APPENDIX I: SMALL PROJECT STORMWATER MANAGEMENT (SWM) SITE PLAN

This small project stormwater site plan has been developed to assist those proposing residential projects to meet the requirements of the Buckingham Township Stormwater Management Ordinance without having to hire professional services to draft a formal stormwater management plan. This small project site plan is only permitted for residential projects proposing less than or equal to 5,000 square feet of impervious surface and less than 1 acre of earth disturbance.

A. What is an applicant required to submit?

A brief description of the proposed stormwater facilities, including types of materials to be used, total square footage of proposed impervious areas, volume calculations, and a simple sketch plan showing the following information:

- Location of proposed structures, driveways, or other paved areas with approximate surface area in square feet.
- Location of any existing or proposed onsite septic system and/or potable water wells showing proximity to infiltration facilities.
- Bucks or Montgomery County Conservation District erosion and sediment control "Adequacy" letter as required by Municipal, County or State regulations.

B. Determination of Required Volume Control and Sizing Stormwater Facilities

By following the simple steps outlined below in the provided example, an applicant can determine the runoff volume that is required to be controlled and how to choose the appropriate stormwater facility to permanently remove the runoff volume from the site. Impervious area calculations must include all areas on the lot proposed to be covered by roof area or pavement which would prevent rain from naturally percolating into the ground, including impervious surfaces such as sidewalks, driveways, parking areas, patios or swimming pools. Sidewalks, driveways or patios that are designed and constructed to allow for infiltration are not included in this calculation.

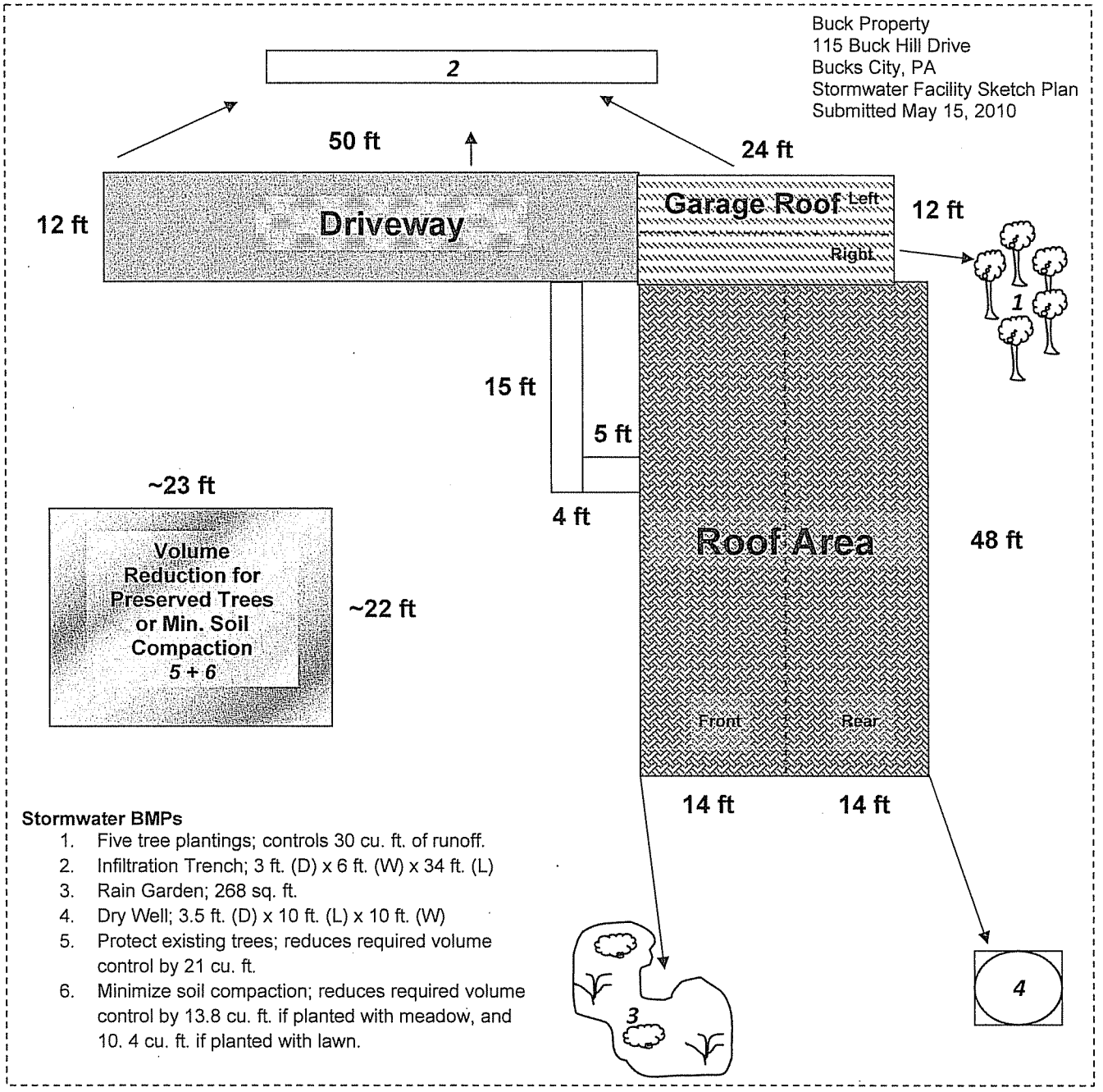
Site Plan Example: Controlling runoff volume from a proposed home site

Step 1: Determine Total Impervious Surfaces

Impervious Surface			Area (sq. ft.)
House Roof (Front)	14 ft. x 48 ft.	=	672 sq. ft.
House Roof (Rear)	14 ft. x 48 ft.	=	672 sq. ft.
Garage Roof (Left)	6ft. x 24 ft.	=	144 sq. ft.
Garage Roof (Right)	6 ft. x 24 ft.	=	144 sq. ft.
Driveway	12 ft. x 50 ft.	=	1000 sq. ft.
Walkway	4 ft. x 20 ft.	=	80 sq. ft.

	Total Impervious		3000 sq ft

Figure 1: Sample Site Sketch Plan



Stormwater BMPs

1. Five tree plantings; controls 30 cu. ft. of runoff.
2. Infiltration Trench; 3 ft. (D) x 6 ft. (W) x 34 ft. (L)
3. Rain Garden; 268 sq. ft.
4. Dry Well; 3.5 ft. (D) x 10 ft. (L) x 10 ft. (W)
5. Protect existing trees; reduces required volume control by 21 cu. ft.
6. Minimize soil compaction; reduces required volume control by 13.8 cu. ft. if planted with meadow, and 10. 4 cu. ft. if planted with lawn.

Step 2: Determine Required Volume Control (cubic feet) using the following equation:

Capture Volume (cu. ft.) = (Total impervious area in square feet x 20 cu.ft./100 Sq.Ft)

(3,000 sq. ft. x 20 cu.ft./100 sq.ft.) = 600 cu. ft.

Step 3: Determining required BMP type per Ordinance Section 303.B

1. At least 20% of Capture Volume to infiltration:
   600 cu.ft x 0.20 = 120 cu.ft.
2. At least 40% of Capture Volume to be reused, evapotranspired, or infiltrated:
   600 cu.ft x 0.40 = 240 cu.ft.
3. Remaining 40% of Capture Volume to be slowly released or infiltrated:
   600 cu.ft x 0.40 = 240 cu.ft.

Step 4: Sizing the Selected Volume Control BMP

Several Best Management Practices (BMPs), as described below, are suitable for small stormwater management projects. However, their application depends on the volume required to be controlled, how much land is available, and the site constraints. Proposed residential development activities can apply both non-structural and structural BMPs to control the volume of runoff from the site. A number of different volume control BMPs are described below. Note that Figure 1 is an example of how these BMPs can be utilized in conjunction to control the total required volume on one site.

Structural BMPs

1. Infiltration Trench

An Infiltration Trench is a linear stormwater BMP consisting of a continuously perforated pipe at a minimum slope in a stone-filled trench. During small storm events, infiltration trenches can significantly reduce volume and serve in the removal of fine sediments and pollutants. Runoff is stored between the stones and infiltrates through the bottom of the facility and into the soil matrix. Runoff should be pretreated using vegetative buffer strips or swales to limit the amount of coarse sediment entering the trench which can clog and render the trench ineffective. In all cases, an infiltration trench should be designed with a positive overflow.

Design Considerations:

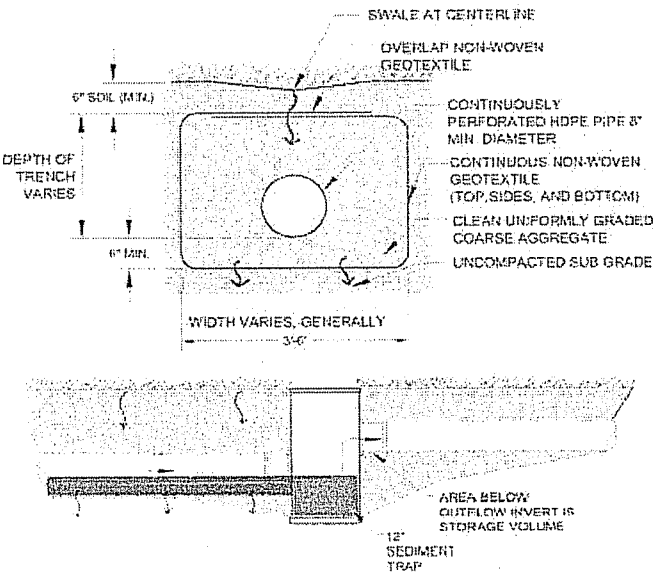
- Although the width and depth can vary, it is recommended that Infiltration Trenches be limited in depth to not more than six (6) feet of stone.
- Trench is wrapped in nonwoven geotextile (top, sides, and bottom).
- Trench needs to be placed on uncompacted soils.
- Slope of the Trench bottom should be level or with a slope no greater than 1%.
- A minimum of 6" of topsoil is placed over trench and vegetated.
- The discharge or overflow from the Infiltration Trench should be properly designed for anticipated flows.

- Cleanouts or inlets should be installed at both ends of the Infiltration Trench and at appropriate intervals to allow access to the perforated pipe.
- Volume of facility = Depth x Width x Length x Void Space of the gravel bed (assume 40%).

Maintenance:

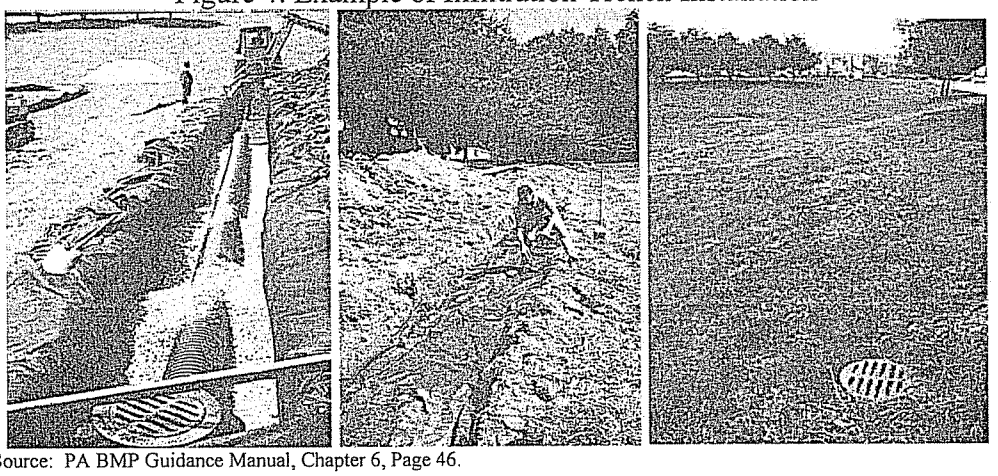
- Catch basins and inlets should be inspected and cleaned at least two times a year.
- The vegetation along the surface of the infiltration trench should be maintained in good condition and any bare spots should be re-vegetated as soon as possible.
- Vehicles should not be parked or driven on the trench and care should be taken to avoid soil compaction by lawn mowers.

Figure 3: Infiltration Trench Diagram



Source: PA BMP Guidance Manual, Chapter 6, page 42.

Figure 4: Example of Infiltration Trench Installation



Source: PA BMP Guidance Manual, Chapter 6, Page 46.

Sizing Example for Infiltration Trench

1. Determine Total Impervious Surface to drain to Infiltration Trench:

Garage Roof (Left)	6 ft. x 24 ft.	=	144 sq ft
Driveway	12 ft. x 50 ft.	=	1000 sq ft
Walkway	4 ft. x 20 ft.	=	80 sq ft

2. Determine the required infiltration volume:

   (1224 sq. ft./100 sq. ft. x 20 cu. ft) = 245 cu. ft. / 0.4* = 612 cu. ft.
   (*0.4 assumes 40% void ratio in gravel bed)

3. Sizing the infiltration trench facility:

   Volume of Facility = Depth x Width x Length

   Set Depth to 3 feet and determine required surface area of trench.

   612 cu. ft / 3 ft = 204 sq ft.

   The width of the trench should be greater than 2 times its depth (2 x D), therefore in this example the trench width of 6 feet selected.

   Determine trench length: L = 204 sq. ft. / 6 ft. = 34 ft.

   Final infiltration trench dimensions: 3 ft. (D) x 6 ft. (W) x 34 ft. (L)

2. Rain Garden

A Rain Garden is a planted shallow depression designed to catch and filter rainfall runoff. The garden captures rain from a downspout or a paved surface. The water sinks into the ground, aided by deep rooted plants that like both wet and dry conditions. The ideal location for a rain garden is between the source of runoff (roofs and driveways) and the runoff destination (drains, stream, low spots, etc).

Design Considerations:

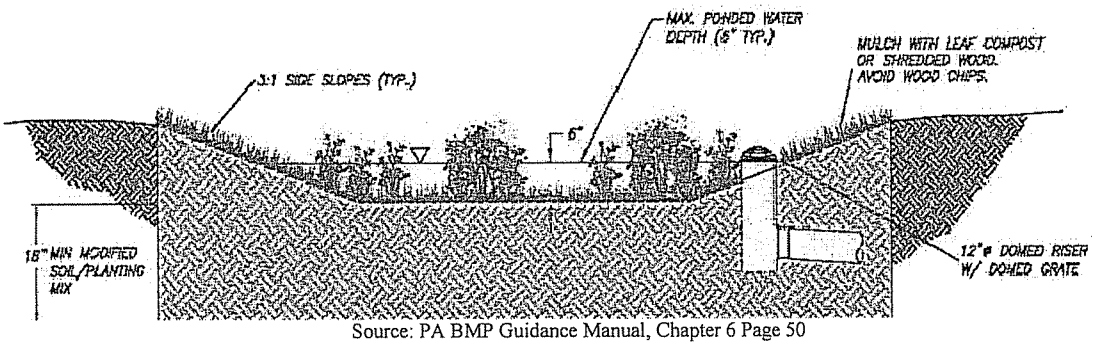
- A maximum of 3:1 side slope is recommended.
- The depth of a rain garden can range from 6 - 8 inches. Ponded water should not exceed 6 inches.
- The rain garden should drain within 72 hours.
- The garden should be at least 10-20 feet from a building's foundation and 25 feet from septic system drainfields and wellheads.
- If the site has clay soils, soil should be amended with compost or organic material.

- Choose native plants. See http://pa.audubon.org/habitat/PDFs/RGBrochure_complete.pdf for a native plant list. To find native plant sources go to www.pawildflower.org.
- At the rain garden location, the water table should be at least 2' below the soil level. If water stands in an area for more than one day after a heavy rain you can assume it has a higher water table and is not a good choice for a rain garden.

Maintenance:

- Water plants regularly until they become established.
- Inspect twice a year for sediment buildup, erosion and vegetative conditions.
- Mulch with hardwood when erosion is evident and replenish annually.
- Prune and remove dead vegetation in the spring season.
- Weed as you would any garden.
- Move plants around if some plants would grow better in the drier or wetter parts of the garden.

Figure 5: Rain Garden Diagram



Source: PA BMP Guidance Manual, Chapter 6 Page 50

Sizing Example for Rain Garden

1. Pick a site for the rain garden between the source of runoff and between a low lying area, a.k.a., a drainage area.

2. Perform an infiltration test to determine the depth of the rain garden:
   - Dig a hole 8″ x 8″
   - Fill with water and put a popsicle stick at the top of the water level.
   - Measure how far it drains down after a few hours (ideally 4).
   - Calculate the depth of water that will drain out over 24 hours.

3. Determine total volume of water to drain to rain garden:

House Roof (Front)	14 ft. x 48 ft.	=	672 sq ft

Volume = (672 sq. ft. /100 sq. ft. x 20 cu. ft) = 134.4 cu. Ft

4. Sizing the rain garden:

For this example the infiltration test determined 6″ of water drained out of a hole in 24 hours. The depth of the rain garden should be set to the results of the infiltration test so that the rain garden completely drains in 24 hours. In this case, 6″ is used for the depth of the rain garden.

Volume of Facility = Depth x Rain Garden Surface Area

Set Depth to 6" (0.5ft) and determine required surface area of rain garden.

134 cu. ft / 0.5 ft = 268 sq ft.

The rain garden should be about 270 sq. ft. in size and 6″ deep.

3. Dry Well (a.k.a., Seepage Pit)

A Dry Well, sometimes called a Seepage Pit, is a subsurface storage facility that temporarily stores and infiltrates stormwater runoff from the roofs of structures. By capturing runoff at the source, Dry Wells can dramatically reduce the increased volume of stormwater generated by the roofs of structures. Roof leaders connect directly into the Dry Well, which may be either an excavated pit filled with uniformly graded aggregate wrapped in geotextile, or a prefabricated storage chamber or pipe segment. Dry Wells discharge the stored runoff via infiltration into the surrounding soils. In the event that the Dry Well is overwhelmed in an intense storm event, an overflow mechanism (surcharge pipe, connection to a larger infiltration are, etc.) will ensure that additional runoff is safely conveyed downstream.

Design Considerations:

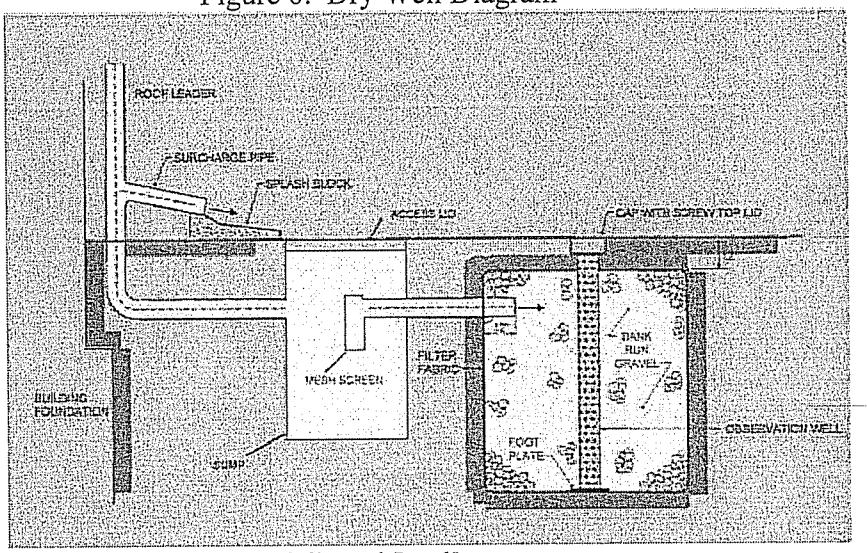
- Dry Wells typically consist of 18 to 48 inches of clean washed, uniformly graded aggregate with 40% void capacity (AASHTO No. 3, or similar). "Clean" gravel fill should average one and one-half to three (1.5 – 3.0) inches in diameter.
- Dry Wells are not recommended when their installation would create a significant risk for basement seepage or flooding. In general, 10 - 20 feet of separation is recommended between Dry Wells and building foundations.
- The facility may be either a structural prefabricated chamber or an excavated pit filled with aggregate.
- Depth of dry wells in excess of three-and-a-half (3.5) feet should be avoided unless warranted by soil conditions.
- Stormwater dry wells must never be combined with existing, rehabilitated, or new septic system seepage pits. Discharge of sewage to stormwater dry wells is strictly prohibited.

Maintenance:

- Dry wells should be inspected at least four (4) times annually as well as after large storm events.
- Remove sediment, debris/trash, and any other waste material from a dry well.
- Regularly clean out gutters and ensure proper connections to the dry well.

- Replace the filter screen that intercepts the roof runoff as necessary.

Figure 6: Dry Well Diagram



Source: PA BMP Guidance Manual, Chapter 6, Page 65.

Sizing Example for Dry Wells:

1. Determine contributing impervious surface area:

House Roof (Rear)	14 ft. x 48 ft.	=	672 sq. ft.

2. Determine required volume control:

   (672 sq. ft. /100 sq. ft. * 20 cu.ft.) = 134.4 cu. ft.

   134.4 cu ft / 0.4 = 336 cu. ft. (assuming the 40% void ratio in the gravel bed)

3. Sizing the dry well:

   Set depth to 3.5 ft; Set width equal to length for a square chamber.

   336 cu. ft. = 3.5 ft. x L x L; L = 9.7 ft.

   Dimensions = 3.5 ft. (D) x 10 ft. (L) x 10 ft. (W)

Non-Structural BMPs

1. Tree Plantings and Preservation

Trees and forests reduce stormwater runoff by capturing and storing rainfall in the canopy and releasing water into the atmosphere through evapotranspiration. Tree roots and leaf litter also create soil conditions that promote the infiltration of rainwater into the soil. In addition, trees and forests reduce pollutants by taking up nutrients and other pollutants from soils and water through their root systems. A development site can reduce runoff volume by planting new trees or by preserving trees which existed on the site prior to development. The volume reduction calculations either determine the cubic feet to be directed to the area under the tree canopy for infiltration or determine a volume reduction credit which can be used to reduce the size of any one of the planned structural BMPs on the site.

Tree Considerations:

- Existing trees must have at least a 4″ trunk caliper or larger.
- Existing tree canopy must be within 100 ft. of impervious surfaces.
- A tree canopy is classified as the continuous cover of branches and foliage formed by a single tree or collectively by the crowns of adjacent trees.
- New tree plantings must be at least 6 ft. in height and have a 2″ trunk caliper.
- All existing and newly planted trees must be native to Pennsylvania. See http://www.dcnr.state.pa.us/forestry/commontr/commontrees.pdf for a guide book titled *Common Trees of Pennsylvania* for a native tree list.
- When using trees as volume control BMPs, runoff from impervious areas should be directed to drain under the tree canopy.

Determining the required number of planted trees to reduce the runoff volume:

1. Determine contributing impervious surface area:

Garage Roof (Right)	6 ft. x 24 ft.	=	144 ft

2. Calculate the required control volume:

   (144 sq. ft. /100 sq. ft. x 20 cu.ft.) = 28.8 cu. ft.

3. Determine the number of tree plantings:

   - A newly planted deciduous tree can reduce runoff volume by 6 cu. ft.
   - A newly planted evergreen tree can reduce runoff volume by 10 cu. ft.

   28 cu. ft./ 6 cu. ft. = 4.8, plant 5 Deciduous Trees

Determining the volume reduction for preserving existing trees:

1. Calculate approximate area of the existing tree canopy:

~22 sq. ft. x ~23 sq. ft = 500 sq. ft.

2. Measure distance from impervious surface to tree canopy: 35 ft.

3. Calculate the volume reduction credit by preserving existing trees:

   - For Trees within 20 feet of impervious cover:
     Volume Reduction cu. ft. = (Existing Tree Canopy sq. ft. x 1 inch) / 12
   - For Trees beyond 20 feet but not farther than 100 feet from impervious cover:
     Volume Reduction cu. ft. = (Existing Tree Canopy sq. ft. x 0.5 inch) / 12

   (500 sq. ft. x 0.5 inches) / 12 = 21 cu. ft.

   This volume credit can be utilized in reducing the size of any one of the structural BMPs planned on the site. For example, the 21 cu. ft. could be subtracted from the required infiltration volume when sizing the infiltration trench;

   612 cu. ft – 21 cu. ft. = 591 cu. ft.

   591 cu. ft. / 3 ft (Depth) = 197 / 6 ft. (Width) = 32.8 ft (Length)

   Using the existing trees for a volume credit would decrease the length of the infiltration trench to 32.8 ft. instead of 34.0 ft.

2. Minimize Soil Compaction and Replant with Lawn or Meadow

When soil is overly compacted during construction it can cause a drastic reduction in the permeability of the soil and rarely is the soil profile completely restored. Runoff from vegetative areas with highly compacted soils similarly resembles runoff from an impervious surface. Minimizing soil compaction and re-planting with a vegetative cover like meadow or lawn, not only increases the infiltration on the site, but also creates a friendly habitat for a variety of wildlife species.

Design Considerations:

- Area shall not be stripped of topsoil.
- Vehicle movement, storage, or equipment/material lay down shall not be permitted in areas preserved for minimum soil compaction.
- The use of soil amendments and additional topsoil is permitted.
- Meadow should be planted with native grasses. Refer to *Meadows and Prairies: Wildlife-Friendly Alternatives to Lawn* at http://pubs.cas.psu.edu/FreePubs/pdfs/UH128.pdf for reference on how to properly plant the meadow and for a list of native species.

Determining the volume reduction by minimizing soil compaction and planting a meadow:

1. Calculate approximate area of preserved meadow:

   ~22 ft x ~23 ft = 500 sq. ft.

2. Calculate the volume reduction credit by minimizing the soil compaction and planting a lawn/meadow:

   - For Meadow Areas: Volume Reduction (cu. ft.) = (Area of Min. Soil Compaction (sq. ft.) x 1/3 inch of runoff) / 12

     (500 sq. ft. x 1/3 inch of runoff) / 12 = 13.8 cu. ft.

   - For Lawn Areas: Volume Reduction (cu. ft.) = (Area of Min. Soil Compaction (sq. ft.) x 1/4 inch of runoff) / 12

     (500 sq. ft. x 1/4 inch of runoff) / 12 = 10.4 cu. ft.

This volume credit can be used to reduce the size of any one of the structural BMPs on the site. See explanation under the volume credit for preserving existing trees for details.

Alternative BMP to Capture and Reuse Stormwater

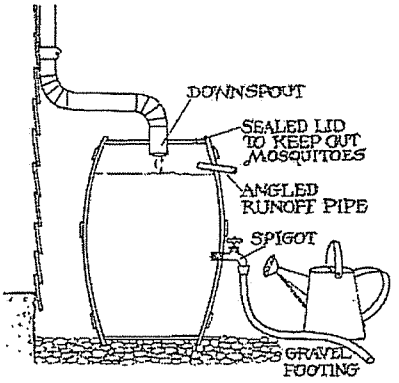
Rain Barrels

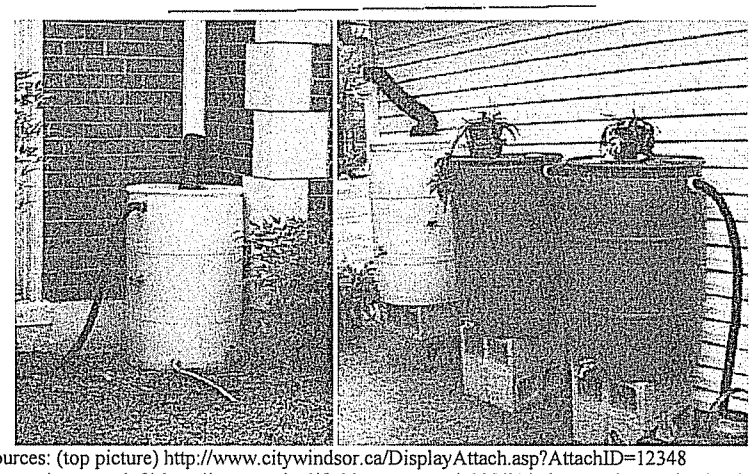
Rain barrels are large containers that collect drainage from roof leaders and temporarily store water to be released to lawns, gardens, and other landscaped areas after the rainfall has ended. Rain barrels are typically between 50 and 200 gallons in size. It is not recommended for rain barrels to be used as a volume control BMP because infiltration is not guaranteed after each storm event. For this reason, a rain barrel is not utilized in the site plan example. However, the information is included to provide an alternative for a homeowner to utilize when considering capture and reuse stormwater methods.

Design Considerations:

- Rain barrels should be directly connected to the roof gutter/spout.
- There must be a means to release the water stored between storm events to provide the necessary storage volume for the next storm.
- When calculating rain barrel size, rain barrels are typically assumed to be 25% full because they are not always emptied before the next storm.
- Use screens to filter debris and cover lids to prevent mosquitoes.
- An overflow outlet should be placed a few inches below the top with an overflow pipe to divert flow away from structures.
- It is possible to use a number of rain barrels jointly for an area.

Figure 2: Rain Barrel Diagram and Examples





Sources: (top picture) http://www.citywindsor.ca/DisplayAttach.asp?AttachID=12348
(bottom picture on left) http://repurposinglife.blogspot.com/2009/05/rainwater-harvesting.html
(bottom picture on right) http://www.floridata.com/tracks/transplantedgardener/Rainbarrels.cfm

Sizing Example for a Rain Barrel

1. Determine contributing impervious surface area:

Garage Roof (Right)	6 ft. x 24 ft.	=	144 sq ft

2. Calculate the volume to be captured and reused:

   (144 sq. ft. /100 sq. ft. x 20 cu.ft.) = 28.8 cu. ft.

3. Size the rain barrel:

   1 cu. ft. = 7. 48 gallons

28.8 cu. ft. x 7.48 = 215.42 gallons

215.42 gallons x (0.25*) = 53.86 gallons (*assuming that the rain barrel is always at least 25% full)

215.42 gallons + 53.86 gallons = 269.3 gallons

The rain barrel or barrels should be large enough hold at least 269.3 gallons of water.

Step 5: Verify Compliance with Volume Requirements (600 cu.ft.)

1. Total stormwater infiltrated = 245 cu.ft. (Infiltration Trench) + 134.4 cu.ft. (Rain Garden) + 134.4 cu.ft. (Dry Well) = 513.80 cu.ft.
2. Total Amount reused, evapotranspired or infiltrated through nonstructural BMPs = 30 cu.ft. (Tree Planting) + 21 cu.ft (Tree Protection) + 13.8 cu.ft. (Minimization of Soil Compaction) + 28.8 cu.ft. (Rain barrels) = 93.60 cu.ft.
3. Slowly Released from Site through other BMPs = 0

Total Capture Volume = 513.80 cu.ft. + 93.60 cu.ft + 0 cu.ft. = 607.40 cu.ft. > 600 cu.ft.