PENNSYLVANIA HOUSING RESEARCH CENTER

DESIGN AND CONSTRUCTION OF DRY WELLS IN PENNSYLVANIA

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INTRODUCTION

State-level regulations require a stormwater permit (NPDES) with engineered stormwater management facilities for projects with over 1 acre of earth disturbance; however, many municipalities have ordinances that require stormwater management for projects with smaller areas of disturbance. Disconnecting downspouts to a dry well or sump is a way for a single-family home to meet local stormwater ordinances. This Builder Brief will outline the design, sizing, and construction considerations for dry wells. The sizing and construction criteria in this Brief are based on the PA Stormwater BMP Manual (2006) and the PA DEP Model Stormwater Management Ordinance (2016). See Figure 1 for a flow chart to help determine if your project needs an NPDES permit. Please note that this Brief should only be used as a guide. Special soil or geologic conditions may require design calculations by an engineer. Your county conservation district or municipal engineer can confirm if this approach is adequate.

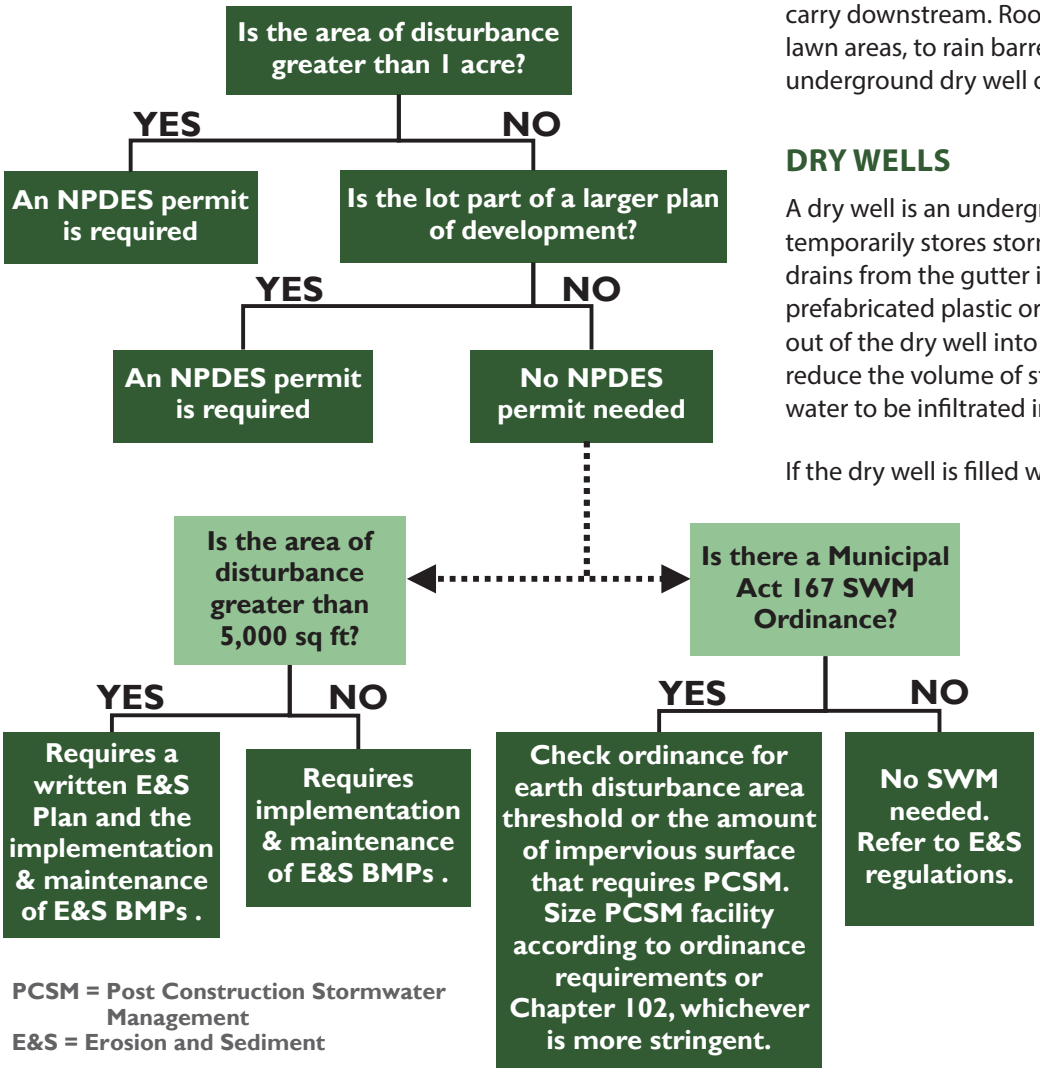

Figure 1: Flow chart to highlight the situations where an NPDES permit is required.

DISCONNECTED DOWNSPOUTS

Traditionally, roof gutter downspouts were connected directly to underground storm drain pipes. Disconnecting the downspout allows the roof runoff to be managed right on your property, not allowing it to pick up pollutants to carry downstream. Roof runoff can be directed to grassy lawn areas, to rain barrels and cisterns for reuse, or to an underground dry well or sump for infiltration.

DRY WELLS

A dry well is an underground storage facility that temporarily stores stormwater runoff from roofs. The runoff drains from the gutter into either a gravel filled pit or a prefabricated plastic or concrete tank. Runoff slowly drains out of the dry well into the surrounding soil. Dry wells reduce the volume of stormwater runoff by allowing the water to be infiltrated into the soil.

If the dry well is filled with gravel, the rock typically consists of clean washed, uniformly graded aggregate with 40% void capacity (AASHTO No. 3, or similar) at a depth ranging from 18 to 48 inches. Dry well aggregate is wrapped in a nonwoven geotextile, which keeps the surrounding soil out of the rock of the dry well. An alternative to a gravel dry well is a subsurface, prefabricated chamber made of concrete or plastic. A variety of prefabricated dry wells are currently available on the market. See Figure 2 for a typical detail of the components of a dry well.

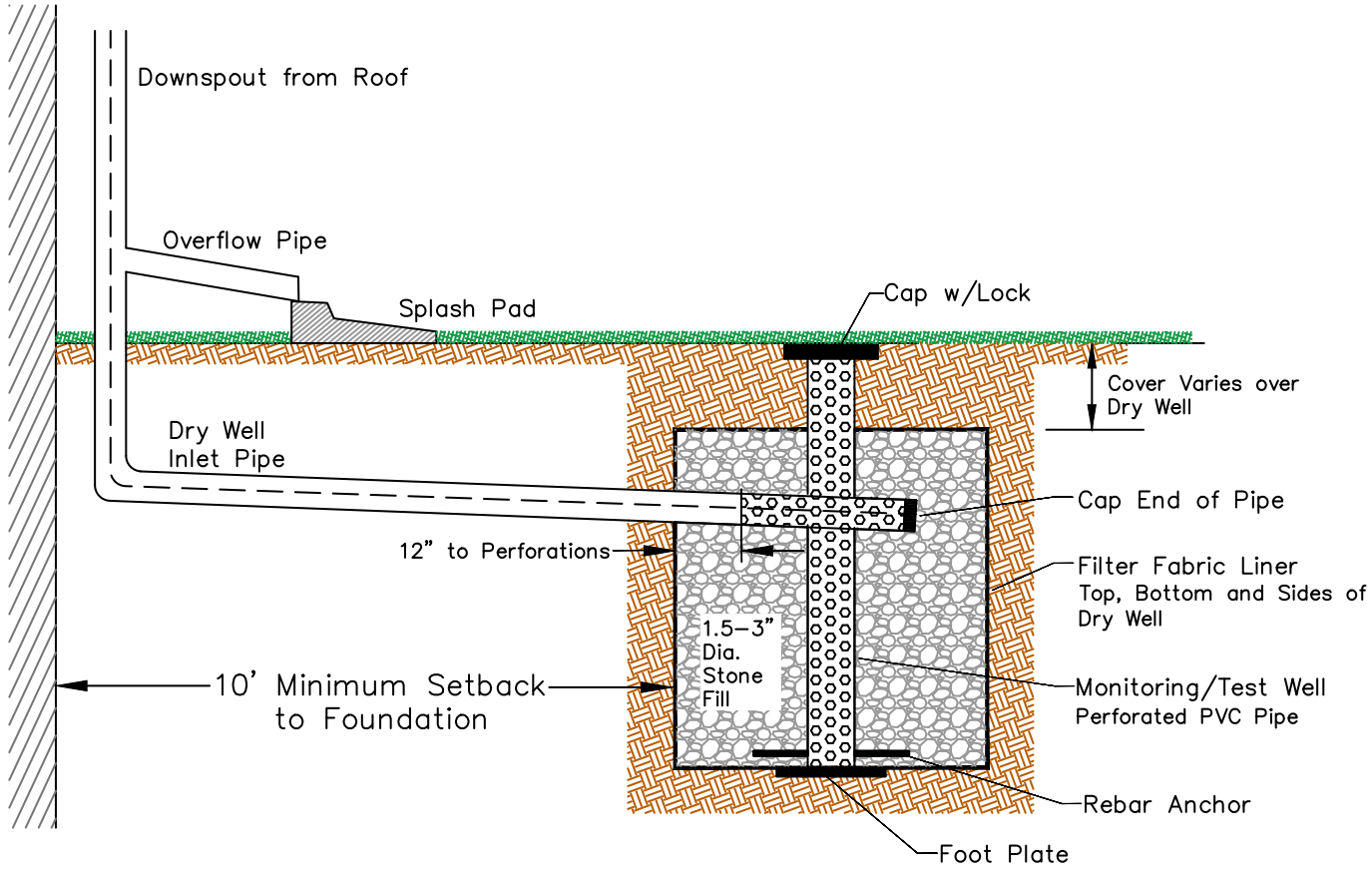

Figure 2: Construction detail for a stormwater dry well.

The dry well bottom should be 2 feet above the seasonally high water table or bedrock, and the top should be approximately 1 foot below the ground surface. An overflow pipe is necessary to allow for conveyance of overflow during large events.

A dry well may also be designed with a pre-treatment sump that collects leaf, sediment, and other debris, reducing the risk of clogging the dry well. The sump will have a cleanout access hatch to allow for the periodic removal of accumlated material. The only way to clean out a clogged gravel pit dry well is through removal and replacement of the gravel, so a pre-treatment sump is particularly important for this type of construction. See Figure 3 for the typical detail of a sump to collect debris and prevent clogging of the dry well.

Important design criteria and considerations for dry wells are listed below.

- Dry wells should empty within 72 hours of a rain event.
- The bottom of the dry well should be 2 feet above the seasonally high water table or bedrock.
- The top of a dry well should have approximately 1 foot of cover.
- Ten feet of separation is recommended between dry wells and building foundations to reduce risk for basement seepage or flooding. This distance may be shortened at the discretion of the designer. An impermeable liner may need to be installed on the building side of the dry well if the separation distance is less than 10'.
- A filtering screen should be installed in the bottom of the gutter below the surcharge pipe in order to screen out leaves and other debris.
- An access pipe for inspection and maintenance should be provided.
- Roof gutter guards can prevent leaves, sediment and other debris from clogging the dry well. A roof leader clean-out with sump or an intermediate sump box can be installed between the downspout and the dry well to provide pre-treatment, further reducing the amount of sediment and debris entering and potentially clogging the dry well.
- An overflow surcharge pipe or connection to a larger infiltration area is needed to ensure that additional runoff is safely conveyed downstream during an intense storm event that overflows the dry well.
- The homeowner must be provided with a maintenance plan for the dry well. The plan must include the location of the dry well, as well as regular and long-term maintenance requirements.

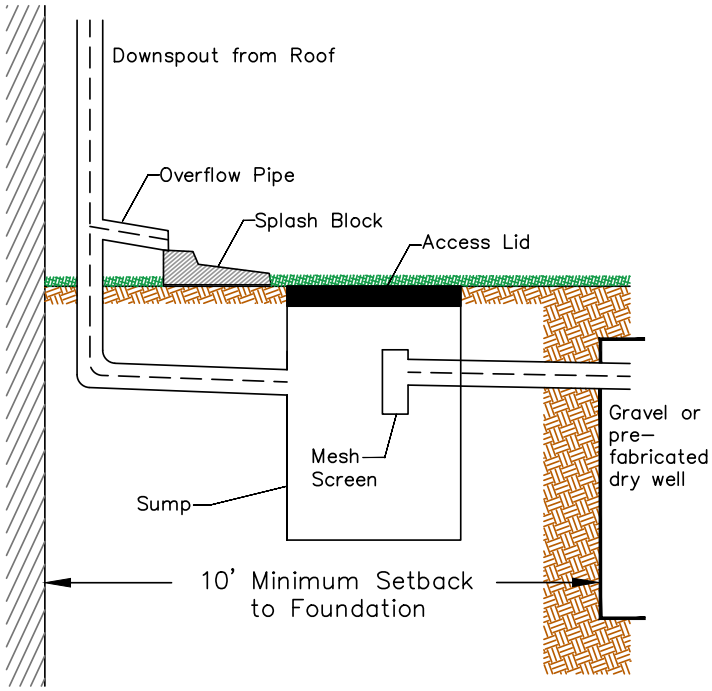

Figure 3: Detail for a pre-treatment sump.
The pre-treament sump will collect leaves, sediment and other debris that could clog the dry well. The sump must have an access lid to allow the sump to be cleaned and assumulated material to be removed.

DRY WELL SIZING

The dimensions of the dry well are dependent on (1) the amount of runoff being directed to the facility, (2) the soil conditions, including the permeability of the soils, and (3) the distance to seasonally high water table or bedrock.

If soil permeability data is available, that measured value should be used in the calculations to size the dry well. If no soil permeability data is available, assume a conservative value of 0.5 inches/hr.

The dry well is essentially a box filled with gravel, and you need to find the height, length, and width of the box to store the runoff. Figure 3 shows a sketch of a typical single-family home with 2 dry wells to manage roof runoff. The example that follows will determine the dimensions for one of the dry wells.

1. Calculate runoff volume

The volume of runoff that must be managed is the area of the roof surface that is contributing runoff multiplied by a depth of rainfall. Many ordinances are requiring the permanent removal of the first 1 inch of runoff, based on Control Guidance 2 from the PA Best Practices Manual (2006). If your ordinance requires control of a different depth, substitute that depth for 1 inch in the runoff volume equation.

$$\text{Runoff Volume}(\text{cu ft}) = \text{Roof area}(\text{sq ft}) \times \text{Control Volume (in)} \times \frac{1\text{ ft}}{12\text{ in}}$$

2. Calculate required volume of dry well

If you are using a prefabricated tank that doesn't use gravel, the required volume of the dry well is the same as the runoff volume.

In a gravel-filled dry well, much of the space will be occupied by the rock, so there is less room for water storage. About 40% of gravel is air or void space, which means that in a dry well filled with gravel, only about 40% of the volume can store water. Divide the runoff volume by the 40% void space to find the volume of the dry well. If using a material that has a different void space, substitute that value for the 0.40 in the equation below.

$$\text{Dry well volume}(\text{cu ft}) = \frac{\text{runoff volume}(\text{cu ft})}{0.40}$$

3. Calculate the dimensions of the dry well

The total volume of the dry well will be used to determine the dimensions of the dry well box. The volume is the height, multiplied by the length, multiplied by the width. The height of the box may be the limiting factor due to the depth to a seasonally high ground water or bedrock, combined with providing approximately 1 foot of cover over the dry well. The bottom of the dry well must be 2 feet above the seasonally high water table. Even if ground water or bedrock aren't an issue, a dry well for a residential home typically doesn't have a height of more than 48 inches.

Height = Depth to SHWT or bedrock - 3'
(3' → 2' for separation to SWHT or bedrock + 1' for cover on top)

The volume of the dry well is the height, multiplied by the length, multiplied by the width, and the height is known. Plug numbers for the length and width to find a box volume that is larger than or equal to the required dry well volume calculated in Step 2.

Volume = Height (ft) × Length (ft) × Width (ft)

4. Calculate drain time of the dry well

The dry well must drain in less than 72 hours to prevent mosquito problems. The drain rate is a function of the soil permeability rate and the surface area of the dry well through which the water will drain. Once you know how quickly water will drain out of the dry well, you can use the runoff volume to determine how long it will take for the dry well to empty, or the drain time.

The 2006 Pennsylvania Stormwater Best Management Practices Manual allows for the bottom and side areas

of the dry well to all be counted as surfaces that will drain or allow for infiltration. More recent design guides tend to only allow for infiltation through the bottom of the dry well. The equation below uses the more conservative approach of only counting the bottom area.

$$\text{Drain rate}\left(\frac{\text{cu ft}}{\text{hr}}\right) = \text{soil permeability rate}\left(\frac{\text{in}}{\text{hr}}\right) \times \frac{1\,\text{ft}}{12\,\text{in}} \times \text{bottom area (sq ft)}$$

$$\text{Drain time}(\text{hr}) = \frac{\text{runoff volume}\ (\text{cu ft})}{\text{drain rate}\left(\frac{\text{cu ft}}{\text{hr}}\right)}$$

If the drain time is longer than the allowable 72 hours, the bottom area of the dry well must be increased to provide additional area for the water to drain into the soil. Making the bottom area larger can decrease the height of the dry well.

CONSTRUCTION INSTRUCTIONS

1. Mark off the area where the dry wells will be located, and do not allow equipment to travel over this area which would compact the soil.
2. Install dry wells after site construction has occurred and the site has been stabilized to prevent sedimentation and/or damage from construction activity. If construction of the dry well cannot be delayed, the dry well location must be protected with a berm, silt fence, or compost sock to prevent sediment from collecting in the area.
3. The dry well bottom must be uniform, level, and uncompacted. The bottom must be free from rocks and debris. Do NOT compact subgrade. Excavation should be performed with the lightest practical equipment, and the equipment should be located outside the limits of the dry well.
4. Completely wrap the dry well with nonwoven geotextile. If sediment and/or debris have accumulated in dry well bottom, remove prior to geotextile placement. Geotextile rolls should overlap by a minimum of 24 inches.
5. Install continuously perforated pipe, observation wells, and all other dry well structures. Connect roof leaders to perforated pipe.
6. Place uniformly graded, clean-washed aggregate in 12-inch lifts. Compact lightly between lifts.
7. Fold and secure nonwoven geotextile over trench, with minimum overlap of 12 inches.
8. Place 12 inches of topsoil cover over the dry well.
9. Seed and stabilize topsoil.
10. Connect surcharge pipe to downspout and position over splash block.

REFERENCES

- New Jersey Department of Environmental Protection. (2016) New Jersey Stormwater Best Management Practices Manual. Available online at http://www.njstormwater.org/bmp_manual2.htm.
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