Description

Wet detention basins (WDBs) are open earthen basins that feature a permanent pool of water that is displaced by storm water flow, in part or in total, during storm runoff events. Like Extended Detention Basins (see T-3), WDBs are designed to temporarily detain the Stormwater Quality Design Volume (SQDV) of stormwater runoff and to slowly release this volume over a specified period (12 hours). WDBs differ from EDBs in that the influent runoff flow water mixes with and displaces the permanent pool as it enters the basin. The drawdown time for WDBs (12 hours) is shorter than for EDBs (40 hours), because enhanced treatment is provided in the permanent pool. A dry-weather base flow is required to maintain the permanent pool. The basic elements of a WDB are shown in Figure 5-7.

General Application

Wet Detention Basins function similarly to EDBs, serving to reduce peak stormwater runoff rates and providing treatment of runoff primarily through sedimentation. These basins can improve the quality of urban runoff from roads, parking lots, residential neighborhoods, commercial areas, and industrial sites and are generally used as a regional or follow-up treatment because of the base-flow requirements. Because there is a permanent pool present, wet detention basins can also serve as passive recreational areas during the dry season, and can be designed into flood control basins or sometimes retrofitted into existing flood control basins.

Wet detention basins can serve essentially any size tributary area from an individual commercial development to a large residential or regional area, but are typically used for areas greater than 10 acres. These basins work well in conjunction with other BMPs, such as upstream onsite source controls and downstream filter basins or wetland channels.

Advantages/Disadvantages

General

Wet Detention Basins may be designed to provide other benefits such as passive recreation, wildlife habitat, and open space. Safety issues must be addressed through proper design.

Site Suitability

Wet Detention Basin space requirements are significant. Land requirements for WDBs typically range from approximately 0.5 to 2 percent of the tributary development area. These basins are also not suitable for dense urban areas or sites with steep and unstable slopes. Although site suitability concerns are similar to those stated for an EDB, Wet Detention Basins are not suitable for areas with long dry spells and high evaporation rates without perennial groundwater base flow or supplemental water to maintain permanent pool and aquatic vegetation. A complete water budget under the projected watershed conditions should be performed to assure that the base flow will exceed evaporation, evapotranspiration, and seepage losses. This control measure is most appropriate for sites with low-permeability soils (Type C and D).

Vegetation Maintenance

Considerable resources must be committed to properly maintain peripheral aquatic vegetation in WDBs to control mosquito propagation and to maintain effective permanent pool volume.

Pollutant Removal

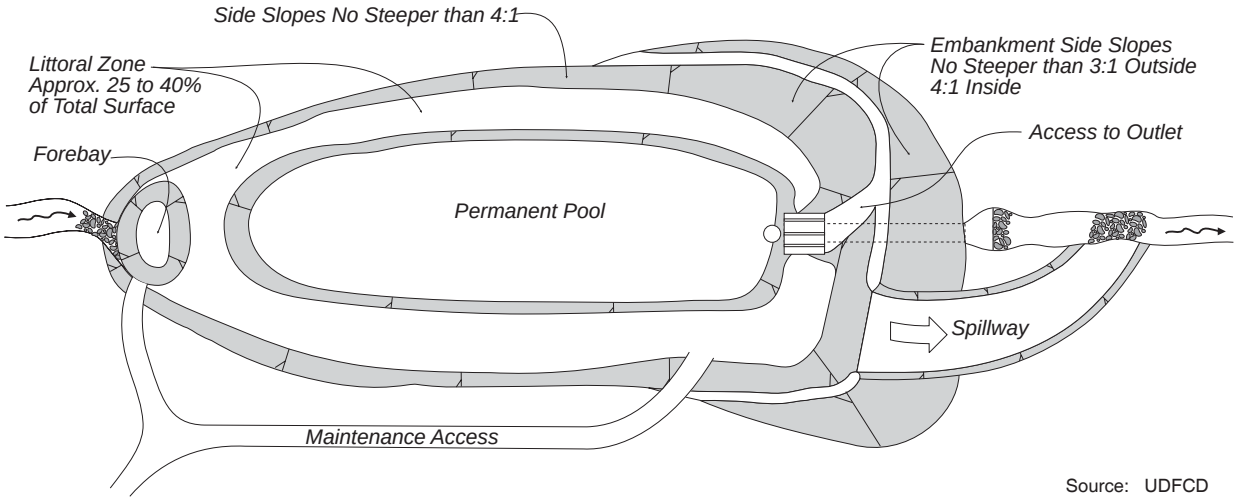
Relative pollutant removal effectiveness of a Wet Detention Basin is presented in Table 5-1. Removal effectiveness of WDBs for sediment and particulate forms of metals, nutrient and other settleable solids is considered high to moderate. WDBs also remove flotables and achieve some degree of dissolved contaminant removal, but effectiveness against dissolved contaminants is low. WDBs may be used upstream of control measures that are more effective at removing soluble pollutants, such as infiltration basins, filters or wetlands.

Design Criteria and Procedure

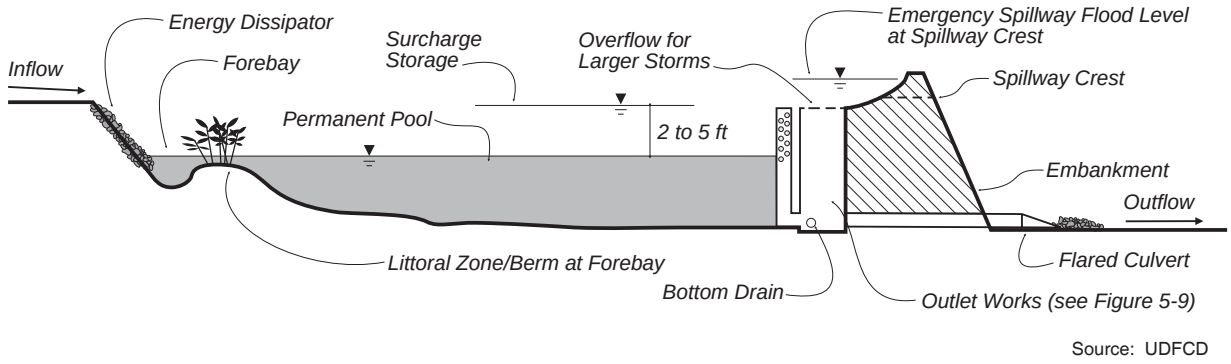
Principal design criteria for WDBs are listed in Table 5-7.

Table 5-7. Wet Detention Basin Design Criteria

Design Parameter	Unit	Design Criteria
Drawdown time for SQDV / 50% SQDV	hrs	12
SQDV	acre-ft	80% annual capture. Use Figure 5-1 @ 12-h drawdown
Inlet/outlet erosion control	–	Energy dissipater to reduce inlet/outlet velocity
Permanent Pool volume	–	1.0 to 1.5 x SQDV
2 Depth Zones Required	–	Littoral Zone (6-12 inches deep, 25-40% of permanent pool surface area) Deeper Zone (4-8 feet average depth of remaining pond area, 12 feet max. depth)
Forebay volume/ drain time	%/min	5 to 10% of SQDV. Drain time < 45 minutes
Length to width ratio (minimum)	–	2:1 (larger preferred)
Minimum bottom width	ft	30
Freeboard (minimum)	ft	1.0
Embankment side slope (H:V)	–	≥ 4:1 inside/ ≥3:1 outside (without retaining walls)
Maintenance access ramp slope (H:V)	hrs	10:1 or flatter
Maintenance access ramp width	ft	16.0 – approach paved with asphalt concrete



Plan View



Section View

Figure 5-7. Conceptual Layout of Wet Detention Basin

Design procedure and application of design criteria for WDBs are outlined in the following steps:

1. Basin Surcharge Volume — Provide a surcharge volume equal to the SQDV, based on a 12-hr drawdown time, above the lowest outlet (i.e. perforation or orifice) in the basin.

   a. Determine the percent imperviousness of the tributary area (I_a).

   b. Determine effective imperviousness (I_{wq}) by adjusting for site design source controls using Figure 3-4, as appropriate.

   c. Determine required unit basin storage volume (V_u) using Figure 5-1 with 12-hr drawdown and I_{wq} value from step 1.b.

   d. Calculate the SQDV in acre-ft as follows:

   $$SQDV = (V_u / 12) \times Area$$

   where Area = Watershed area tributary to WDB (acres)

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

   a. Determine the volume of the permanent pool (V_p), which is 1.0 to 1.5 times the SQDV.

   b. Depth Zones (see Figure 5-8)

      Littoral Zone should be between 6 to 12 inches deep that is between 25 to 40 percent of the permanent pool surface for aquatic plant growth along the perimeter of the pool.

      Deeper Zone should be 4 to 8 feet average depth with a maximum depth of 12 feet. This zone should cover the remaining pond area and promote sedimentation and nutrient uptake by phytoplankton.

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 base flow available at the time.

$$Q_{net} = Q_{inflow} - Q_{E-P} - Q_{seepage} - Q_{ET}$$

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_{E-P} = Loss due to evaporation minus the precipitation (acre-ft/year)

$Q_{seepage}$ = Loss or gain due to seepage to groundwater (acre-ft/year)

Q_{ET} = Loss due to 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 SQDV (i.e. not Design Volume) over a 12-hour period. Refer to Figure 5-9 for schematics pertaining to structure geometry; grates, trash racks, and outlet.

a. For perforated pipe outlets or vertical plates with multiple orifices, use the following equation to determine required area per row of perforations, based on the SQDV(acre-ft) and depth of water above the centerline of the bottom perforation D (ft).

$$\text{Area/row } (in^2) = SQDV/K_{12}$$

where

$$K_{12} = 0.008D^2 + 0.056D - 0.012$$

Select appropriate perforation diameter and number of perforations per row (columns) with the objective of minimizing the number of columns and using a maximum perforation diameter of 2 inches. Rows are spaced at 4 inches on center from the bottom perforation. Thus, there will be 3 rows for each foot of depth plus the top row. The number of rows (nr) may be determined as follows:

$$nr = 1 + (D \times 3)$$

Calculate total outlet area by multiplying the area per row by number of rows.

$$\text{Total orifice area} = \text{area/row} \times nr$$

b. For single orifice outlet control or single row of orifices at the basin bottom surface elevation use the following equation based on the SQDV (ft^3) and depth of water above orifice centerline D (ft) to determine orifice area (in^2):

$$\text{Total orifice area} = (SQDV) \div [(60.19)(D^{0.5})(T)]$$

where

$$T = \text{drawdown period (hrs)} = 12 \text{ hrs}$$

5. 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, preferable 5:1 or flatter. The littoral zone should be very flat (40:1 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.
6. Forebay Design	The forebay provides a location for sedimentation of larger particles and has a solid bottom surface to facilitate mechanical removal of accumulated sediment. The forebay volume should be 5 to 10 percent of the SQDV. 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.
9. Inlet/Outlet Design	Basin inlet and outlet points should provided with an energy dissipation structure and/or erosion protection.
10. Vegetation	Bottom vegetation provides erosion protection and sediment entrapment. Berms, and side slopes may be planted with native grasses or with irrigated turf. The shallow littoral bench should have a 4 to 6 inch thick organic topsoil layer and be vegetated with aquatic species.
11. Embankment	Design embankments to conform to requirements State of California Division of Safety of Dams, if the basin dimensions cause it to fall under that agency's jurisdiction. Interior slopes should be no steeper than 4:1 and exterior slopes no steeper than 3:1. Flatter slopes are preferable.
12. Access	All-weather access to the bottom, forebay, and outlet works shall be provided for maintenance vehicles. Maximum grades of access ramps should be 10 percent and minimum width should be 16 feet. Ramps should be paved with concrete.
13. Bypass	Provide for bypass or overflow of runoff volumes in excess of the SQDV. Spillway and overflow structures should be designed in accordance with applicable standards of the City of Woodland Storm Drainage Guidance and Criteria.
14. 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 pond's 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 to document the design procedure are provided in Appendix G. A completed design form follows as a design example.

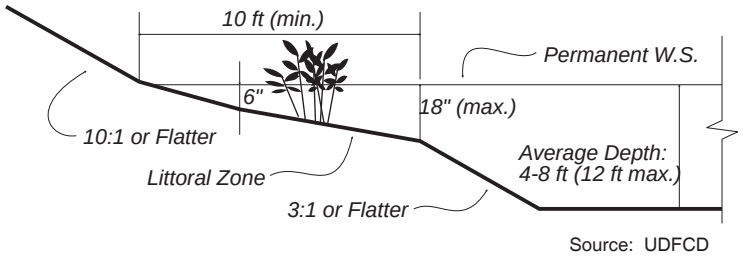
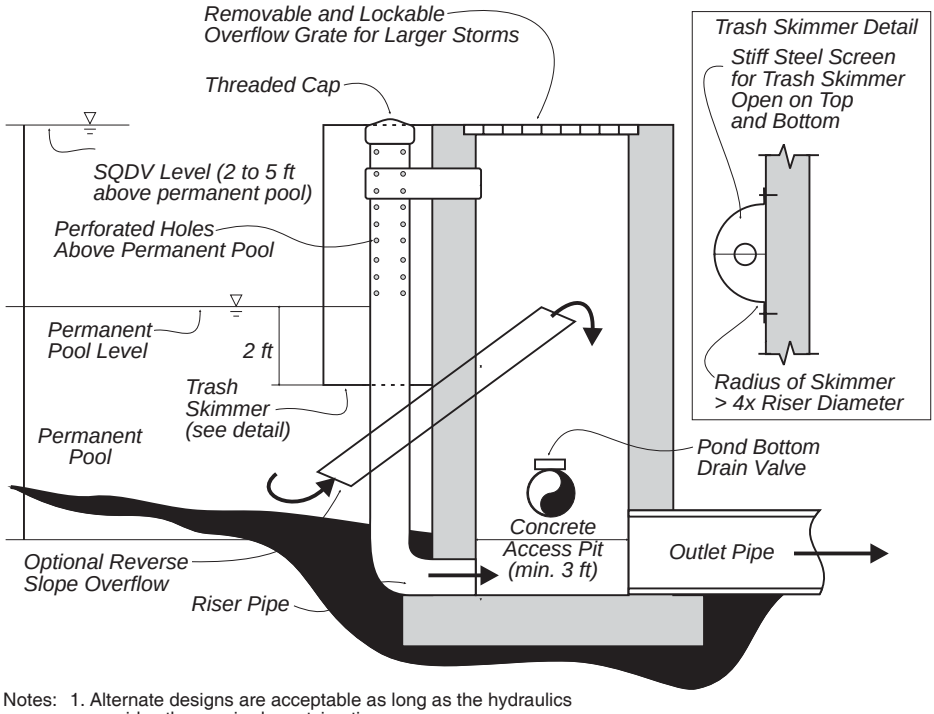


Figure 5-8. Depth Zones for Wet Detention Basin



Notes: 1. Alternate designs are acceptable as long as the hydraulics provides the required emptying times.
2. Use trash skimmer screens of stiff green steel material to protect perforated riser. Must extend from the top of the riser to 2 ft below the permanent pool level.

Source: UDFCD

Figure 5-9. Outlet Works for Wet Detention Basin

Design Procedure Form for T-4: Wet Detention Basin

Designer: _____

Company: _____

Date: _____

Project: _____

Location: _____

1. Determine Basin Storage Volume			
a. Percent Imperviousness of Tributary Area	I_a =	64	%
b. Effective Imperviousness (Determine using Figure 3-4	I_{wq} =	60	%
c. Required Unit Basin Storage Volume (V_u) Use Figure 5-1 with 12 hr drawdown and I_{wq}	V_u=	0.28	in.
d. Watershed Area Tributary to EDB	Area =	100.0	acres
Calculate SQDV = (V_u / 12) x Area	SQDV =	2.33	acre-ft
2. Permanent Pool			
a. Volume of Permanent Pool (1.0 to 1.5 times SQDV minimum)	V_p =	2.33	acre-ft
b. Depth			
1) Littoral Zone Depth (6 to 12 inches)	Depth =	1.0	feet
2) Deeper Zone Depth (4 to 8 ft average, 10 ft max)	Average Depth =	6.0	feet
	Max Depth =	9.0	feet
c, Permanent Pool Surface Area			
1) Littoral Zone Area (25%-40% Permanent Pool Surface)	Area =	0.175	acres
	% of total	30.0	%
2) Deeper Zone Area (60%- 40% Permanent Pool Surface)	Area =	0.408	acres
	% of total	70.0	%
3) Total Area	Total area =	0.583	acres
3. Estimated Net Base Flow (must be > 0)			
$Q_{net} = Q_{inflow} - Q_{evap} - Q_{seepage} - Q_{evapotranspiration}$	Q_{inflow} =	2.33	acre-ft
	Q_{evap} =	0.3	acre-ft
	$Q_{seepage}$ =	0.8	acre-ft
	$Q_{evapotranspiration}$	0.8	acre-ft
	Q_{net} =	0.43	acre-ft

Design Procedure Form for T-4: Wet Detention Basin (Page 2 of 3)

Project: _____

4.	Outlet Works			
	a. Outlet Type (check one)	Single Orifice	X (1 row)	
		Multi-orifice Plate		
		Perforated Pipe		
		Other		
	b. Depth of water above bottom orifice	Depth =	3.0	feet
	c. Single Orifice Outlet			
	1) Total Area	A =	81.13	square inches
	2) Diameter or L x W	D =	4 @ 5.08	inches
	d. Multiple Orifice Outlet			
	1) Area per row of perforations	A =		
	2) Perforation Diameter (2 inches max.)	D =		
	3) No. of Perforations (columns) per Row	Perforations =		
	4) No. of Rows (4 inch spacing)	Rows =		
	5) Total Orifice Area (Area per row) x (Number of Rows)	Area =		
5.	Trash Rack or Gravel Pack Present?	Yes/No	Yes	
6.	Basin Shape			
	a. Length-Width Ratio	Ratio =	3:1	L/W
7.	Forebay Design			
	a. Forebay Volume (5-10% of SQDV min.)	Volume =	0.12	acre-ft
	b. Outlet pipe drainage time (< 45 minutes)	Drainage Time	45	mins.
8.	Embankment Slope			
	a. Interior Slope (4:1 max.)	Interior Slope =	4:1	L/W
	b, Exterior Slope (3:1 max.)	Exterior Slope =	3:1	L/W

Design Procedure Form for T-4: Wet Detention Basin (Page 3 of 3)

Project: _____

9. Vegetation (Check type used or describe "Other")	__X__ Native Grasses _____ Irrigated Turf Grass _____ Emergent Aquatic Plants (specify type / density) _____ Other _____
10. Underdrains Provided?	Yes /No ____No____

Notes:

Maintenance Requirements

The following maintenance requirements apply to wet detention basins

Maintenance Agreement

On-site treatment control measures are maintained by the owner/operator. Maintenance agreements between the owner/operator and the City may be required. However, if pretreatment is recommended but not included in the design, a maintenance agreement will be required. If required, a maintenance agreement must be executed by the owner/operator before the improvement plans are approved. (See Appendix C for example maintenance agreement.)

Maintenance Plan

A post-construction Maintenance Plan shall be prepared and made available at the City's request. The Maintenance Plan should address at least the following items (see Appendix D for more detailed suggested Maintenance Plan content and format:

- Operation plan and schedule, including a site map
- Maintenance and cleaning activities and schedule
- Equipment and resource requirements necessary to operate and maintain facility
- Responsible party for operation and maintenance

Maintenance Activities

- Inspect basin semiannually, after each significant storm, or more frequently, if needed.. Some important items to check for include: differential settlement, cracking; erosion, leakage, or tree growth on the embankment; the condition of the riprap in the inlet, outlet and pilot channels; sediment accumulation in the basin; and the vigor and density of the grass turf on the basin side slopes and floor. Correct observed problems as necessary.
- Remove litter and debris from banks and basin bottom as required.
- Repair erosion to banks and bottom as required.
- Remove sediment when accumulation reaches 25% of original design depth, or if resuspension is observed. Clean in early spring so vegetation damaged during cleaning has time to re-establish.
- Inspect outlet for clogging a minimum of twice a year, before and after the rainy season, after large storms, and more frequently if needed. Correct observed problems as necessary.
- Clean forebay frequently to reduce frequency of main basin cleaning.
- Control mosquitoes, as necessary. Mosquito control is an important issue for WDBs and may require extensive and frequent control of peripheral vegetation.