Designing Stormwater Ponds for Water Quality

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Designing Stormwater Ponds for Water Quality

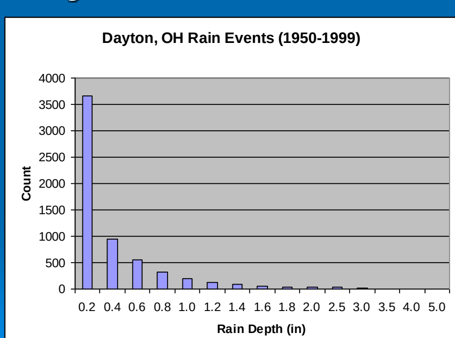
- Water Quality Volume
- Outlets
- Other Design Considerations

The Purpose of Stormwater Regulations/Management

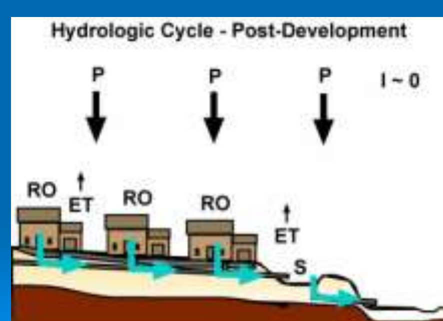
- Minimize impacts to receiving waters
- Offset or mitigate for the changed site hydrology and the loss of natural watershed services

Traditional stormwater management approaches (e.g., Critical Storm Method) were aimed at matching post-development to pre-development peak discharges for infrequent (extreme) storm events, resulting in large detention basins with large outlets

Long-term Rainfall Characteristics



Manmade Stormwater Management Systems



Stormwater Management Regulation in Ohio

Problems/concerns with peak discharge control methods (e.g., Critical Storm Method)

- Problem 1: Too little detention time for effective pollutant removal
- Problem 2: Peak discharge control methods allow smaller rainfall events to become channel eroding events

Water Quality Volume (WQv)

- Urban Runoff Quality Management, ASCE Manual of Practice No. 87, Amercan Society of Civil Engineers, Reston, VA, (1998).

Ohio Application of WQv Formula

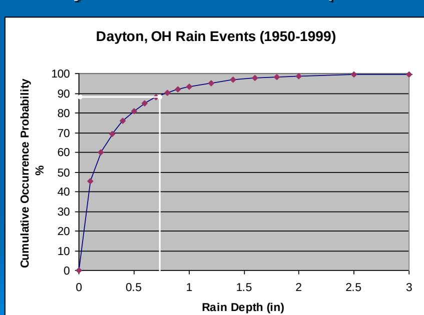
- WQv = C * P * A / 12

Where:

WQv = water quality volume (ac-ft)

- C = runoff coefficient
- P = 0.75 inch precipitation
- A = area draining to the BMP (acres)

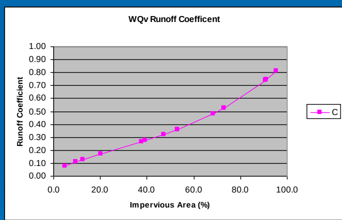
Why 0.75" Rainfall Depth?



Clarification of WQv

- Runoff Coefficient
- Drawdown Requirement

WQv Runoff Coefficient



$$C = 0.858i^3 - 0.78i^2 + 0.774i + 0.04$$

C = runoff coefficient

i = watershed imperviousness ratio (percent total imperviousness divided by 100)

Source: Urban Runoff Quality Management, ASCE, 1998, p. 175.

WQv Runoff Coefficient

$$C = 0.858i^3 - 0.78i^2 + 0.774i + 0.04$$

C = runoff coefficient

i = watershed imperviousness ratio (percent total imperviousness divided 100)

Table 1
Runoff Coefficients Based on the Type of Land Use

Land Use	Runoff Coefficient
Industrial & Commercial	0.8
High Density Residential (>6 dwellings/acre)	0.5
Medium Density Residential (4 to 6 dwellings/acre)	0.4
Low Density Residential (<4 dwellings/acre)	0.3
Open Space and Recreational Areas	0.2

Example

Determine the Runoff Coefficient, C, for:

- 100 acre residential development, 0.5 acre lots, with 20% impervious area (i = 0.20)

C = 0.17

WQv = C * P * A / 12 = (**0.17***0.75*100)/12 = 1.06 ac-ft

From Example 1, using Table 1 value of C = 0.8,
WQv = C * P * A / 12 = (**0.3***0.75*100)/12 = 1.88 ac-ft

WQv Formula

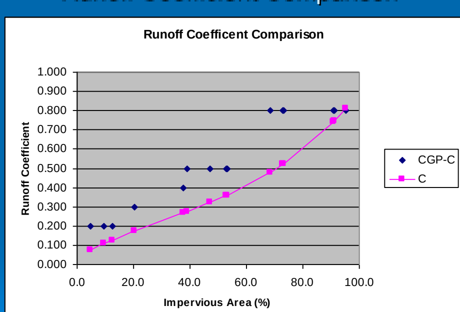
- WQv = C * P * A / 12

Where:

WQv = water quality volume (ac-ft)

- P = 0.75 inch precipitation
- A = area draining to the BMP (acres)
- **C = runoff coefficient - ????**

Runoff Coefficient Comparison



Runoff Coefficient Comparison

SLU - Standard Land Use	Impervious Area %	Calculated Runoff Coefficient C	Published Runoff Coefficient C	Calc WQv acre-ft	Publ WQv acre-ft	Increase WQv %
Urban Open Space	4.9	0.08	0.20	0.5	1.25	163
Urban Parks	9.6	0.11	0.20	0.7	1.25	85
Low Density Residential	20.3	0.17	0.30	1.1	1.875	74
Med Density Res no alleys	37.7	0.27	0.40	1.7	2.5	50
Duplex	39.1	0.27	0.50	1.7	3.125	82
High Density Res no alleys	53.0	0.36	0.50	2.2	3.125	39
Multi-Family Res no alleys	53.1	0.36	0.50	2.2	3.125	39
Medium Industrial	68.5	0.48	0.80	3.0	5	67
Office Park	73.1	0.52	0.80	3.3	5	53
Strip Commercial	90.7	0.74	0.80	4.6	5	8

Runoff Coefficient Comparison

Land Use	% Impervious	Runoff Coefficient		Wqv (ac-ft)	Increase in Wqv (%)	TSS (lb/ac/yr)	TSS Reduction (%)
Urban Open Space	4.9			No Pond		54.3	-
		Calc	0.08	0.5	-	9.0	83.5
		Publ	0.20	1.25	163	9.3	83.0
Duplex	39.1			No Pond		280	-
		Calc	0.27	1.7	-	59.5	78.8
		Publ	0.50	3.12	82	57.3	79.6
Medium Industrial	68.5			No Pond		703	-
		Calc	0.48	3.0	-	139	80.3
		Publ	0.80	5.0	67	132	81.2

C Determination Method

- Recommendation – Use the formula, not the Table

$$C = 0.858i^3 - 0.78i^2 + 0.774i + 0.04$$

Adjustments to WQv Formula Wet Ponds

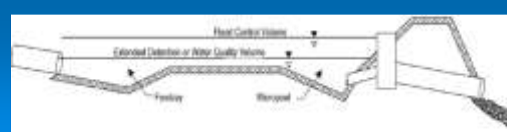
* Provide both a permanent pool and an extended detention volume above the permanent pool, each sized at 0.75 * WQ,

OEPA-CGP p22

Adjustments to WQv Formula Structural BMPs (excl Wet Ponds)

An additional volume equal to 20 percent of the WQ, shall be incorporated into the BMP for sediment storage and/or reduced infiltration capacity. Ohio EPA recommends that BMPs be designed according to the methodology included in the Rainwater and Land Development manual or in another design manual acceptable for use by Ohio EPA.

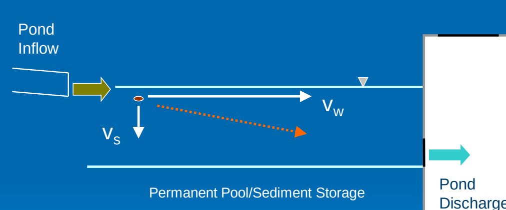
OEPA-CGP p22



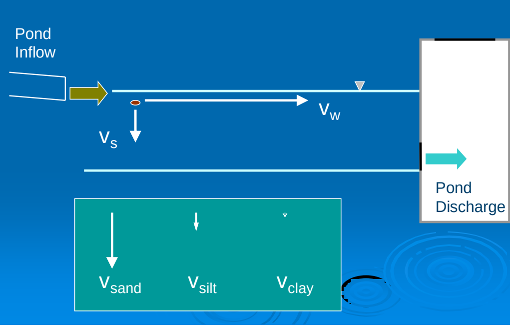
Discharge Rate

- How quickly do we release the WQv to meet our stormwater management goals?

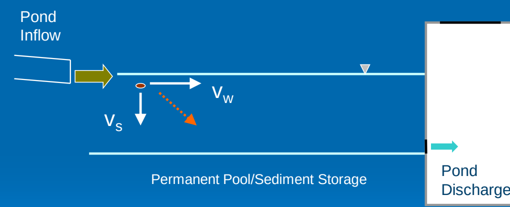
Sediment Settling Process



Sediment Settling Process



Sediment Settling Process



OEPA CGP Drawdown Requirements

- The OEPA CGP lists drain time (or drawdown) requirements for structural BMPs (CGP – Table 2)

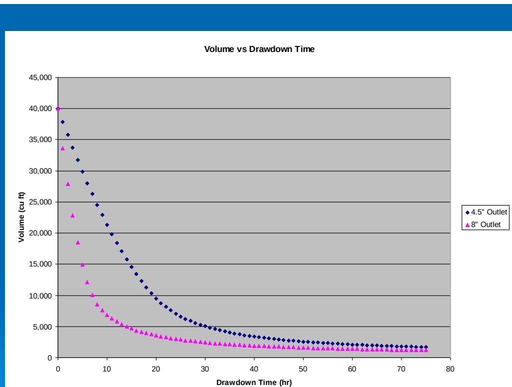
BMPs shall be designed such that the drain time is long enough to provide treatment, but short enough to provide storage available for successive rainfall events as described in Table 2 below.

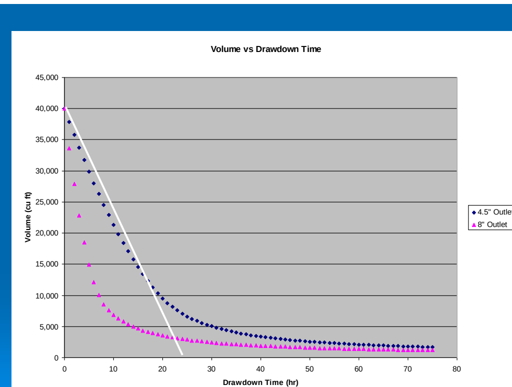
Table 2
Target Draw Down (Drain) Times for Structural Post-Construction Treatment Control Practices

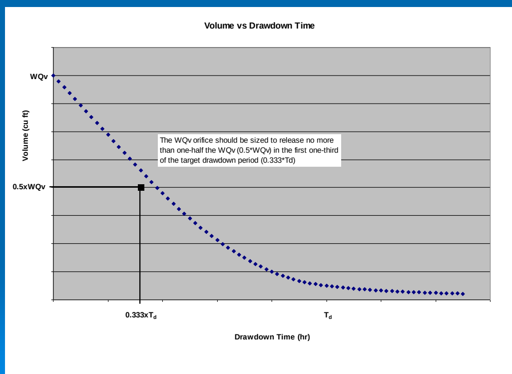
Best Management Practice	Drain Time of WQv
Infiltration	24 – 48 hours
Vegetated Swale and Filter Strip	24 hours
Extended Detention Basin (Dry Basin)	48 hours
Retention Basins (Wet Basins)*	24 hours
Constructed Wetlands (above permanent pool)	24 hours
Media Filtration, Bioretention	40 hours

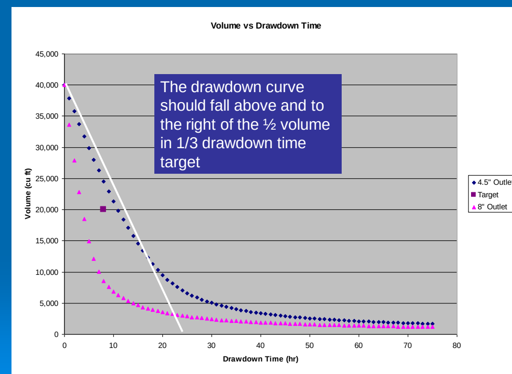
*[illegible]

Select an appropriate outlet to meet drawdown requirement for wet ponds and dry ponds









WQv Outlet - Primary Considerations

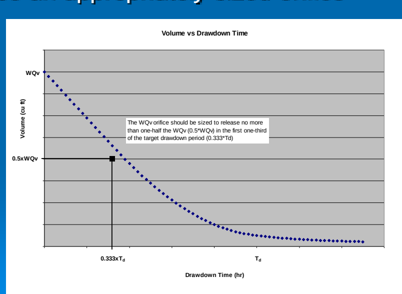
- Performance
- Maintenance

Water Quality Volume (WQv) Outlet

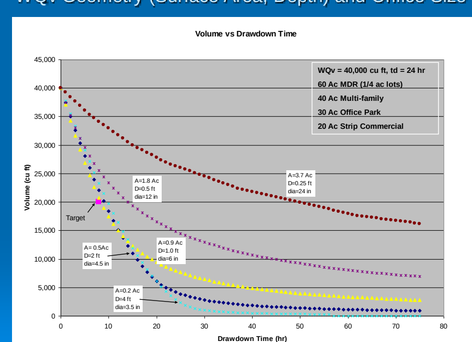
- For most detention pond designs, an orifice needs to be used to meet the drawdown requirements of the Water Quality Volume (WQv).

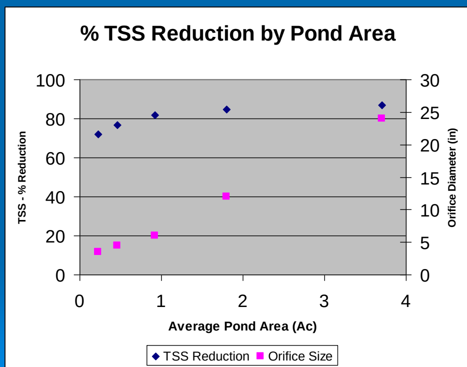
WQv Outlet - Performance

- Use an appropriately sized orifice

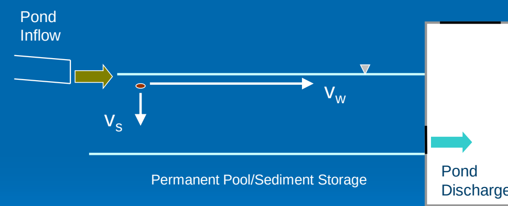


WQv Geometry (Surface Area, Depth) and Orifice Size





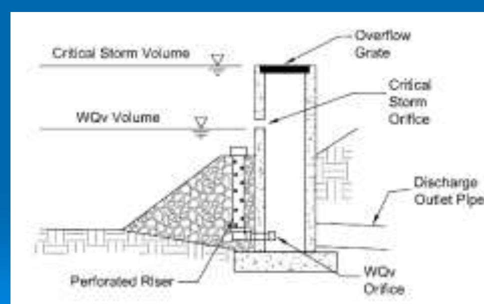
Sediment Settling Process



Multi-Stage Outlets

- Most detention basins that include a Water Quality Volume (WQv) require separate outlets for the WQv and the peak discharge control.
- The exception is very shallow extended detention volumes in large surface area wet detention basins.

Multi-Stage Outlets



Unprotected WQv Outlets

Unprotected WQv Outlets

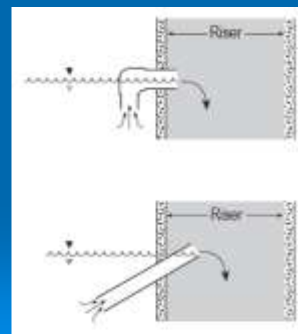




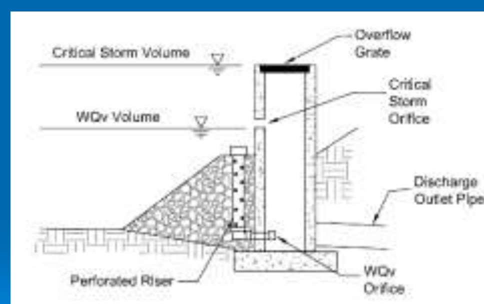

WQv Outlet - Maintenance

- Protect the orifice
- Protected orifice options:
  - Reverse slope pipe
  - Perforated tile/pipe with gravel filter

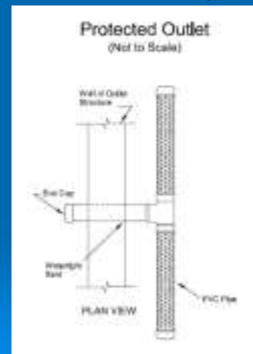
WQv Outlet – Reverse Slope Pipe



WQv Outlet – Perforated Riser/Gravel Filter



WQv Outlet – Perforated Pipe/Gravel Filter



Other Design Considerations

- **Discuss issues related to BMP selection**
- Highlight other issues
  - Health and safety
  - Maintenance
  - Performance

WQv BMP Selection

- Drainage area
- Soil type
- Performance (Source area/pollutants? Local TMDL? Target pollutants? Runoff temperature?)
- State/Local Regulations
- Outlet
- Depth/High Water Table

BMP Selection – Drainage Area

Pond Type	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Extended Detention	[illegible]		Low to Moderate	Low	Moderate	[illegible]
Extended Detention with Forebays and Micropool	[illegible]		Low to Moderate [illegible]	Low	Moderate	[illegible]
Wet Extended Detention	[illegible]	[illegible]	Moderate-high	Moderate-high	High	[illegible]
Wet Extended Detention with wetland fringe	[illegible]	[illegible]	Moderate-high	Moderate-high	High	[illegible]
Wetland	[illegible]	[illegible]	Moderate-high	Moderate-high	Moderate	[illegible]
Wetland (pocket)	Dependent upon baseflow	[illegible]	Variable	Variable	Moderate	[illegible]

BMP Selection – Soil Type

- Soil type
  - HSG-A – 1.2%
  - HSG-B – 18%
  - HSG-C – 61.2%
  - HSG-D – 19.5%

Detention Basin Selection

- Wet pond (or wetland ED basin)
  - Usually the best choice in Ohio given the predominance of C & D soils, water quality treatment performance, maintenance/ aesthetics.
- Dry ED basin
  - May be a reasonable choice for smaller development sites (<20 acres), especially for HSG A&B soils. Many states have eliminated dry basins as an option because of concerns about performance, maintenance and mosquitos (from standing water).

Dry Basins?

Other Design Considerations

- Discuss issues related to BMP selection
- **Highlight other issues**
  - **Health and safety**
  - **Maintenance**
  - **Performance**

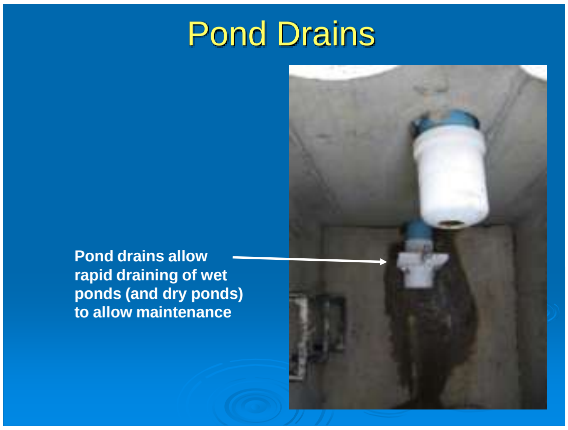
Health and Safety

- Sideslopes
- Safety benches
- Inlets/outlets
- Mosquitos/West Nile virus
- Flood Routing
- Freeboard
- Emergency spillways
- Earthwork (embankments)

Maintenance

- Sediment pre-treatment (filters and forebays)
- Maintenance access
- Pond drains
- Inlets/outlets
- Dry basins
- Permanent Stormwater Maintenance Plan
- Responsible Management Entity (RME)

Sediment Forebays/Maintenance Access


Pond Drains
Pond drains allow rapid draining of wet ponds (and dry ponds) to allow maintenance


Outlet Maintenance
Poor outlet designs require constant attention to work as designed


Dry Basins?


Are Pilot Channels the Answer?


How Big a Concern Is the Wet Spot?


An Attractive Dry Basin?

Performance

- Tailwater elevations/tailwater analysis
- Pretreatment/treatment trains
- Sediment forebays
- Dry basins – forebays and micropools
- Flow path length
- Surface area
- Outlets that work
- Conversion from sed-pond to detention pond

Pretreatment Opportunities

Pretreatment Opportunities?

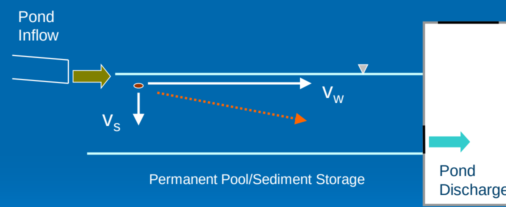
Pretreatment Opportunities?

Sediment Forebays

Micropools

Flow Path Length

Sediment Settling Process



Flow Path Length

Flow Path Length

Outlets and Performance

Having a functional Water Quality pond depends on functional outlets

Detention Pond as Sediment Pond

Sed basins must have appropriate outlet to drain dewatering volume in 48-72 hours – see RLD for guidance

Sediment Pond to Detention Pond Conversion

Sediment basin to post-construction basin outlets and conversion timing should be specified in SWPPP, checked during inspections

References
- Detention Basin Design -

- Rainwater and Land Development, Ohio DNR, Division of Soil & Water Conservation (2006).
http://www.dnr.state.oh.us/soilandwater/default/water/default/tabid/9185/Default.aspx
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