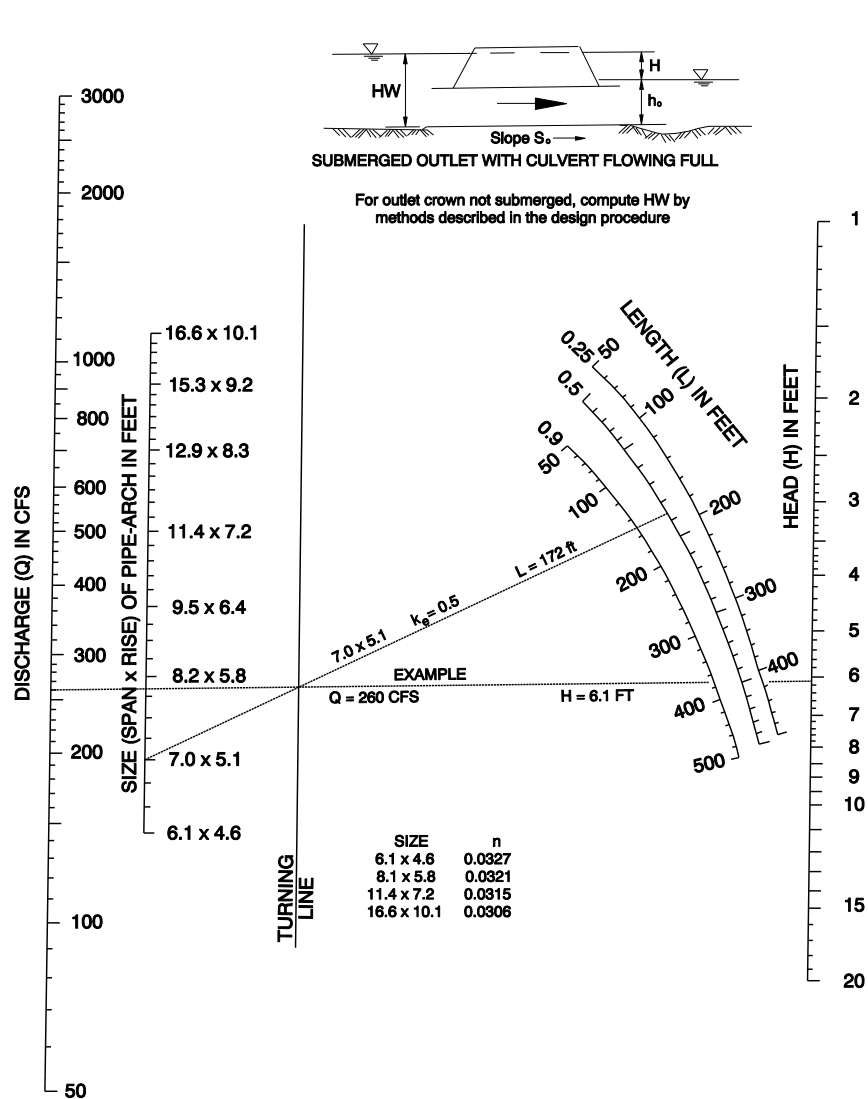
## HEAD FOR STANDARD C.M. PIPE-ARCH CULVERTS FLOWING FULL IN OUTLET CONTROL

$n = 0.024$



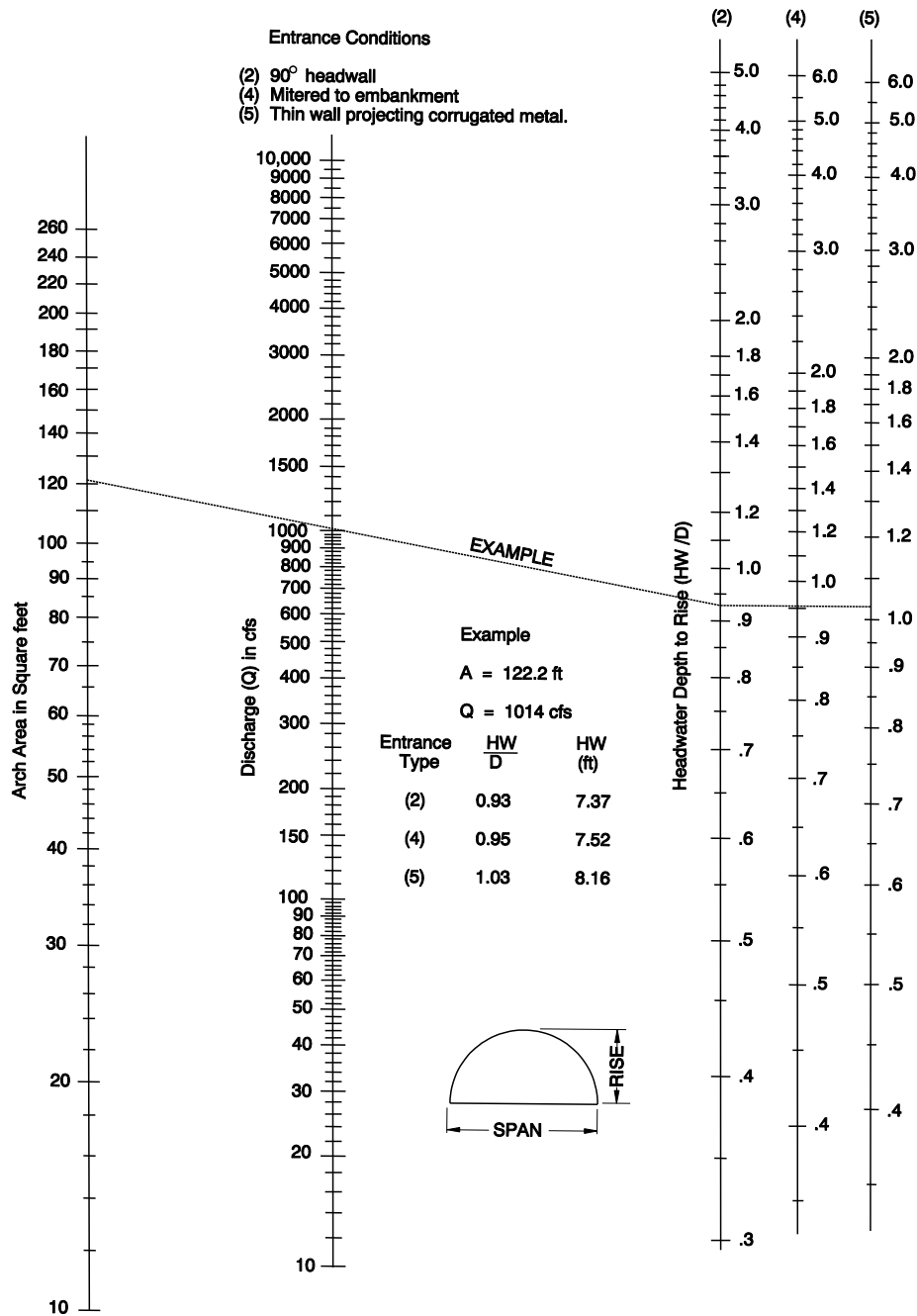
**CHART 17**

**HEAD FOR  
STRUCTURAL PLATE  
CORRUGATED METAL  
PIPE ARCH CULVERTS  
18 IN. CORNER RADIUS  
FLOWING FULL IN OUTLET CONTROL  
 $n = 0.0327$  TO  $0.0306$**



# CHART 18

## HEADWATER DEPTH FOR C.M. ARCH CULVERTS $0.3 \leq \text{RISE} / \text{SPAN} < 0.4$ WITH INLET CONTROL



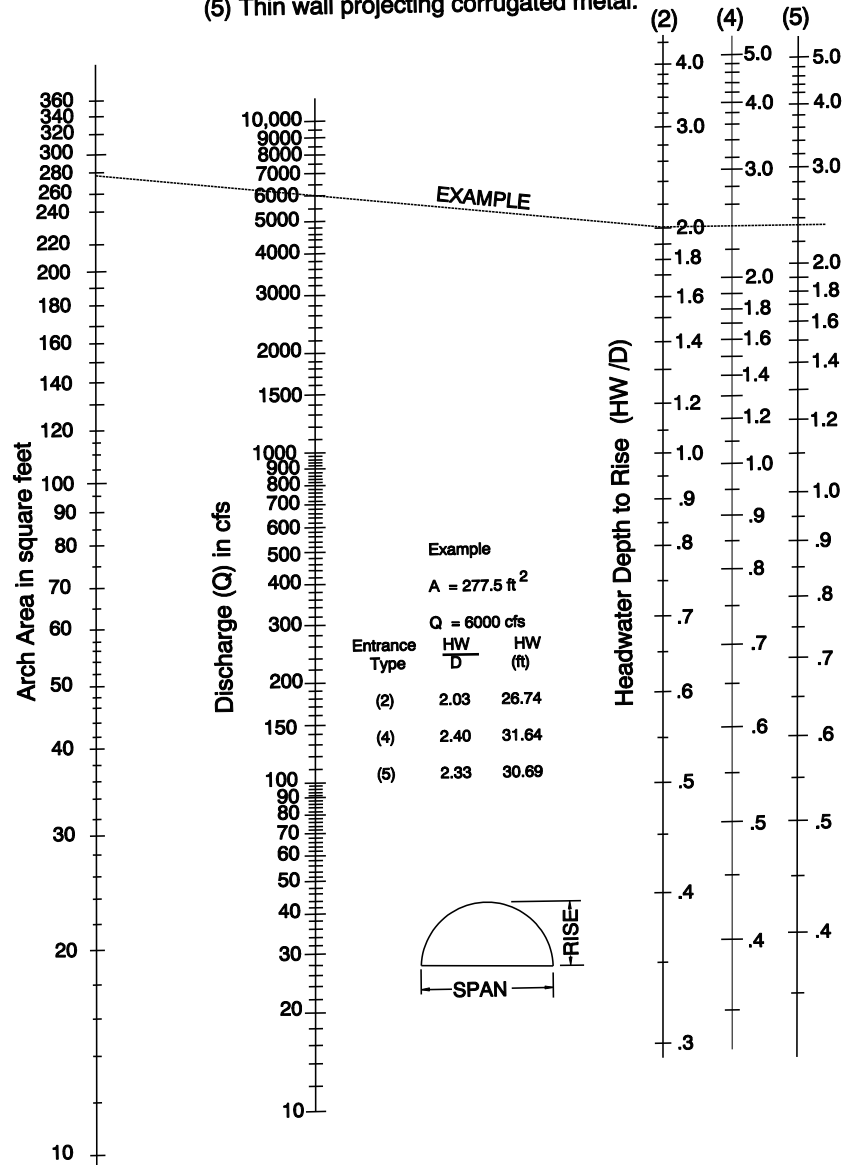
# CHART 19

## HEADWATER DEPTH FOR C.M. ARCH CULVERTS $0.4 \leq \text{RISE} / \text{SPAN} < 0.5$ WITH INLET CONTROL



Entrance Conditions

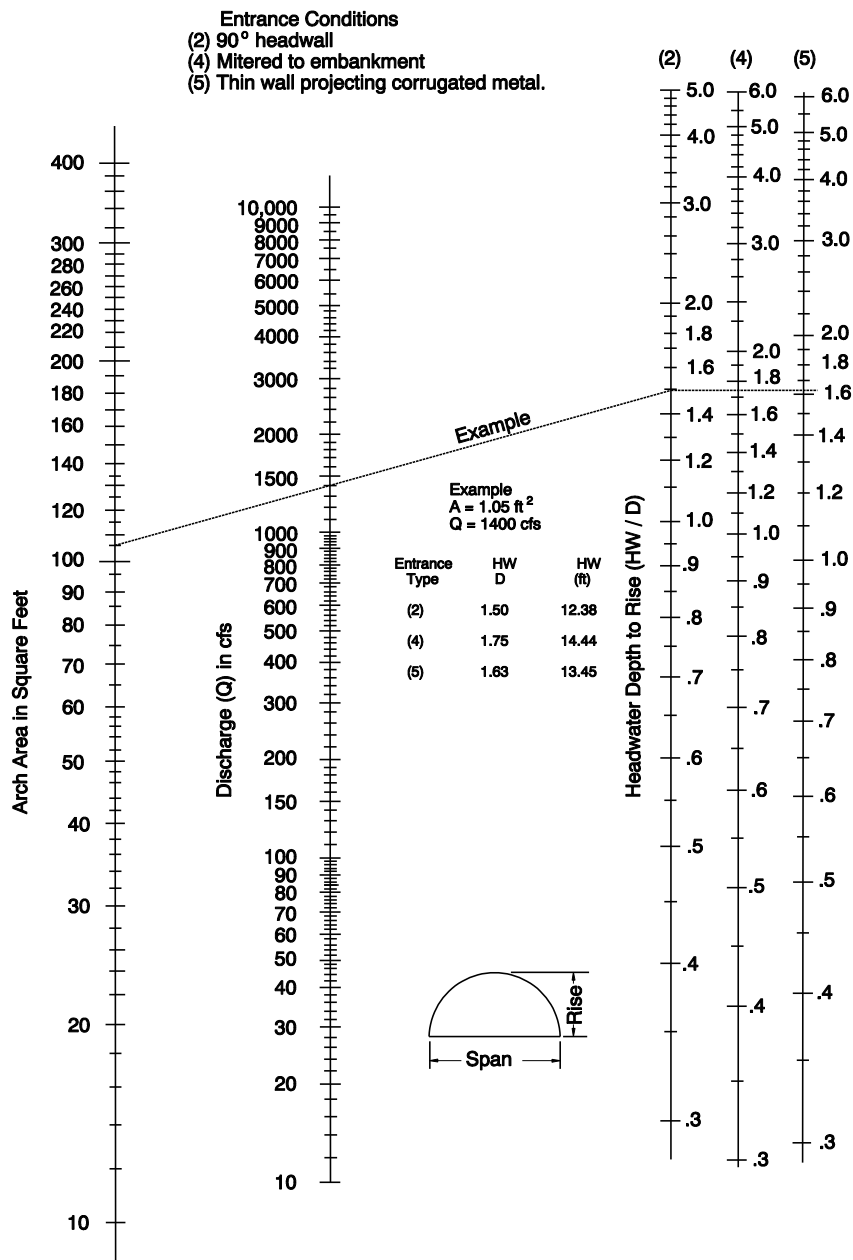
- (2) 90° headwall
- (4) Mitered to embankment
- (5) Thin wall projecting corrugated metal.





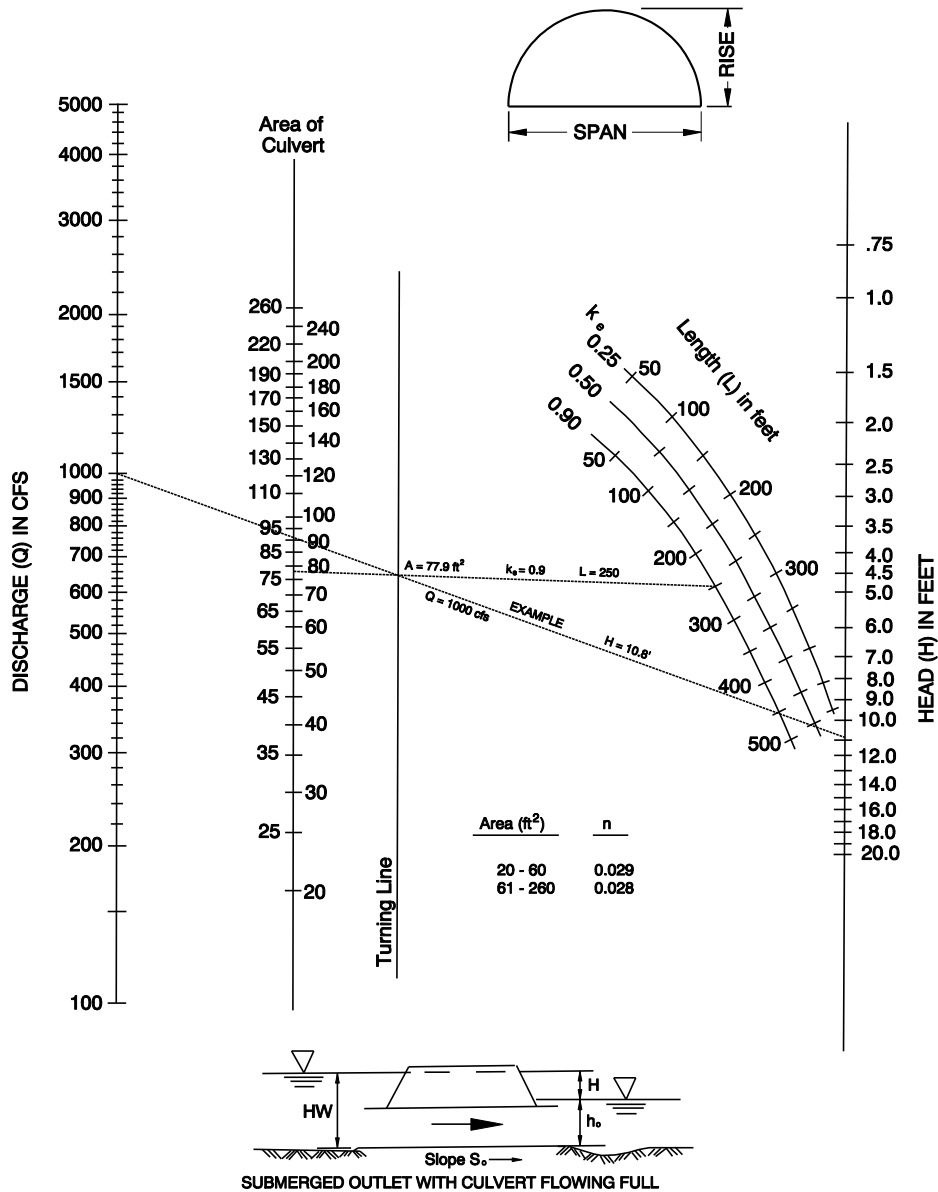
# CHART 20

## HEADWATER DEPTH FOR C.M. ARCH CULVERTS $0.5 \leq \text{RISE} / \text{SPAN}$ WITH INLET CONTROL



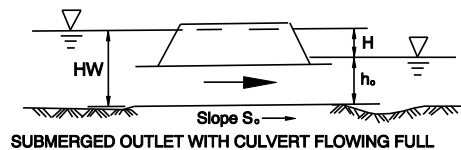
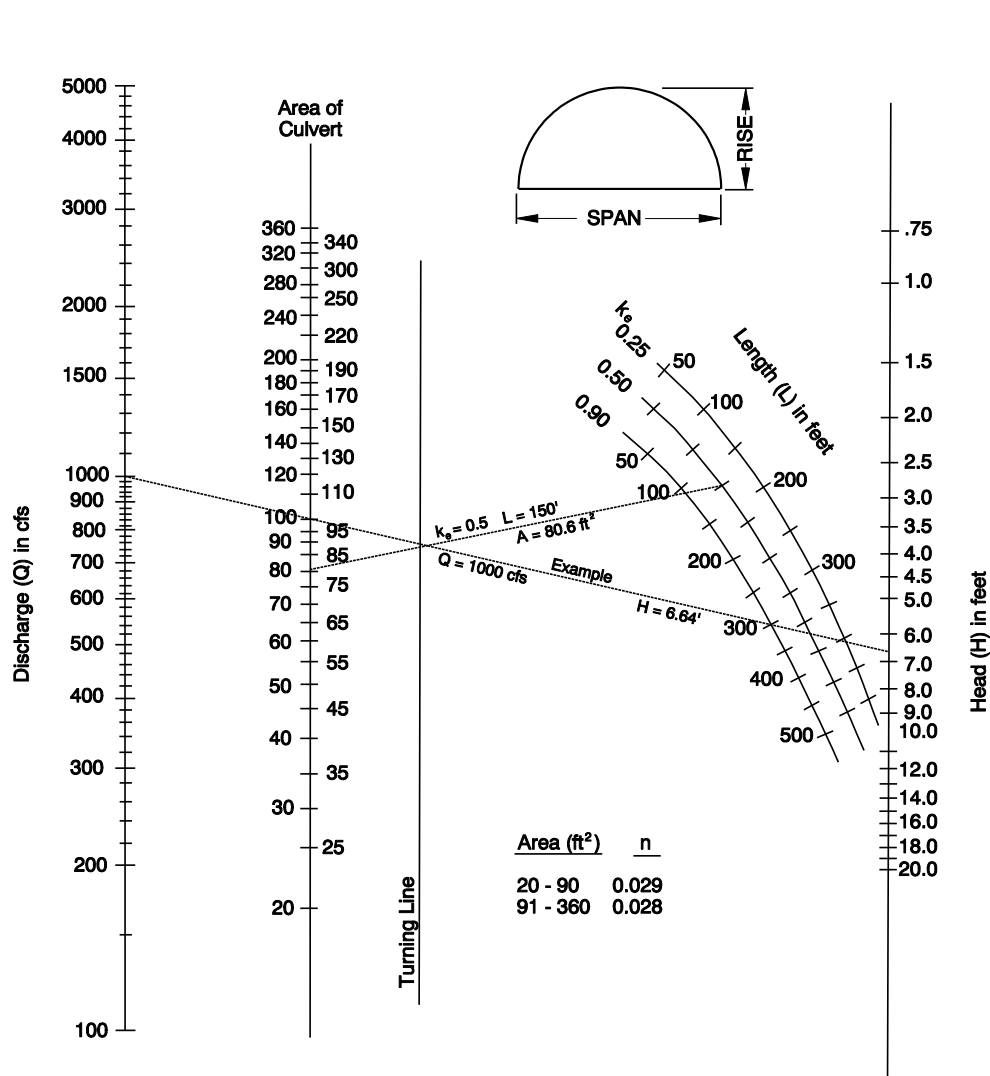
# CHART 21

## HEAD FOR C.M. ARCH CULVERTS FLOWING FULL EARTH BOTTOM ( $n_b = 0.022$ ) $0.3 \leq \text{RISE} / \text{SPAN} < 0.4$



# CHART 22

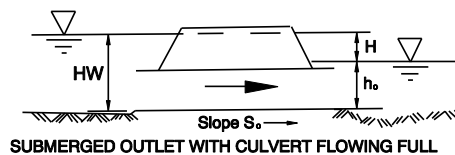
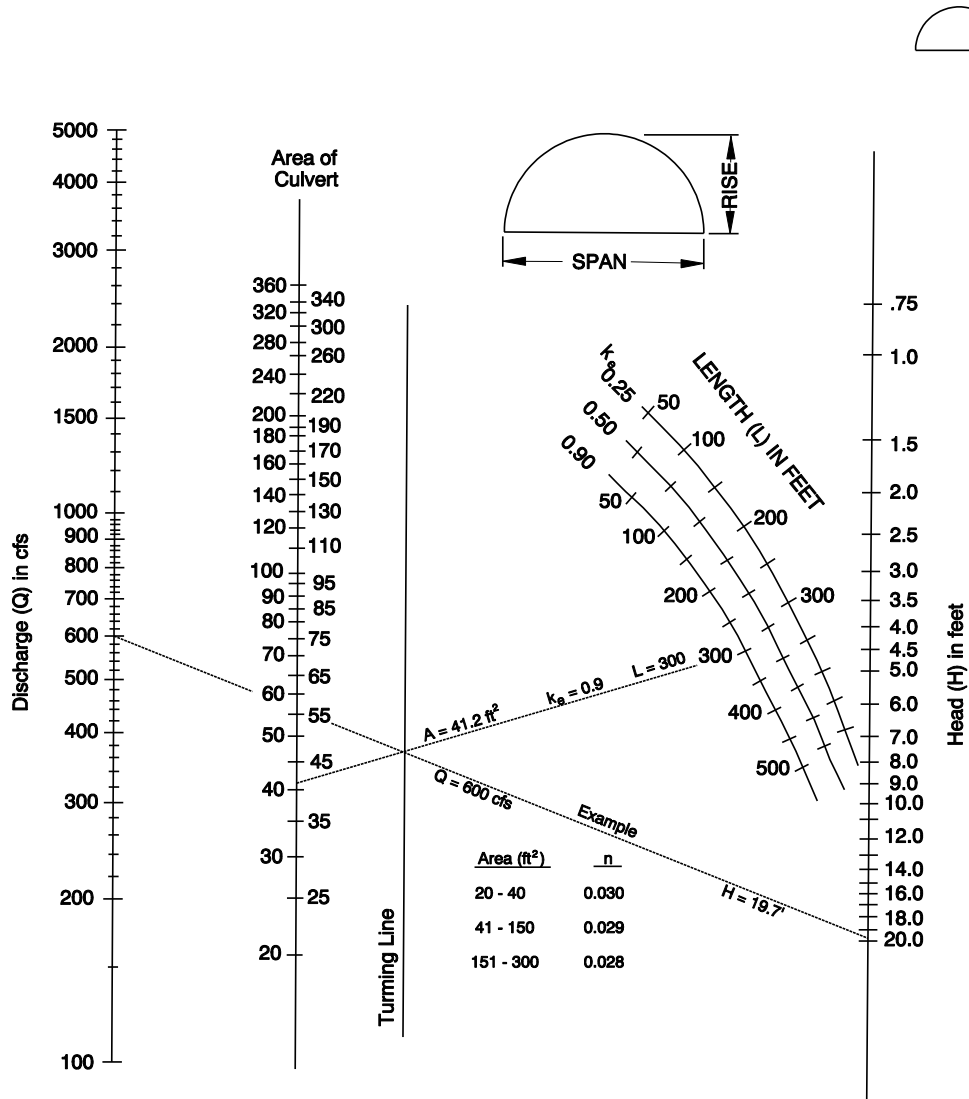
## HEAD FOR C.M. ARCH CULVERTS FLOWING FULL IN OUTLET CONTROL EARTH BOTTOM ( $n_b = 0.022$ ) $0.4 \leq \text{RISE} / \text{SPAN} < 0.5$



For outlet crown not submerged, compute HW by methods described in the design procedure

# CHART 23

## HEAD FOR C.M. ARCH CULVERTS FLOWING FULL IN OUTLET CONTROL EARTH BOTTOM ( $n_b=0.022$ ) $0.5 \leq \text{RISE} / \text{SPAN}$



For outlet crown not submerged, compute HW by  
 methods described in the design procedure