Retention Pond (RP)— Sedimentation Facility

Description

A Retention Pond (RP) is a sedimentation facility and a form of a treatment plant that has a permanent pool of water that is replaced with stormwater, in part or in total, during storm runoff events. In addition, a temporary detention volume is provided above this permanent pool to capture storm runoff and enhance sedimentation. RPs are similar to EDBs because they are designed to capture in total, as a surcharge to the pond, runoff from frequently occurring storms. However, RPs differ from extended detention basins (EDBs) because the influent water mixes with the permanent pool water as it rises above the permanent pool level. The surcharge captured volume above the permanent pool is then released over 12 hours.

RPs require a dry-weather base flow to maintain the permanent pool. They can be very effective in removing pollutants, and, under the proper conditions, can satisfy multiple objectives.

General Application

A RP can be used to improve the quality of urban runoff from roads, parking lots, residential neighborhoods, commercial areas, and industrial sites and is generally used as regional or follow-up treatment because of the base-flow requirements. It can be used as an onsite BMP if the owner provides sufficient water to keep the pond full between storms. A RP works well in conjunction with other BMPs, such as upstream onsite source controls and downstream filter basins or wetland channels.

Advantages/Disadvantages

General

A RP can be cost-effective for larger tributary watersheds. It provides the following:

- Achieves moderate to high removal rates of many urban pollutants.
- Creates wildlife habitat opportunities.
- Provides recreation, aesthetics, and open space opportunities.
- Be a part of a larger flood control basin.

Their primary disadvantages include safety concerns, more difficult maintenance sediment removal than for EDBs, floating litter, scum and algal blooms, possible nuisance odors and possible mosquito problems. Aquatic plant growth can be a factor in clogging outlet works. The permanent pool can attract water fowl, which can add to the nutrient load entering and leaving the pond. Water rights must also be considered.

Physical Site Suitability

Although site suitability concerns are similar to those stated for an EDB, a RP has one primary difference—it requires sufficient continuous base flow to maintain the pool. A complete water budget under the projected urbanized watershed conditions should be performed to assure that the base flow will exceed evaporation, evapotranspiration, and seepage losses.

Pollutant Removal

See Table ND-2 for pollutant removal ranges. A RP achieves moderate to high removal rates for particulate matter through sedimentation during and shortly after the runoff event. During a storm event, a portion or all of the permanent pool water is displaced and the pool becomes a mixture of the former pool water and new runoff. The period between storms allows biological uptake of soluble nutrients and metals from the water column in the permanent pool while also providing time for quiescent settling of fine sediment particles that remain in the pool after a storm. Some of the sediment can resuspend and soluble compounds can remobilize if a large storm event causes intense mixing or when unfavorable chemical conditions exist in the pool (such as low dissolved oxygen [DO] or pH). Also, algal growth and other biological activity can produce suspended solids and increased concentrations of certain forms of phosphates and nitrogen compounds in dry-weather base flow discharges from the pond.

Without a sufficient continuous base flow, a wet pond can concentrate levels of salts and algae between storm events through evaporation. Besides contributing to nuisance problems, the water quality of the pool is very important. A storm event will displace any concentrated pond water, and in some instances, can result in discharges of water with pollutant concentrations exceeding the inflow, exactly the opposite of the intent for providing this BMP.

Aesthetics and Multiple Uses

A RP offers improved aesthetics and multiple-uses beyond those typically found at an EDB. The bulk of the capture volume occurs as a surcharge above the permanent pool, with some of it occurring above the dry-weather bank areas. As a result, most of the sediment deposits are left behind within the permanent pool zone, where they are not seen by the public. Also, the permanent pool offers some aquatic habitat and is a habitat for water fowl. However, water fowl can be a nuisance because of the fecal matter they deposit on the banks and in the pool.

Design Considerations

The required total basin design volume of a RP facility includes the volume needed for a permanent pool (≥water quality capture volume) plus a water quality capture volume as a surcharge above the permanent pool. If desired, a flood routing detention volume can be provided above the water quality capture volume.

Whenever desirable and feasible, incorporate the RP within a larger flood control basin. Also, whenever possible try to provide for other urban uses such as active or passive recreation, and wildlife habitat. Try to locate recreational areas to limit the frequency of inundation to one or two occurrences a year. Generally, the area within the water quality capture volume is not well suited for active recreation facilities such as ballparks, playing fields, and picnic areas. These should be located above this pool level.

Land requirements are typically 0.5 to 2 percent of the tributary watershed's area. High exfiltration rates can initially make it difficult to maintain a permanent pool in a new RP, but the bottom can eventually seal with fine sediment and become relatively impermeable over time. It is best, however, to seal the bottom and the sides of a permanent pool if the pool is located on permeable soils and to leave the areas above the permanent pool unsealed to promote exfiltration of the stormwater detained in the surcharge water quality capture volume.

There are two primary differences in design between a RP and an EDB:

- The RP requires a base flow to maintain and to flush a permanent pool.
- A RP is designed to empty the surcharge water quality capture volume over a 12-hour period, instead of the longer 40 hours needed for an EDB. The reason for this is that the sediment removal process is more efficient when the outflow occurs above the bottom of the basin. Sediments become trapped below the outlet and sedimentation continues in the pool after the captured surcharge volume is emptied.

Figure RP-1 shows a representative layout for a RP. Although flood storage has not been addressed in these recommendations for the same reasons mentioned under EDBs, it can be easily provided for above the surcharge water quality capture volume. Embankment design and safety design considerations for a RP are identical to those discussed for an EDB, except more attention should be given to cutoff collars on the outlet pipe to safeguard against piping along the outlet.

The amount of construction activity within a basin, the erosion control measures implemented, and the size of the basin will influence the frequency of sediment removal from the pond. It is estimated that accumulated sediment will need to be removed at 5- to 20-year intervals if there are no construction activities within the tributary catchment.

Design Procedure and Criteria

The following steps outline the design procedure and criteria for a RP.

1. Basin Surcharge Storage Volume

Provide a storage volume equal to the WQCV based on a 12-hour drain time, above the lowest outlet (i.e., perforation) in the basin.

A. Determine the WQCV using the tributary catchment's percent imperviousness. Account for the effects of DCIA, if any, on Effective Imperviousness. Using Figure ND-1, determine the reduction in impervious area to use with WQCV calculations.

B. Find the required storage surcharge volume (watershed inches of runoff).

Determine the required water quality capture volume in watershed inches of runoff using Figure RP-2, based on the RP, 12-hour drain time. The water quality capture volume is the surcharge volume above the permanent pool.

Calculate the design surcharge volume in acre-feet as follows:

$$Design\ Surcharge\ Volume = \left(\frac{WQCV_i}{12}\right) * Area$$

In which:

$WQCV_i$	=	Water quality capture volume from Figure RP-2 in watershed inches
Area	=	The tributary drainage area tributary to the RP (acres).

2. Permanent Pool

The permanent pool provides stormwater quality enhancement between storm runoff events through biochemical processes and continuing sedimentation.

A. Volume of the permanent pool:

$$Permanent\ Pool = 1.0\ to\ 1.5\ (WQCV)$$

B. Depth Zones: The permanent pool shall have two depth zones:

1. A littoral zone 6 to 12 inches deep that is between 25 to 40 percent of the permanent pool surface area for aquatic plant growth along the perimeter of the permanent pool, and

2. A deeper zone of 4 to 8 feet average depth in the remaining pond area to promote sedimentation and

nutrient uptake by phytoplankton. Maximum depth in the pond shall not exceed 12 feet.

3. Base Flow

A net influx of water must be available through a perennial base flow and must exceed the losses. The following equation and parameters can be used to estimate the net quantity of baseflow available at a site:

$$Q_{Net} = Q_{Inflow} - Q_{Evap} - Q_{Seepage} - Q_{E.T.}$$

In which:

Q_{net} = Net quantity of base flow (acre-ft/year)

Q_{inflow} = Estimated base flow (acre-ft/year) (Estimate by seasonal measurements and/or comparison to similar watersheds)

Q_{evap} = Loss because of evaporation less the precipitation (acre-ft/year) (Computed for average water surface)

$Q_{Seepage}$ = Loss (or gain) because of seepage to groundwater (ac-ft/year)

$Q_{E.T.}$ = Loss because of plant evapotranspiration (additional loss through plant area above water surface not including the water surface)

4. Outlet Works

The Outlet Works are to be designed to release the WQCV (above the permanent pool elevation) over a 12-hour period. Refer to the *Structural Details* section for schematics pertaining to structure geometry; grates, trash racks, and screens; outlet type: orifice plate or perforated riser pipe; cutoff collar size and location; and all other necessary components.

For a perforated outlet, use Figure RP-3 to calculate the required area per row based on WQCV and the depth of perforations at the outlet. See the *Structural Details* section to determine the appropriate perforation geometry and number of rows (The lowest perforations should be set at the water surface elevation of the permanent pool.) The total outlet area can then be calculated by multiplying the area per row by the number of rows.

5. Trash Rack

Provide a trash rack of sufficient size to prevent clogging of the primary water quality outlet. Size the rack so as not to interfere with the hydraulic capacity of the outlet. Using the total outlet area and the selected perforation diameter (or height), Figures 6, 6a or 7 in the *Structural Details* section will help to determine the minimum open area required for the trash rack. If a perforated vertical plate or riser is used as suggested in this manual, use one-half of the total outlet area to calculate the trash rack's size. This accounts for the variable inundation of the outlet orifices. Figures 6 and 6a were developed as suggested standardized outlet designs for smaller sites.

6. Basin Shape — Shape the pond with a gradual expansion from the inlet and a gradual contraction toward the outlet, thereby limiting short-circuiting. The basin length to width ratio between the inlet and outlet should be between 2:1 and 3:1, with the larger being preferred. It may be necessary to modify the inlet and outlet point through the use of pipes, swales, or channels to accomplish this.

7. Basin Side Slopes — Side slopes should be stable and sufficiently gentle to limit rill erosion and to facilitate maintenance. Side slopes above the permanent pool should be no steeper than 4:1, preferably flatter. The littoral zone should be very flat (that is, 10:1 or flatter) with the depth ranging from 6 inches near the shore and extending to no more than 12 inches at the furthest point from the shore. The side slope below the littoral zone shall be 3:1 or flatter.

8. Dam Embankment — The embankment should be designed not to fail during a 100-year or larger storm. Embankment slopes should be no steeper than 3:1, preferably 4:1 or flatter, covered with turf-forming grasses to limit erosion. Poorly compacted native soils should be removed and replaced. Embankment soils should be compacted to 95 percent of their maximum density according to ASTM D 698-70 (modified proctor).

9. Vegetation — Vegetation provides erosion control and enhances site stability. Berms and side-sloping areas should be planted with native turf-forming grasses or irrigated turf, depending on the local setting and proposed uses for the pond area. The shallow littoral bench should have a 4- to 6-in. organic topsoil layer and be vegetated with aquatic species.

10. Maintenance Access — Access to the basin bottom, forebay, and outlet area must be provided to maintenance vehicles. Maximum grades should be 10 percent, and a solid driving surface of gravel, rock, or concrete shall be provided.

11. Inlet	Dissipate flow energy at the inlet to limit erosion and to diffuse the inflow plume where it enters the pond. Inlets should be designed in accordance with the drop-structure and energy-dissipating structure criteria in the Design Criteria section of the City of Colorado Springs and El Paso County Drainage Criteria Manual.
12. Forebay Design	To provide an opportunity for larger particles to settle out, install an area that has a solid driving surface bottom to facilitate sediment removal. A berm consisting of rock and topsoil mixture should be part of the littoral bench to create the forebay and have a minimum top width of 8 feet and side slopes no steeper than 4:1. The forebay volume of the permanent pool should be 5 to 10 percent of the design water quality capture volume.
13. Underdrains	Provide underdrain trenches near the edge of the pond. The trenches should be no less than 12 inches wide filled with ASTM C-33 sand to within 2 feet of the ponds permanent pool water surface, and with an underdrain pipe connected through a valve to the outlet. These underdrains will permit the drying out of the pond when it has to be "mucked out" to restore volume lost due to sediment deposition.

Design Example

Design forms that provide a means of documenting the design procedure are included in the *Design Forms* section. A completed form follows as a design example.

Maintenance Recommendations

The amount of construction activity within a basin, the erosion control measures implemented, and the size of the basin will influence the frequency of sediment removal from the pond. When aggressive erosion control is practiced in the tributary watershed, it is estimated that accumulated sediment will need to be removed at 5- to 20-year intervals. Table RP-1 summarizes the required maintenance activities and their frequency for retention ponds.

TABLE RP-1
Retention Pond Basin Maintenance Considerations

Required Action	Maintenance Objective	Frequency of Action
Lawn mowing and lawn care	Mow occasionally to limit unwanted vegetation. Maintain irrigated turf grass 2 to 4 inches tall and non-irrigated native turf grasses at 4 to 6 inches.	Routine – depending on aesthetic requirements.
Debris and litter removal	Remove debris and litter from the entire pond to minimize outlet clogging and aesthetics. Include the removal of floatable material from the pond's surface.	Routine – including just before annual storm seasons (that is, April and May) and following significant rainfall events.

TABLE RP-1
Retention Pond Basin Maintenance Considerations

Required Action	Maintenance Objective	Frequency of Action
Erosion and sediment control	Regrade and revegetate eroded and slumped areas above the pond and along channels. Repair damaged inlet and outlet energy dissipators.	Nonroutine – periodic and repair as necessary based on inspection.
Inspections	Inspect the retention pond for functioning as initially intended. Pay attention to outlet clogging. Also note erosion, slumping, sedimentation levels, overgrowth, embankment and spillway integrity, and damage to structural elements of the facility.	Routine – annual inspection of hydraulic and structural facilities. Biannual performance and maintenance inspections.
Nuisance control	Address odor issues, insects, and overgrowth with appropriate measures.	Nonroutine – as necessary per inspection or local complaints.
Structural repairs	Repair such items as inlet/outlet works and energy dissipator liners. Stabilize banks and berms. Repair damage caused by larger storm events.	Nonroutine – as necessary per inspection.
Sediment removal	Empty the pond, divert the base flow, and dry out bottom sediments in fall and winter months to allow access with backhoe. Remove accumulated sediment along with aquatic growth overlaying them. Re-establish original design grades and volumes and replant aquatic vegetation.	Nonroutine – as indicated per inspections and sediment accumulation. Expect to do this every 10 to 20 years if no construction activities take place in the tributary watershed. More often if they do. Expect to clean out the forebay every 1 to 5 years.
Aquatic Growth Harvesting	Remove aquatic plants such as cattails or reeds, which also permanently removes nutrients. Use an aquatic harvester and dispose of the material offsite.	Nonroutine – perform every 5 to 15 years or as needed to control their accumulation.

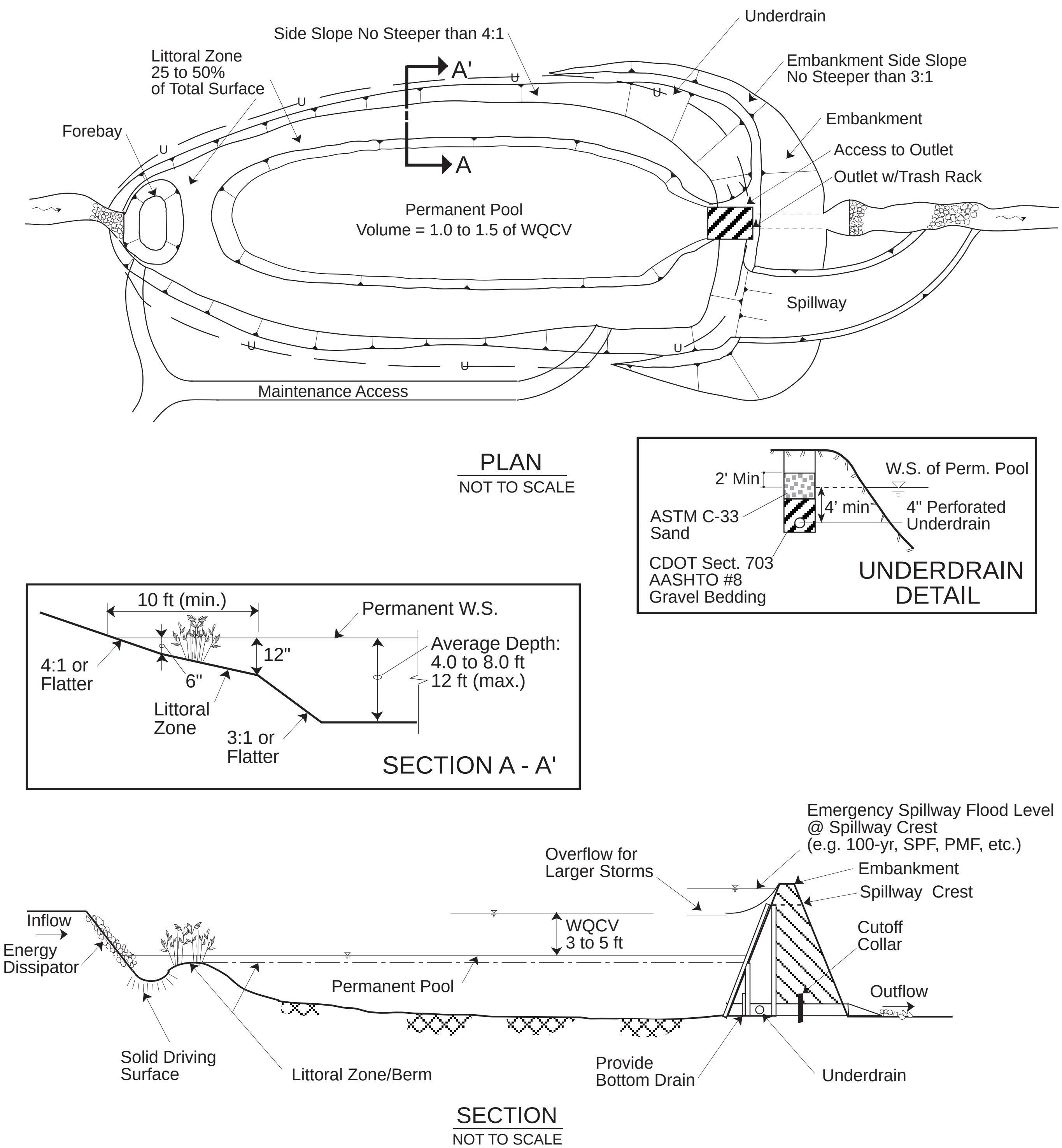


FIGURE RP-1
Plan And Section Of a Retention Pond - Sedimentation Facility

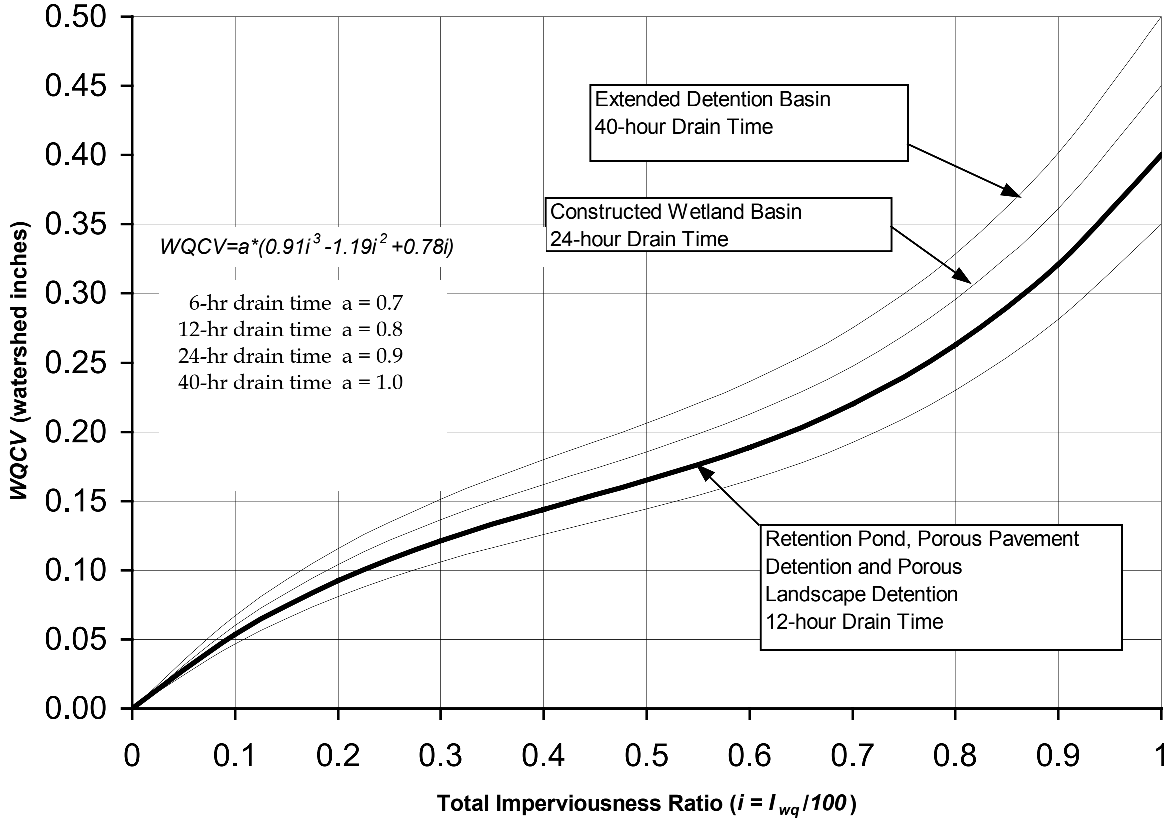
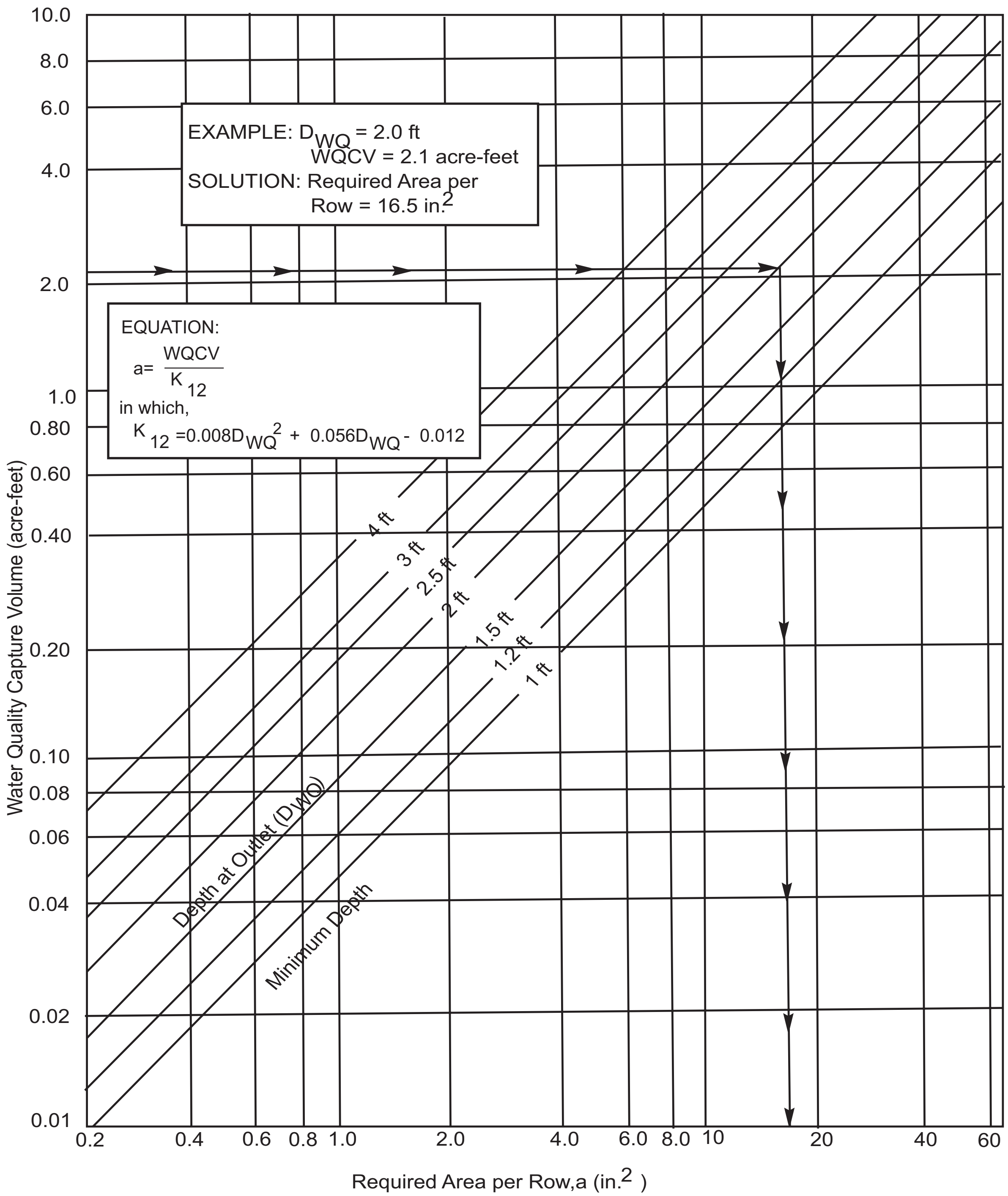


FIGURE RP-2
Water Quality Capture Volume (WQCV), 80th Percentile Runoff Event



Source: *Douglas County Storm Drainage and Technical Criteria*, 1986.

FIGURE RP-3
Water Quality Outlet Sizing: Retention Pond – Sedimentation Facility with a 12-hour Drain Time of Capture Volume

Design Procedure Form: Retention Pond (RP) - Sedimentation Facility (Sheet 1 of 3)

Designer: ____________________
Company: ____________________
Date: **September 22, 1999**
Project: ____________________
Location: ____________________

1. Basin Storage Volume			
	I_a =	50.00	%
A) Tributary Area's Imperviousness Ratio ($i = I_a / 100$)	i =	0.50	
B) Contributing Watershed Area (Area)	Area =	100.00	acres
C) Water Quality Capture Volume (WQCV) (WQCV =0.8 * (0.91 * I^3 - 1.19 * I^2 + 0.78 * I))	WQCV =	0.17	watershed inches
D) Design Volume: Vol = (WQCV / 12) * Area	Vol =	1.38	acre-feet
2. Permanent Pool			
A) Volume: Vol_{Pool} = (1.0 to 1.5) * Vol		1.40	acre-feet
B) Average Depth Zone 1 = Littoral Zone - 6 to 12 inches deep		0.75	feet
Zone 2 = Deeper Zone - 4 feet to 8 feet deep	Zone 2	6.00	feet
C) Maximum Zone 2 Pool Depth (not to exceed 12 feet)	Depth =	9.00	feet
D) Permanent Pool Water Surface Area (Estimated Minimum)			
(Zone 1 - Littoral Zone = 25% to 40% of the total surface area)	% =	37.3	acres = 0.129
(Zone 2 - Deeper Zone = 60% to 75% of the total surface area)	% =	62.7	acres = 0.217
Total Estimated Minimum Surface Area (A_{Total})	% =	100.0	acres = 0.346
3. Annual/Seasonal Water Balance (Q_{net} has to be positive)	Q_{inflow}	181.00	acre-feet/year
	Q_{evap}	1.30	acre-feet/year
	$Q_{seepage}$	2.10	acre-feet/year
	$Q_{E.T.}$	0.80	acre-feet/year
	Q_{net}	176.80	acre-feet/year
4. Outlet Works			
A) Outlet Type (Check One)	___	Orifice Plate	
	X	Perforated Riser Pipe	
	___	Other:	____________________
B) Depth at Outlet Above Lowest Perforation (H)	H =	4.00	feet
C) Required Maximum Outlet Area per Row, (A_o)	A_o =	1.99	square inches
D) Perforation Dimensions **(enter one only)**:			
i) Circular Perforation Diameter **OR**	D =	1.1250	inches, **OR**
ii) 2" Height Rectangular Perforation Width	W =		inches
E) Number of Columns (nc)	nc =	2	Number

Design Procedure Form: Retention Pond (RP) - Sedimentation Facility (Sheet 2 of 3)

Designer: ______
Company: ______
Date: **September 22, 1999**
Project: ______
Location: ______

F) Actual Design Outlet Area per Row (A_o)	A_o = 1.99 square inches
G) Number of Rows (nr)	nr = 12 Number
H) Total Outlet Area (A_{ot})	A_{ot} = 23.86 square inches
5. Trash Rack	
A) Needed Open Area: $A_t = 0.5 * (\text{Figure 7 Value}) * A_{ot}$	A_t = 799 square inches
B) Type of Outlet Opening (Check One)	X ≤ 2" Diameter **Round** __ 2" High **Rectangular** __ Other: ______
C) For 2", or Smaller, **Round Opening** (Ref.: Figure 6a):	
I) Width of Trash Rack and Concrete Opening (W_{conc}) from Table 6a-1	W_{conc} = 24 inches
ii) Height of Trash Rack Screen (H_{TR})	H_{TR} = 72 inches
iii) Type of Screen (Based on Depth H), Describe if "Other"	X S.S. #93 VEE Wire (US Filter) __ Other: ______
iv) Screen Opening Slot Dimension, Describe if "Other"	X 0.139" (US Filter) __ Other: ______
v) Spacing of Support Rod (O.C.) Type and Size of Support Rod (Ref.: Table 6a-2)	1 inches **TE 0.074 in. x 0.75 in.**
vi) Type and Size of Holding Frame (Ref.: Table 6a-2)	**1.00 in. x 1.50 in. angle**
D) For 2" High **Rectangular Opening** (Refer to Figure 6b):	
I) Width of Rectangular Opening form 4.D.ii. (W)	W = ______ inches
ii) Width of Perforated Plate Opening (W_{conc} = W + 12")	W_{conc} = ______ inches
iii) Width of Trash Rack Opening ($W_{opening}$) from Table 6b-1	$W_{opening}$ = ______ inches
iv) Height of Trash Rack Screen (H_{TR})	H_{TR} = ______ inches
v) Type of Screen (based on depth H) (Describe if "Other")	__ Klemp™ KPP Series Aluminum __ Other: ______
vi) Cross-bar Spacing (Based on Table 6b-1, Klemp™ KPP Grating). Describe if "Other"	______ inches __ Other: ______ 96.00

Design Procedure Form: Retention Pond (RP) - Sedimentation Facility (Sheet 3 of 3)

Designer: ____________________
Company: ____________________
Date: **September 22, 1999**
Project: ____________________
Location: ____________________

vii) Minimum Bearing Bar Size (Klemp™ Series, Table 6a-2) (Base on depth of WQCV surcharge)	____________________
6. Basin length to width ratio	1.80 (L/W)
7. Basin Side Slopes (Z:1) A) Above the Permanent Pool: Z= B) Below the Permanent Pool Z= Z=	 5.0 (horizontal/vertical) Zone 1= 5.0 (horizontal/vertical) Zone 2= 3.0 (horizontal/vertical)
8. Dam Embankment Side Slopes Z=	4.0 (horizontal/vertical)
9. Vegetation (Check the type used or describe if "Other")	____ Native Grass **X** Irrigated Turf Grass **X** Emergent Aquatic Species* ____ Other: ____________ *Specify types and densities: ____________________
10. Forebay Storage (5% to 10% of Design Volume in 1D)	Storage= 0.12 acre-feet
11. Underdrains	**Yes** yes/no

Notes: ____________________