EXTENDED DETENTION BASIN EXAMPLE	1117-6
	REFERENCE SECTION 1117

Given:

- Total Tributary Area = 7.5 ac
  - Tributary Area within Existing R/W = 5.8 ac
  - Tributary Area, Impervious, Outside of R/W = 0.0 ac
  - Tributary Area, Pervious, Outside of R/W = 1.7 ac
  - Tributary Area, Pavement and Paved Shoulders = 1.5 ac
  - Tributary Area, Berms and Slopes 4:1 or Flatter = 6.0 ac
- Rainfall Area B
- Time of Concentration, t_C = 25 min (calculation shown in this example)

Calculate the water quality volume WQ_V:

- $WQ_V = (R_V * P * A) / 12$
- P = 0.90 in
- A = 7.5 ac
- RV = 0.05 + 0.9 * i
  - i = impervious area divided by the total area (within the BMP drainage area)
  - The area within existing ODOT right-of-way is considered impervious area for the purpose of post-construction BMP design considerations. (L&D Vol 2, Sec. 1115.6.1)
  - $i = \frac{5.8\ ac + 0.0\ ac}{7.5\ ac} = 0.773$
- $R_V = 0.05 + 0.9 * 0.773 = 0.746$
- $WQ_V = (0.746 * 0.90\text{ in} * 7.5\text{ ac}) / 12$
- WQ_V = <u>0.42 ac-ft</u>

Calculate the minimum detention basin volume, forebay volume, and micropool volume:

- Minimum basin volume = WQ_V * 1.2 (due to 20% increase)
  = WQ_V*1.2 = 0.42 ac-ft *1.2 = 0.504 ac-ft
- 10% WQ_V for forebay volume, 10% * 0.42 ac-ft = <u>0.042 ac-ft</u>
- 10% WQ_V for micropool volume, 10% * 0.42ac-ft = <u>0.042 ac-ft</u>

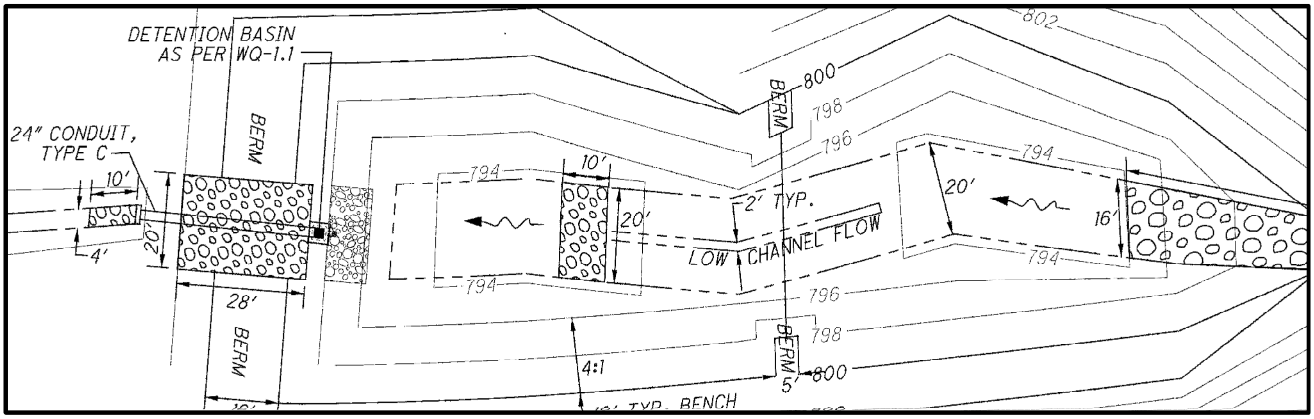
Layout a detention basin configuration that meets the following requirements:

- Forebay volume below the lowest outlet elevation at upstream end of the basin
- Micropool volume below the lowest water quality outlet invert elevation at the downstream end of the basin
- Maximum 4:1 side slopes
- Include provisions for vehicle access

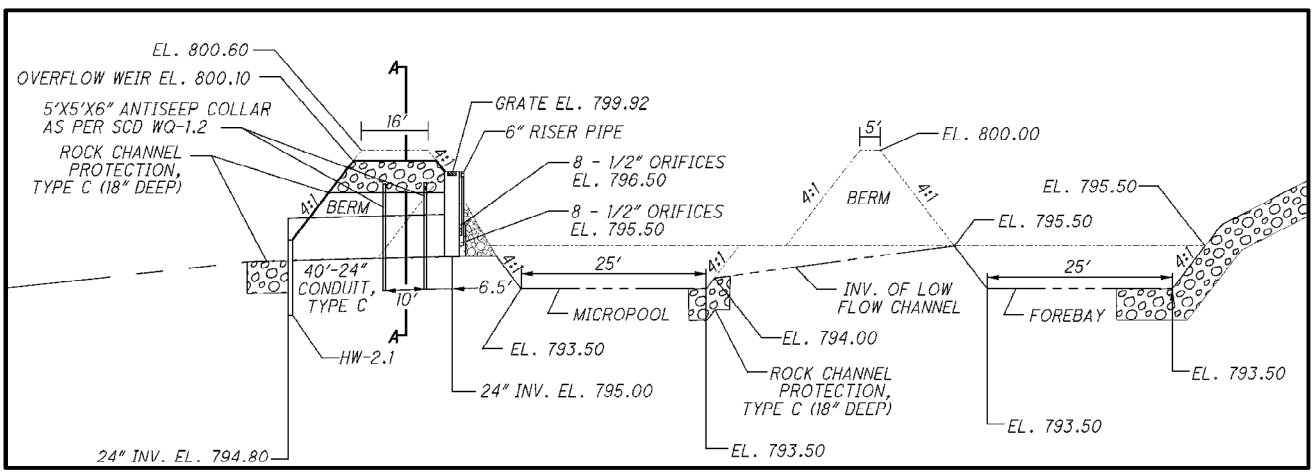
EXTENDED DETENTION BASIN EXAMPLE (C0NTINUED)

1117-6
REFERENCE SECTION 1117

Detention Basin Plan View:



Detention Basin Profile View:



Forebay:

- The forebay volume is the volume stored upstream of the low flow channel. The volume in the forebay is held in a permanent pool, and is unable to flow downstream towards the outlet. The purpose of the forebay is to allow runoff to slow enough for coarse sediment to settle out. This improves performance and reduces the maintenance burden by concentrating sediment buildup in one location designed for maintenance access.
- Forebay volume must be greater than or equal to 0.042 ac-ft.
- Forebay depth = 795.5 – 793.5 = 2 ft
- Forebay bottom area = 25 ft * 18 ft = 450 ft^2
- Forebay top area = 41 ft * 34 ft = 1,394 ft^2
- Approximate forebay volume = (450 ft^2 + 1,394 ft^2) / 2 * 2ft / 43,560 = 0.042 ac-ft
- 0.042 ac-ft is equal to the 0.042 ac-ft requirement: <u>Acceptable</u>

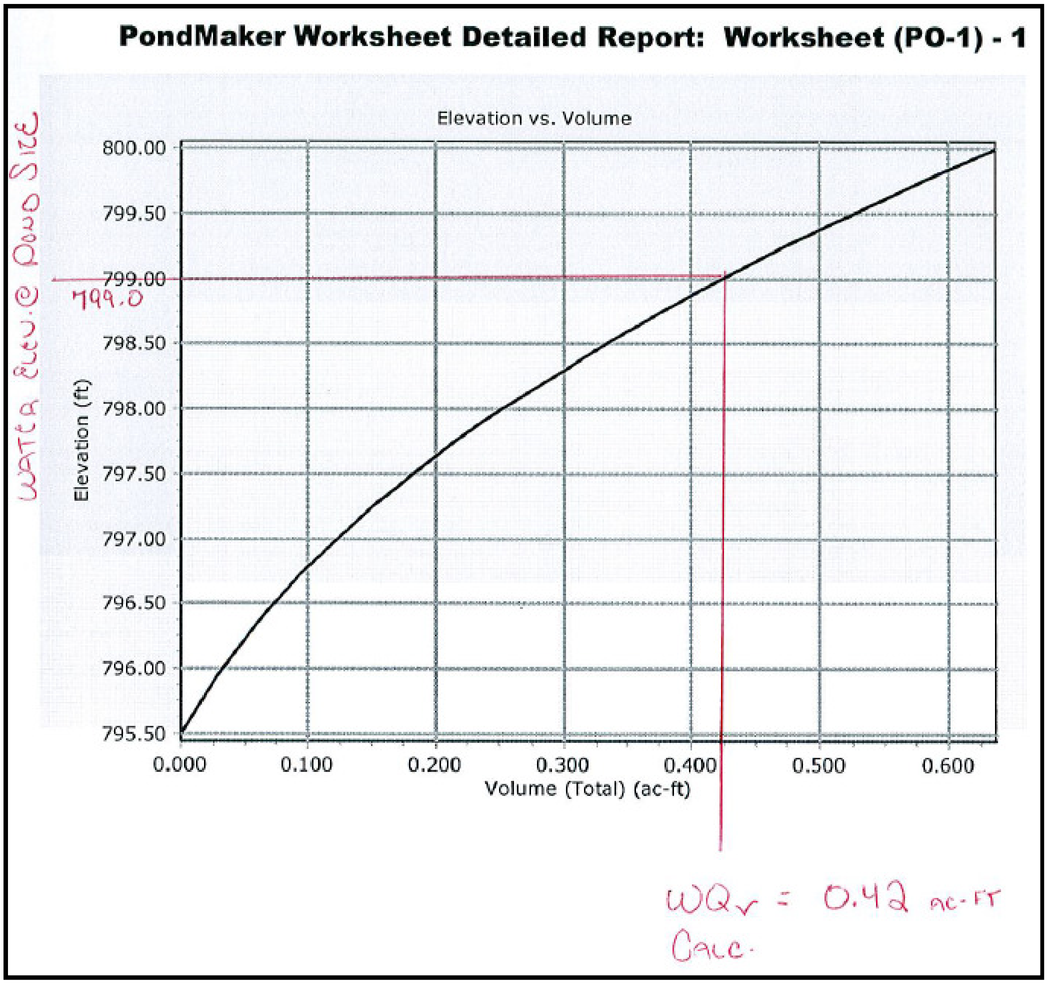
Micropool:

- The micropool volume is the volume that is stored below the lowest invert elevation of the lowest water quality outlet. The purpose of the micropool is to slow runoff draining towards the outlet structure, promote sediment settling below the outlet structure, and allow use of a non-clogging outlet. This improves performance and reduces clogging and maintenance.
- Micropool volume must be greater than or equal to 0.042 ac-ft.
- Micropool depth = 795.5 – 793.5 = 2 ft
- Micropool bottom area = 25 ft * 20 ft = 500 ft^2
- Micropool top area = 41 ft * 36 ft = 1,476 ft^2
- Approximate micropool volume = (500 ft^2 + 1,476 ft^2) / 2 * 2ft / 43,560 = 0.045 ac-ft
- 0.045 ac-ft is greater than 0.042 ac-ft requirement: <u>Acceptable</u>

Water Quality Volume (WQ_V) Storage:

- The WQ_V must be fully stored above the lowest water quality outlet elevation.
- The lowest water quality outlet is at an elevation of 795.5 ft.
- The WQ_V (0.42 ac-ft) must be stored between 795.5 ft and catch basin overflow.

Stage (Elevation) vs. Volume Curve:

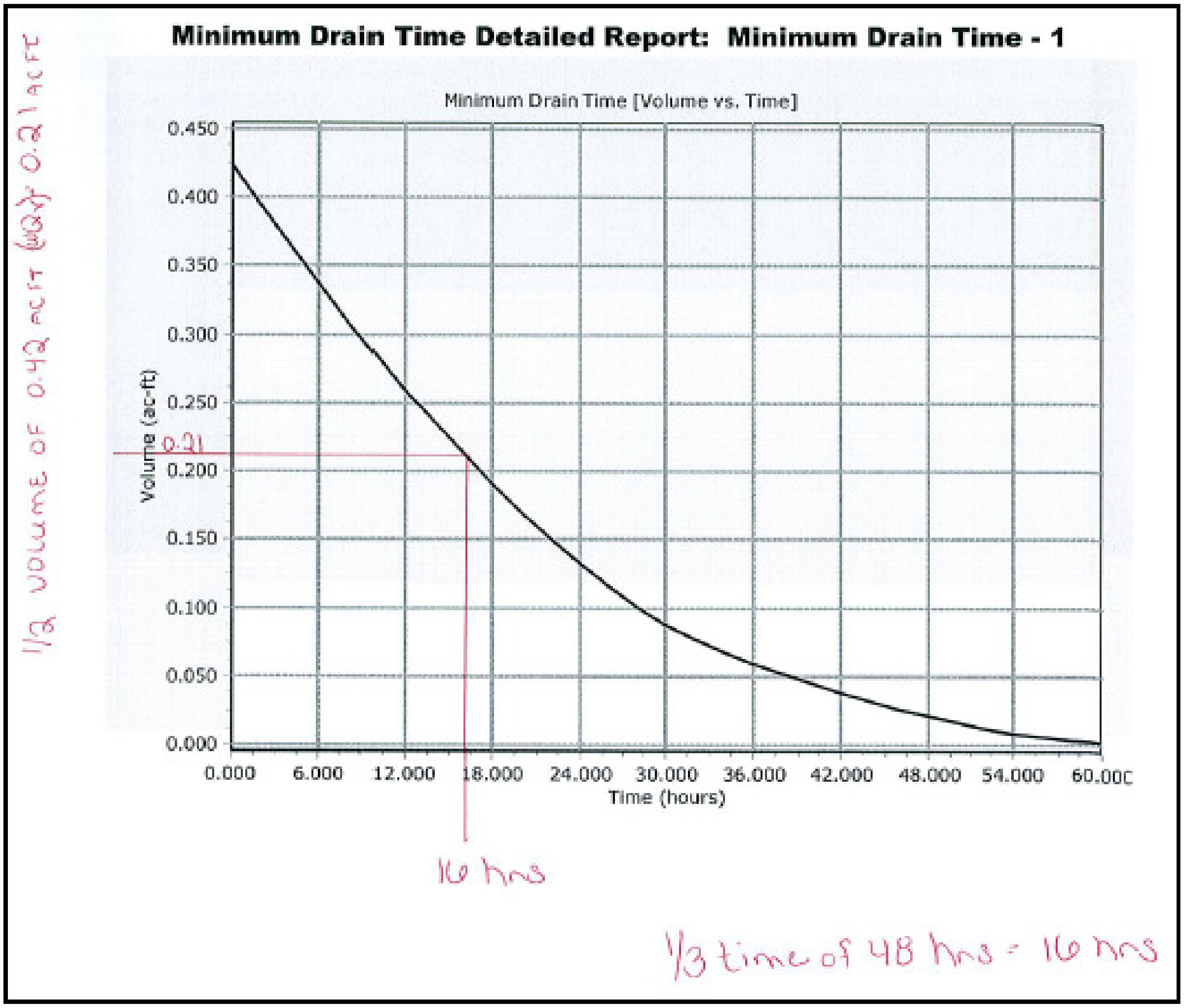


The graph shows that the full WQ_V is stored between 799.00 and 795.50 ft in the detention basin. The forebay and micropool have been excluded from this stage vs. volume graph since the volume associated with the forebay and micropool is constantly standing water.

Design the Detention Basin Water Quality Outlet:

- The minimum discharge time of the WQ_V is 48 hours with no more than 50% of the WQ_V being released from the detention basin in the first one-third of the 48 hour drain time.
- WQ_V = 0.42 ac-ft; must take 48 hours or longer to drain
- 50% or less of the WQ_V (i.e. 0.21 ac-ft) must be drained in 16 hours.
- Choose eight 0.5 inch diameter circular orifices at 795.50 ft and eight 0.5 inch diameter circular orifices at 796.50 ft.
- Calculate the drawdown curve.
    - This calculation can be done by hand by creating a stage vs. discharge table and interpolating between values, but it is generally easier to use a model to simulate runoff through a detention basin such as PondPack or HydroCAD.
- Do not route a design storm hydrograph through a detention basin to determine the drawdown curve. Start the simulation with the water surface at a level equivalent to the WQ_V storage (for this example, at an elevation of 799.00). Then allow the pooled water filling the WQ_V to drain by gravity out of the water quality outlet structure. Include all detention basin outlets that would affect this drawdown curve. Include any downstream constraints such as tailwater or limiting conveyance downstream. For this example, there is no tailwater and there is a free discharge from the detention basin.

Modeled Drawdown Curve using Pond Pack:



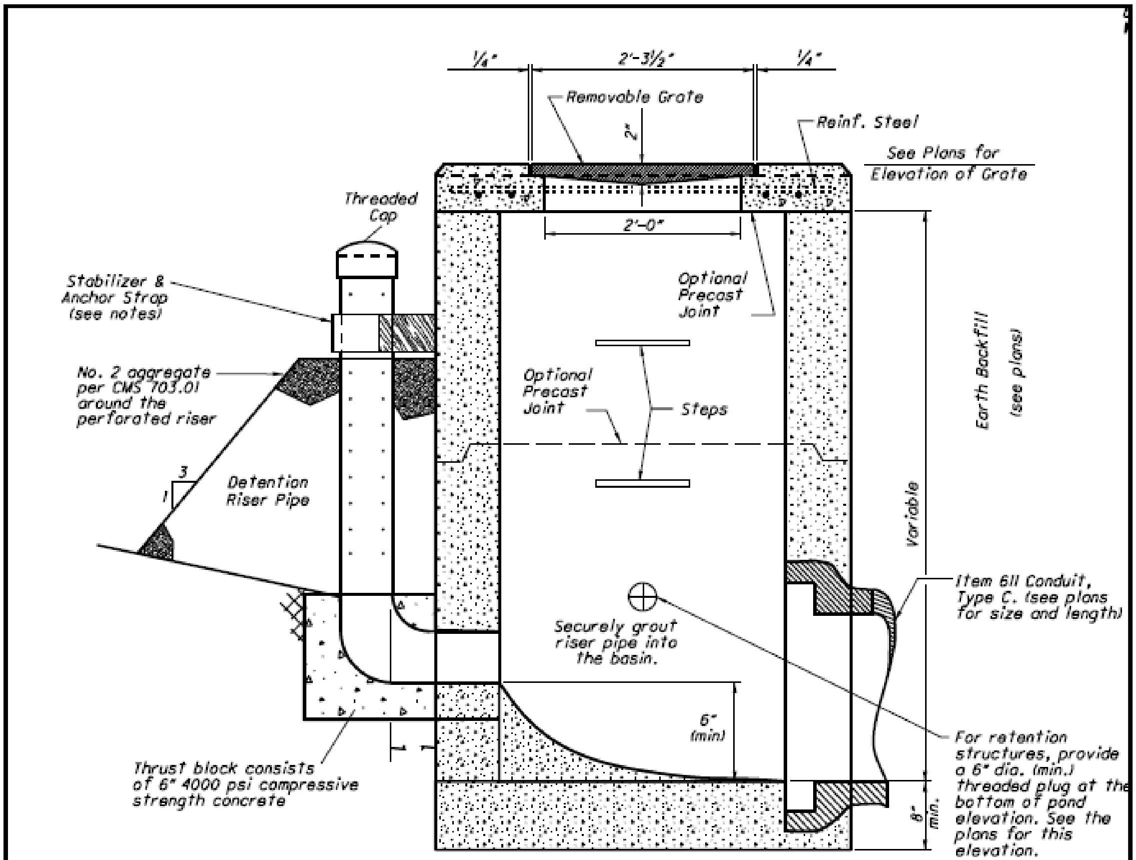
- The graph shows that it takes longer than 48 hours to drain the WQ_V (0.42 ac-ft); therefore, it is acceptable.
- The graph shows that it takes 16 hours to drain one half of the WQV (0.21 ac-ft); therefore, it is acceptable.

Size the Primary Detention Basin Outlet:

- There are three main parts of a typical extended detention basin discharge structure:
  - Water quality outlet(s)
  - Primary outlet
  - Overflow weir

- The primary detention basin outlet normally consists of a catch basin grate and the conduit that conveys discharges from the detention basin during all but the least frequent precipitation events.
- The primary outlet should be sized to convey the 10-year design storm.

ODOT Water Quality Catch Basin Detail (WQ-1.1):



SECTION A-A (DETENTION SHOWN)
NOT TO SCALE

Determine the 10-year peak flow rate:

- For the purposes of post-construction BMP calculations, all existing right-of-way is to be considered impervious. For the purpose of general conveyance sizing, runoff coefficients should be calculated using Table 1101-2 in ODOT's L&D Vol. 2.
- Q = CiA

Calculate the weighted C value:

1.5 acres of tributary area are pavement and paved shoulders: C = 0.9

6.0 acres of tributary area are berms and slopes 4:1 or flatter: C = 0.5

$C_{weighted} = \frac{1.5\ ac*0.9+6.0\ ac*0.5}{7.5\ ac} = 0.58$

Determine the precipitation intensity:

Rainfall Area B

t_C = 25 min

(The time of concentration is given in this example as 25 minutes because there is significant overland flow over grassed area. The time of concentration should be calculated for each site based on the site-specific flow path. 25 minutes would likely be too high of a value if the detention basin were receiving flow from a piped system. See the time of concentration calculations below.)

L&D Vol. 2, Figure 1101-2: Area B, 10-year frequency, 25 min t_C: i = 3.4 in/hr

- Q = 0.58 * 3.4 in/hr * 7.5 ac = <u>14.79 cfs</u>

  Time of Concentration (t_C) Calculations:

  - t_C = Time of overland flow (t_O) + Time of shallow concentrated flow (t_S) + Time of channel flow (t_C)
  - Overland Flow (t_O)
    - $t_O = \frac{1.8(1.1-C)(L)^{1/2}}{s^{1/3}}$
    - C = Runoff Coefficient (0.58 for this example)
    - L = Distance to most remote location in drainage in feet (max. 300 ft.) (200 ft. in this example)
    - s = Overland slope (percent) (0.33% in this example)
    - $t_O = \frac{1.8(1.1-0.58)(200)^{1/2}}{0.33^{1/3}}$ = **19.16 minutes**
  - Shallow Concentrated Flow (t_S)
    - V_S = Velocity of shallow concentrated flow (ft/sec) = $3.281ks^{0.5}$
    - k = Intercept Coefficient (L&D Table 1101-1) = (0.457 in this example)
    - s = Overland slope (percent) (0.33% in this example)
    - $V_S = 3.281 * 0.457 * 0.33^{0.5}$ = 0.86 ft/sec
    - Length of shallow concentrated flow = 200 ft.
    - t_S = 200 ft. / 0.86 ft/sec = 233 sec = **3.88 minutes**

- Channel Flow (t_C)
  - Manning's Equation: V = $\frac{1.49 r^{2/3} s^{1/2}}{n}$
  - V = velocity in the channel (ft/sec)
  - r = hydraulic radius (0.69 ft. in this example)
  - s = channel slope (0.01 ft/ft in this example)
  - n = Manning's Roughness Coefficient (L&D Vol. 2, Table 1102-3) (0.03 in this example)
  - V = $\frac{1.49 * 0.69^{2/3} * 0.01^{1/2}}{0.03}$ = 3.88 ft/sec
  - Channel length = 500 ft. (for this example)
  - t_C = 500 ft. / 3.88 ft/sec = 129 sec. = **2.15 minutes**
- $t_C = t_O + t_S + t_C$ = 19.16 + 3.88 + 2.15 = 25.19 minutes. Use t_C = **25 minutes**

Size the primary detention basin discharge conduit:

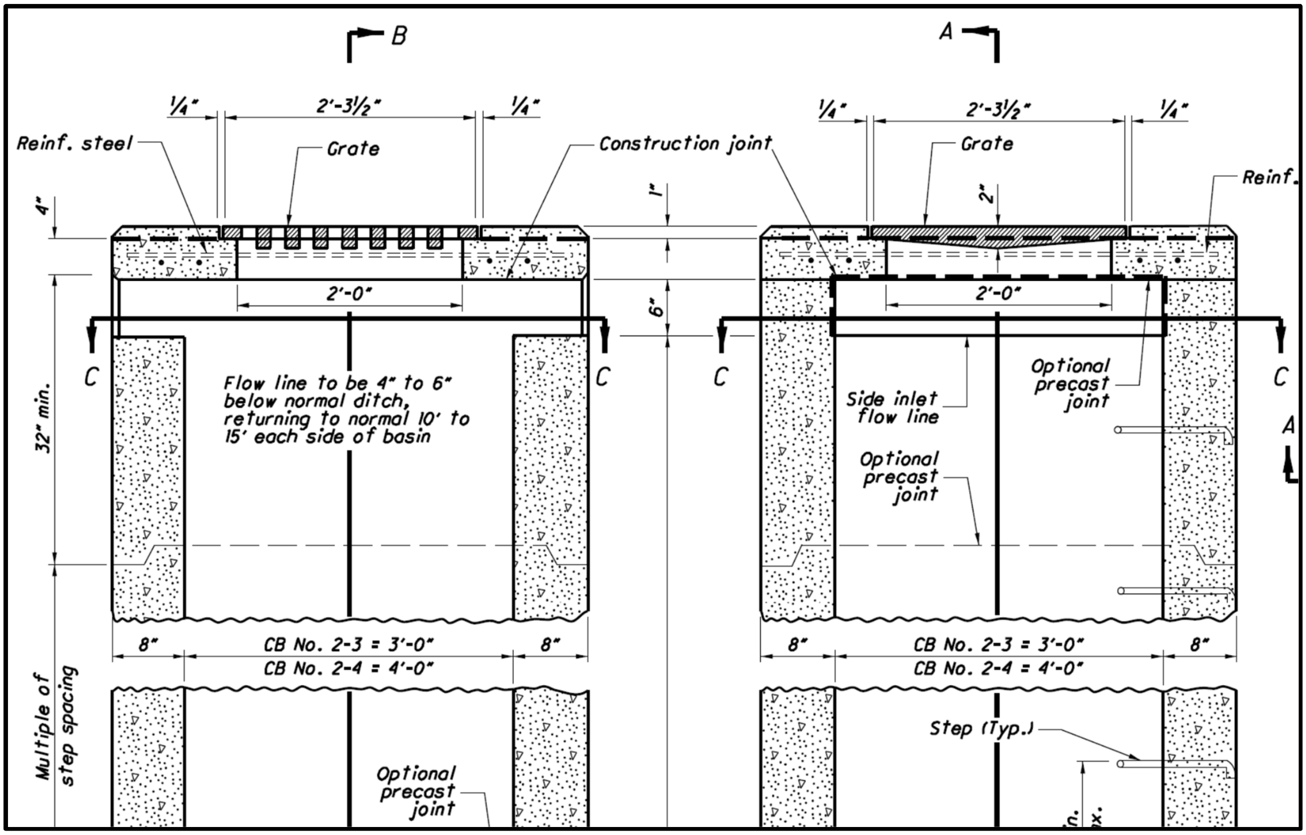
- The discharge conduit must be large enough to convey the 10-year design storm, keeping the maximum hydraulic grade line within the crown of the pipe.
- This example has the following conduit characteristics:
  - Conduit slope = 0.005 ft/ft
  - No Tailwater; free discharge
  - Pipe Roughness Coefficient = 0.015 (L&D Vol. 2, Section 1104.4.5)
- The minimum conduit size that conveys the 10-year peak flow (14.79 cfs) with the given characteristics is a 24-inch diameter pipe.

Set the catch basin grate elevation:

- The WQ_V fills the detention basin to an elevation of 799.0 ft. At water surface elevations of 799.0 ft and below, all discharge should pass through the water quality outlet. (In this example, the water quality outlet is the two rings of 0.5 inch orifices at 795.5 ft and 796.5 ft.)
- The ODOT standard water quality catch basin detail (SCD WQ-1.1) calls for either Catch Basin No. 2-3 or 2-4 depending on the outlet pipe size. Both catch basins have a 6-inch high side inlet that is either 3 or 4 feet wide depending on the catch basin. See the detail:

EXTENDED DETENTION BASIN EXAMPLE (C0NTINUED)	1117-6
	REFERENCE SECTION 1117

ODOT Catch Basin No. 2-3 and No. 2-4:



- However, SCD WQ-1.1 calls for a catch basin used for a detention basin to not have the side inlet windows. Therefore, side inlets should not be included in a detention basin outlet structure.
- The elevation of the top of the grate should be set at the WQ_V elevation. Therefore, any volume above the WQ_V may discharge into the catch basin through the grate.
    - Catch basin grate elevation = 799.0 ft

Set the Overflow Weir Invert Elevation:

- The 10-year peak flow rate (14.79 cfs) should pass fully through the primary discharge. Therefore, no flow should discharge from the overflow weir until the 10-year flow rate has been exceeded.
- Set the overflow weir invert elevation just high enough above the catch basin grate such that the full 10-year peak flow rate is conveyed through the primary discharge.

- For this example, the primary discharge pipe is sized at 24 inches in diameter; therefore, Catch Basin No. 2-3 is appropriate.
- Catch Basin No. 2-3 has the same grate as Catch Basin No. 2-2B.
- The water quality catch basin has one opening to allow runoff inside; Grate No. 2-2-B.
- Use L&D Vol. 2, Figure 1102-1 to determine the necessary head above a No. 2-2-B grate to pass the 10-year peak flow rate (14.79 cfs).
- According to Figure 1102-1, 1.25 ft of head is required to pass a flow rate of 14.79 cfs.
- Add the necessary head to the grate elevation (799.0 ft)
  - 799.0 ft + 1.25 ft = 800.25 ft
- <u>Set the overflow weir elevation at 800.25 ft</u>.

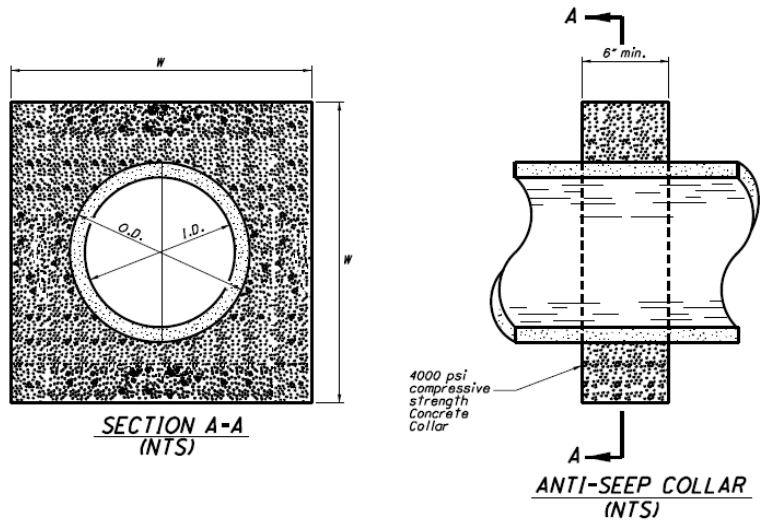
Size the Emergency Overflow Weir and Set the Top of Basin Elevation:

- L&D Vol. 2, Section 1104.4.2 states that the hydraulic grade line should be checked for the 25-year storm.
- The 25-year peak flow rate should pass fully through the overflow weir.
- Calculate the peak flow rate:
  - 25-year intensity @ t_C = 25 min and Rainfall Area B: 3.8 in/hr
  - 25-year storm peak flow rate: Q = CiA = 0.58 * 3.8 in/hr * 7.5 ac = 16.53 cfs
- Calculate the required weir length for each design storm flow:
  - Overflow weir elevation = 800.25 ft
  - Assume a top of detention basin elevation of 800.75 ft.
  - Maximum height at overflow weir = 800.75 ft – 800.25 ft = 0.5 ft
  - Weir equation: $Q = C*L*H^{1.5}$
    - C = 3
    - H = 0.5
    - L = ?
  - Length of a weir: $L = \frac{Q}{C*H^{1.5}}$
  - 25-year: $L = \frac{16.53}{3*0.5^{1.5}} = 15.6$ ft
- Provide a <u>16 ft wide overflow weir</u>.
- The <u>top of basin elevation is 800.75 ft</u>.
- The overflow weir length could be reduced by increasing the top of basin elevation. Or the top of basin elevation can be lowered by increasing the overflow weir length. The 25-year peak flow rate must fully pass through the overflow weir without overtopping the detention basin.
- Flow rates greater than the 25-year peak flow rate may overtop the detention basin uncontrolled.
- Provide erosion protection at the overflow weir, to the bottom of the berm, and continuing downstream if there is erosion potential.

Design Anti-Seep Collars:

- Anti-seep collars reduce the conveyance of flow along pipe bedding, outside of a conduit and increase the flow path for the seepage of water. This helps protect the berm above the discharge conduit from a detention basin from internal erosion.

ODOT Standard Drawing WQ-1.2



DIAMETER (I.D.) (FT.)	CONCRETE (C.Y.) DIMENSION OF COLLAR W X W (FT.)		
	3X3	4X4	5X5
1	0.15	0.28	0.45
2	N/A	0.24	0.40
3	N/A	N/A	0.33

- Calculate the saturated zone length along the conduit (Ls)
  - Ls = Y(Z+4)[1+S/(0.25-S)]
  - Y = depth of water during the 10-year storm
  - Z = slope of embankment
  - S = slope of conduit
- Maximum elevation at 10-year storm = 800.25 ft
- Conduit elevation = 795.0 ft
- Y = 800.25 ft – 795.0 ft = 5.25 ft
- Z = 4
- S = 0.005
- Ls = 5.25(4+4)[1+0.005/(0.25-0.005)] = 42.86 ft
- ΔLs = 0.15*Ls = 0.15 * 42.86 ft = 6.4 ft
- Total Projection: P = W – D
  - W = 2ft + 2 ft diameter + 2 ft = 6 ft
  - P = 6 ft – 2 ft = 4 ft
- Number of collars = ΔLs / P = 6.4 ft / 4 ft = 1.6
  - Minimum of 2 collars per outlet conduit
  - Use 2 anti-seep collars
- Place both anti-seep collars in the saturation zone (within 42.86 ft of front edge of berm).
- Spacing between collars: between 10 and 25 feet

Additional Considerations:

- Vegetate the sides of the detention basin with Item 670 Slope Erosion Protection per L&D Vol. 2, Section 1117.3.1.
- For all open water carriers at each inlet and discharge from the detention basin, check the shear stress and ensure appropriate lining per L&D Vol. 2, Section 1102.3.2.
- For all culverts that discharge into or out of a detention basin, ensure that appropriate rock channel protection is included per L&D Vol. 2, Section 1107.2.
- Include calculated detention basin ponding elevations in the calculation of the hydraulic grade line for the upstream conveyance system per L&D Vol. 2, Section 1104.4.2.
- Attempt to locate structures outside of designated flood plains. If a detention basin encroaches on a flood plain, follow the flood assessment requirements in L&D Vol. 2 Section 1005.
- Ensure that safety criteria are met in the clear zone per L&D Vol. 1, Section 600.2.
- Ensure that no more than one foot of permanent standing water is located within the clear zone without barrier protection, per L&D Vol. 1, Section 601.1.1.
- Engage local project stakeholders in potential public safety considerations associated with detention basins.
- Develop a plan for how regular maintenance will be performed.
    - Vehicle access
    - Mowing
    - Removal of woody vegetation
    - Regular unclogging of the water quality outlet