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**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.

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<td>Concrete</td>
<td>Inlet</td>
<td>Inlet projecting or in headwall</td>
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<tr>
<td>2</td>
<td>Circular</td>
<td>Concrete</td>
<td>Inlet</td>
<td>Prefabricated concrete end section</td>
</tr>
<tr>
<td>3</td>
<td>Circular</td>
<td>Metal</td>
<td>Inlet</td>
<td>Corrugated or structural plate pipe with inlet projecting, mitered, or in headwall. (Use Scale 2 for ODOT sloped end with or without slope paving.)</td>
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<td>Circular</td>
<td>Metal</td>
<td>Inlet</td>
<td>Safety end section with bars (Use for concrete or metal barrel.)</td>
</tr>
<tr>
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<td>Circular</td>
<td>Metal</td>
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<td>Concrete</td>
<td>Inlet</td>
<td>Top edge beveled with wingwalls (Use Scale 2 for box culvert shown on ODOT Standard Drawing BR 800.)</td>
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<td>Inlet</td>
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<td>Pipe-Arch</td>
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<td>Structural plate pipe-arch with inlet projecting, or in headwall with or without beveled edge and 31-inch corner radius</td>
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<td>Structural plate arch with inlet projecting, mitered, or in headwall with $0.3 \leq \text{Rise/Span} &lt; 0.4$</td>
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<td>Shape</td>
<td>Material</td>
<td>Control</td>
<td>Comments</td>
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<td>---------</td>
<td>----------</td>
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<td>Metal</td>
<td>Inlet</td>
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<td>Arch</td>
<td>Metal</td>
<td>Inlet</td>
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</tr>
<tr>
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<td>Arch</td>
<td>Metal</td>
<td>Outlet</td>
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<td>Arch</td>
<td>Metal</td>
<td>Outlet</td>
<td>Structural plate arch with earth bottom and $0.4 \leq \text{Rise/Span} &lt; 0.5$</td>
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<td>Arch</td>
<td>Metal</td>
<td>Outlet</td>
<td>Structural plate arch with earth bottom and $0.5 &lt; \text{Rise/Span}$</td>
</tr>
</tbody>
</table>
CHART 1

HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

Example:

D = 42 inches [3.5 feet]
Q = 120 cfs

HW
D

(1) 2.5 0.5
(2) 2.1 7.4
(3) 2.2 7.7

* D in feet

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

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CHART 2
HEADWATER DEPTH FOR PREFABRICATED CONCRETE END SECTION IN INLET CONTROL

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CHART 3

HEADWATER DEPTH FOR C.M. CULVERTS WITH INLET CONTROL

EXAMPLE
\[ \frac{H}{D} = \text{feet} \]

(1) \[ \frac{H}{D} = 1.8 \]
(2) \[ \frac{H}{D} = 2.1 \]
(3) \[ \frac{H}{D} = 2.2 \]

* D in feet

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CHART 4

HEADWATER DEPTH FOR SAFETY END SECTIONS WITH SAFETY BARS IN INLET CONTROL

Example:
\[ D = 48 \text{ in} \]
\[ D = 36 \text{ ft} \]
\[ H/W = 0.83 \]
\[ H/W = 40° \]

Developed by ODOT from Kansas Department of Transportation
Report No. 1/C/13/435-0/0-8-4

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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

\( n = 0.024 \)

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

Example:

- $Q_{in} = 76$ cfs
- $Q_{dis} = 16$ cfs
- Initial HWD: 1.78

Scales:

- Scales (1), (2), (3) for different angles of wingwall flares:
  - (1): $90^\circ$ to $75^\circ$
  - (2): $90^\circ$ and $15^\circ$
  - (3): $0^\circ$ extensions of side

To use scale (2) or (3), project vertically from (1) then use straight ruled line through (2) and (3) 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
CHART 13

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

EXAMPLE
Size: 36" x 24"
Q = 20 cfs

<table>
<thead>
<tr>
<th>HW/D</th>
<th>HW (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.10</td>
<td>2.0</td>
</tr>
<tr>
<td>1.15</td>
<td>2.1</td>
</tr>
<tr>
<td>1.22</td>
<td>2.3</td>
</tr>
</tbody>
</table>

* D in feet

HEADWATER DEPTH IN TERMS OF RISE (HW/D)

EXPLANATION:

1. Headwall
2. Mitered to conform to slope
3. Protruding

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

* ADDITIONAL SIZES NOT DIMENSIONED ARE LISTED IN FABRICATORS' CATALOGS

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CHART 14

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

<table>
<thead>
<tr>
<th>EXAMPLE</th>
<th>TYPE OF INLET</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIZE 18.8&quot; X 6.3&quot;</td>
<td>0° HEADWALL: 33.7&quot; X 0.10 D BEVEL</td>
</tr>
<tr>
<td>PROJECTING</td>
<td>NO BEVEL</td>
</tr>
</tbody>
</table>

| PROJECTING INLET | PROJECTING OR HEADWALL INLET |
| HEADWALL WITH OR WITHOUT EDGE BEVEL |

HEADWATER DEPTH IN TERMS OF ARCH RISE (ft)
CHART 15

HEADWATER DEPTH FOR STRUCTURAL PLATE PIPE-ARCH CULVERTS WITH INLET CONTROL
CHART 16

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

For outlet crown not submerged, compute HW by methods described in the design procedure.
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 ≤ RISE / SPAN < 0.4 WITH INLET CONTROL

Example
A = 122.2 ft
Q = 1014 cfs

<table>
<thead>
<tr>
<th>Entrance Type</th>
<th>HW</th>
<th>HW</th>
<th>HW</th>
</tr>
</thead>
<tbody>
<tr>
<td>(2)</td>
<td>0.95</td>
<td>7.87</td>
<td></td>
</tr>
<tr>
<td>(4)</td>
<td>0.26</td>
<td>7.52</td>
<td></td>
</tr>
<tr>
<td>(5)</td>
<td>1.03</td>
<td>8.18</td>
<td></td>
</tr>
</tbody>
</table>

Entrance Conditions
(2) 90° headwall
(4) Millared to embankment
(5) Thin wall projecting corrugated metal.
CHART 19

HEADWATER DEPTH
FOR C.M. ARCH CULVERTS
0.4 ≤RISE / SPAN <0.5
WITH INLET CONTROL

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

[Diagram with tables and data points]

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CHART 20

HEADWATER DEPTH
FOR C.M. ARCH CULVERTS
0.5 ≤ RISE / SPAN
WITH INLET CONTROL

Entrance Conditions
(3) 90° headwall
(4) Filtered to embankment
(5) Thin wall projecting corrugated metal.

<table>
<thead>
<tr>
<th>Type</th>
<th>Discharge (Q) in cfs</th>
<th>Arch Area in Square Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>1.80</td>
<td>10,000</td>
</tr>
<tr>
<td>3</td>
<td>1.75</td>
<td>12,500</td>
</tr>
<tr>
<td>4</td>
<td>1.60</td>
<td>15,000</td>
</tr>
<tr>
<td>5</td>
<td>1.50</td>
<td>18,000</td>
</tr>
</tbody>
</table>

Example

Q = 1,260 cfs

Headwater Depth to Rise (HW / D):

0.4

Span
CHART 21

HEAD FOR C.M. ARCH CULVERTS
FLOWING FULL
EARTH BOTTOM (n_b = 0.022)
0.3 ≤ RISE / SPAN < 0.4

For culvert crown not submerged, compute HW by methods described in the design procedure.
CHART 22

HEAD FOR C.M. ARCH CULVERTS
FLOWING FULL IN OUTLET CONTROL
EARTH BOTTOM (n_b = 0.022)
0.4 ≤ RISE / SPAN < 0.5

For outlet crown not submerged, compute HW by methods described in the design procedures.
CHART 23

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

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