

APPENDIX O

Stormwater Credits For Effective Site Planning

0.1 Stormwater Credits

In Pennsylvania, there are many programs at both the State and local level that seek to minimize the impact of land development. Critical areas, forest conservation, and local stream buffer requirements are designed to reduce nonpoint source pollution. Non-structural practices can play a significant role in reducing water quality impacts and are increasingly recognized as a critical feature of every stormwater BMP plan, particularly with respect to site design. In most cases, non-structural practices must be combined with structural practices to meet stormwater requirements. The key benefit of non-structural practices is that they can reduce the generation of stormwater from the site; thereby reducing the size and cost of stormwater storage. In addition, they can provide partial removal of many pollutants. Non-structural practices have been classified into six broad groups and are designed to mesh with existing state and local programs (e.g., forest conservation, stream buffers, etc.). To promote greater use, a series of six stormwater credits are provided for designers that use these site planning techniques.

- Credit 1. Natural Area Conservation
- Credit 2. Disconnection of Rooftop Runoff
- Credit 3. Disconnection of Non-Rooftop Runoff
- Credit 4. Sheet Flow to Buffers
- Credit 5. Grass Channel
- Credit 6. Environmentally Sensitive Development

This Appendix describes each of the credits for the six groups of non-structural practices, specifies minimum criteria to be eligible for the credit, and provides an example of how the credit is calculated. Designers should check with the Municipal Engineer to ensure that the credit is applicable to their jurisdiction.

In general, the stormwater sizing criteria provide a strong incentive to reduce impervious cover at development sites. Storage requirements for all five stormwater sizing criteria are directly related to impervious cover. Thus, significant reductions in impervious cover result in smaller required storage volumes and, consequently, lower BMP construction costs.

These and other site design techniques can help to reduce impervious cover, and consequently, the stormwater treatment volume needed at a site. The techniques presented in this Chapter are considered options to be used by the designer to help reduce the need for stormwater BMP storage capacity. Due to local safety codes, soil conditions, and topography, some of these site design features will be restricted. Designers are encouraged to consult with the Municipal Engineer to determine restrictions on non-structural strategies.

NOTE: In this chapter, *italics* indicate mandatory performance criteria, whereas suggested design criteria are shown in normal typeface.

These credits are an integral part of a project's overall stormwater management plan and BMP storage volume calculation. Therefore, use of these credits shall be documented at the initial (concept) design stage, documented with submission of final grading plans, and verified with "as-built" plans. If a planned credit is not implemented, then BMP volumes shall be increased appropriately to stormwater sizing criteria.

Table O.1 Summary of Stormwater Credits

Stormwater Credit	WQ_v	Re_v	Cp_v or Q_p
Natural Area Conservation	Reduce Site Area	No credit. Use as receiving area w/Percent Area Method.	Forest/meadow CN for natural areas
Disconnection of Rooftop Runoff	Reduced R _v	No credit. Use with Percent Area Method.	Longer tc (increased flow path). CN credit.
Disconnection of Non-Rooftop Runoff	Reduced R _v	No credit. Use with Percent Area Method.	Longer tc (increased flow path) CN credit
Sheet Flow to Buffers	Subtract contributing site area to BMP	Reduced Re _v	CN credit
Open Channel Use	May meet WQ _v	Meets Re _v	Longer tc (increased flow path) No CN credit
Environmentally Sensitive Development	Meets WQ _v	Meets Re _v	No CN credit tc may increase

O.2 Natural Area Conservation Credit

A stormwater credit is given when natural areas are conserved at development sites, thereby retaining pre development hydrologic and water quality characteristics. A simple WQ_v credit is granted for all **conservation areas permanently protected under conservation easements or other locally acceptable means**. Examples of natural area conservation include:

- forest retention areas
- non-tidal wetlands and associated buffers
- other lands in protective easement (floodplains, open space, steep slopes)
- stream systems

Under the credit, a designer can subtract conservation areas from total site area when computing the water quality volume. **The volumetric runoff coefficient, R_v, is still calculated based on the percent impervious cover for the entire site.**

As an additional incentive, the post development curve number (CN) used to compute the Cp_v or Qp2, and Qp10 for all natural areas protected by conservation easements can be assumed to be woods in good condition when calculating the total site CN.

As an example, the required WQ_v for a ten acre site with three acres of impervious area and three acres of protected conservation area before the credit would be:

$$WQ_v = [(P)(R_v)(A)]/12; \text{ where } P= 1.2'', R_v= 0.05+0.009(30\%)$$

$$WQ_v = [(1.2'') (0.32)(10 \text{ acres})]/12 = 0.320 \text{ ac-ft}$$

Under the credit, three acres of conservation are subtracted from total site area, which yields a smaller storage volume:

$$WQ_v = [(P)(R_v)(A)]/12; \text{ where } P=1.2'', R_v=0.05+0.009(30\%)$$

$$WQ_v = [(1.2'')(0.32)(10-3 \text{ acres})]/12 = 0.224 \text{ ac-ft}$$

The recharge requirement (Re_v) is not reduced using this credit.

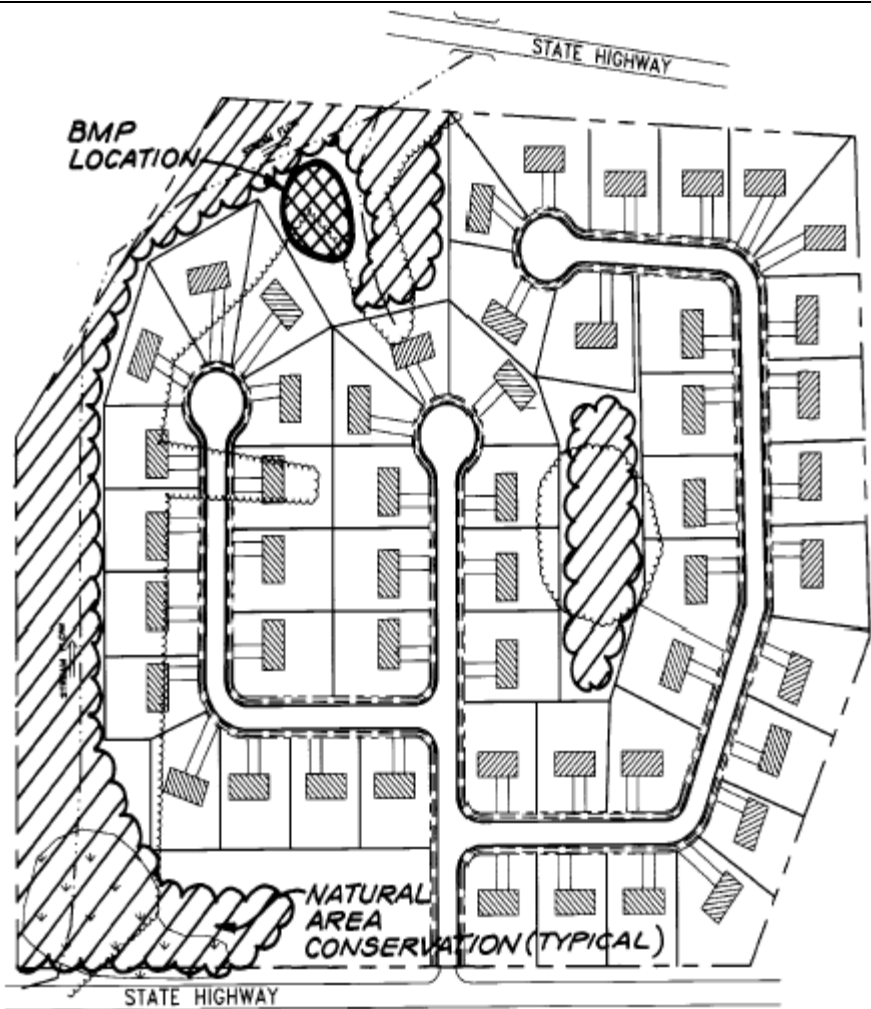
Criteria for Natural Area Credit

To receive the credit, the proposed conservation area:

- *Shall not be disturbed during project construction (e.g., cleared or graded) except for temporary impacts associated with incidental utility construction or mitigation and aforestation projects.*
- *Shall be protected by having the limits of disturbance clearly shown on all construction drawings and delimited in the field except as provided for above.*
- *Shall be located within an acceptable conservation easement or other enforceable instrument that ensures perpetual protection of the proposed area. The easement must clearly specify how the natural area vegetation shall be managed and boundaries will be marked [Note: managed turf (e.g., playgrounds, regularly maintained open areas) is not an acceptable form of vegetation management], and shall be located within the project site.*

Example of Calculating Natural Area Credit

Site Data - 51 Single Family
Lots
Area = 38 ac
Conservation Area = 7.0 ac
Impervious Area = 13.8 ac
 $R_v = .38$, $P = 1.2''$
Post dev. CN = 78
Original $WQ_v = 1.44$ ac-ft
Original $Re_v = 0.25$ ac-ft
Original $Cp_v = 1.65$ ac-ft



Computation of Stormwater Credits

$$\begin{aligned} WQ_v &= [(P)(R_v)(A)]/12 \\ &= [(1.2)(.38)(38.0 - 7.0 \text{ ac})]/12 \\ &= 1.18 \text{ ac-ft} \end{aligned}$$

Re_v = Same as original

(However, area draining to Natural Area may be used with the Percent Area Method)

CN reduced from 78 to 75

O.3 Disconnection of Rooftop Runoff Credit

A credit is given when rooftop runoff is disconnected and then directed to a pervious area where it can either infiltrate into the soil or filter over it. The credit is typically obtained by grading the site to promote overland filtering or by providing bioretention areas on single family residential lots.

If a rooftop is adequately disconnected, the disconnected impervious area may be deducted from total impervious cover (therefore reducing WQ_v). In addition, disconnected rooftops can be used to meet the Re_v requirement as a non-structural practice using the percent area method.

Post development CN's for disconnected rooftop areas used to compute C_p and Q_p can be assumed to be woods in good condition.

Criteria for Disconnection of Rooftop Runoff Credit

The credit is subject to the following restrictions:

- *Rooftop cannot be within a designated hotspot.*
- *Disconnection shall cause no basement seepage.*
- *The contributing area of rooftop to each disconnected discharge shall be 500 square feet or less.*
- *The length of the "disconnection" shall be 75 feet or greater, or compensated using Table O.1*
- *Dry wells, french drains, raingardens, or other similar storage devices may be utilized to compensate for areas with disconnection lengths less than 75 feet. (See Table O.1 and Figure O.1, dry wells are prohibited in "D" soils)*
- *In residential development applications, disconnections will only be credited for lot sizes greater than 6000 sq. ft.*
- *The entire vegetative "disconnection" shall be on an average slope of 5% or less.*
- *The disconnection must drain continuously through a vegetated channel, swale, or through a filter strip to the property line or BMP.*
- *Downspouts must be at least 10 feet away from the nearest impervious surface to discourage "re-connections".*
- *For those rooftops draining directly to a buffer, only the rooftop disconnection credit or the buffer credit may be used, not both.*

Figure O.1 Schematic of Dry Well

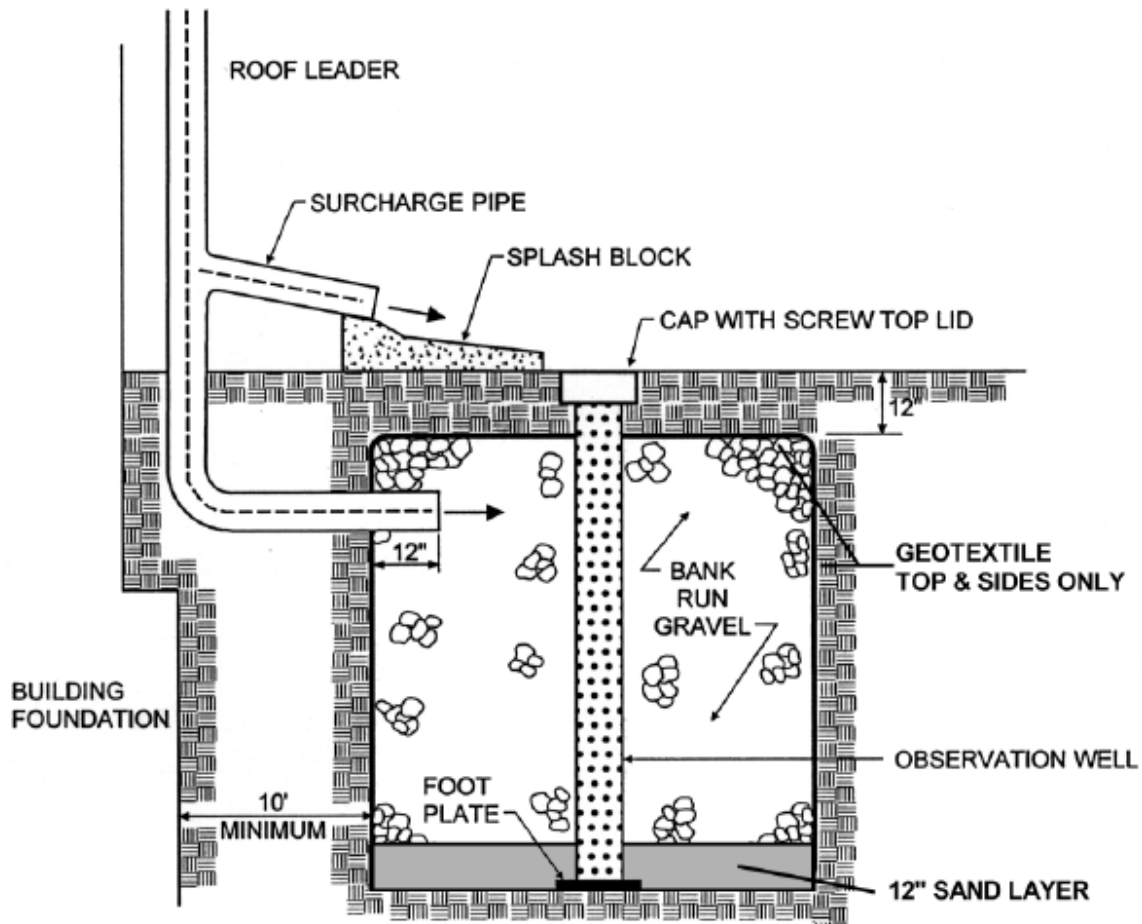


Table O.1 Rooftop Disconnection Compensation Storage Volume Requirements (Per Disconnection Using Drywells, Raingardens, etc.)

Disconnection Length Provided	0 - 14 ft.	15 - 29 ft.	30 - 44 ft.	45 - 59 ft.	60 - 74 ft.	≥75 ft.
% WQ_v Treated by Disconnect	0%	20%	40%	60%	80%	100%
% WQ_v Treated by Storage	100%	80%	60%	40%	20%	0%
Max. Storage Volume*	48 cu-ft.	39 cu-ft.	30 cu-ft.	21 cu-ft.	12 cu-ft.	0 cu-ft.

*Assuming 500 square feet roof area to each downspout.

Example of Using the Rooftop Disconnection Credit

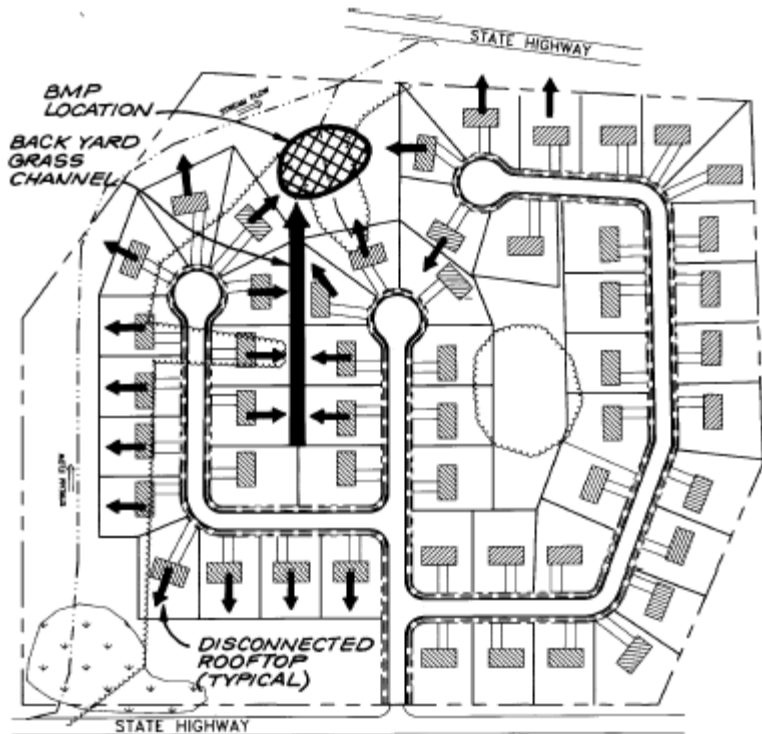
Site Data - 51 Single Family Lots
 Area = 38 ac, ½ ac lots
 Original Impervious Area = 13.80 ac
 Original $R_v = 0.38$
 Post dev. CN = 78
 # of Disconnected Rooftops = 22
 Original $WQ_v = 1.44$ ac-ft
 Original $Re_v = 0.25$ ac-ft
 Original $Cp_v = 1.65$ ac-ft

60% B Soils
 40% C Soils
 Composite $S=0.218$ (21.8%)

22 Lots Disconnected w/5
 Downspouts each
 2500 sf. each lot

Net impervious area reduction =
 $(22)(2500)/43560 = 1.3$ ac

Net Impervious Area =
 $13.8 - 1.3 = 12.5$ ac



Computation of Stormwater Credit:

New $R_v = 0.05 + 0.009 (12.5 \text{ ac}/38 \text{ ac}) = 0.35$
 $WQ_v = [(1.2)(.35)(38 \text{ ac})]/ 12 = 1.33$ ac-ft

Required Re_v (Percent Area Method)

$Re_v = 21.8\% \times 13.8 \text{ ac} = 3.01$ ac

Re_v treated by disconnection = 1.3 ac

Re_v remaining for treatment = 1.71 acres non structurally or 0.14 ac-ft structurally

CN reduced from 78 to 76

O.4 Disconnection of Non-Rooftop Runoff Credit

Credit is given for practices that disconnect surface impervious cover runoff by directing it to pervious areas where it is either infiltrated into the soil or filtered (by overland flow). This credit can be obtained by grading the site to promote overland vegetative filtering or providing bioretention areas on single family residential lots.

These “disconnected” areas can be subtracted from the impervious area when computing WQ_v . In addition, disconnected surface impervious cover can be used to meet the Re_v requirement as a non-structural practice using the percent area method.

Criteria for Disconnection of Non-Rooftop Runoff Credit

The credit is subject to the following restrictions:

- *Runoff cannot come from a designated hotspot.*
- *The maximum contributing impervious flow path length shall be 75 feet.*
- *The disconnection shall drain continuously through a vegetated channel, swale, or filter strip to the property line or BMP.*
- *The length of the “disconnection” must be equal to or greater than the contributing length.*
- *The entire vegetative “disconnection” shall be on an average slope of 5% or less.*
- *The surface impervious area to any one discharge location cannot exceed 1,000 ft².*
- *Disconnections are encouraged on relatively permeable soils (HSG’s A and B).*
- *If the site cannot meet the required disconnect length, a spreading device, such as a french drain, gravel trench or other storage device may be needed for compensation.*
- *For those areas draining directly to a buffer, only the non rooftop disconnection credit or the stream buffer credit can be used, not both.*

Example of Calculating the Non-Rooftop Disconnection Credit

Site Data -Community Center

Area = 3.0 ac

Original Impervious Area =

1.9 ac = 63.3%

Original $R_v = .62$

Post dev. CN = 83

B Soils, $S = 0.27$

Original $WQ_v = 8102 \text{ ft}^3$

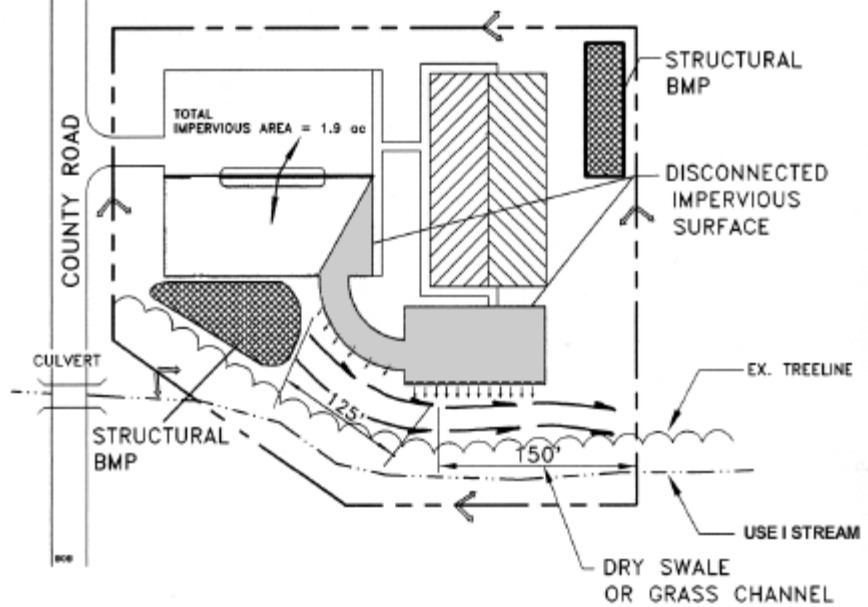
Original $Re_v = 1688 \text{ ft}^3$

Original $Cp_v = \text{N/A}$

0.33 ac of surface imperviousness disconnected

Net impervious area reduction

$1.9 - 0.33 = 1.57 \text{ ac}$



Computation of Stormwater Credit:

New $R_v = 0.05 + .009 (1.57 \text{ ac} / 3.0 \text{ ac}) = .52$

$WQ_v = [(1.2)(0.52)(3.0 \text{ ac})] 12 = 0.16 \text{ ac-ft (6795 ft}^3)$

Required Re_v (Percent area method)

$Re_v = (S)(Ai) = (0.27)(1.9 \text{ ac}) = 0.51 \text{ ac}$

Re_v treated by disconnection = 0.33 ac

Re_v remaining for treatment = 0.18 ac non structurally or 595.8 cf structurally

Post developed CN may be reduced

O.5 Sheetflow to Buffers Credit

This credit is given when stormwater runoff is effectively treated by a natural buffer to a stream or forested area. Effective treatment is achieved when pervious and impervious area runoff is discharged to a grass or forested buffer through overland flow. The use of a filter strip is also recommended to treat overland flow in the green space of a development site.

The credits include:

1. The area draining by sheet flow to a buffer is subtracted from the total site area in the WQ_v calculation.
2. The area draining to the buffer contributes to the recharge requirement, Re_v .
3. A *wooded* CN can be used for the contributing area if it drains to a forested buffer.

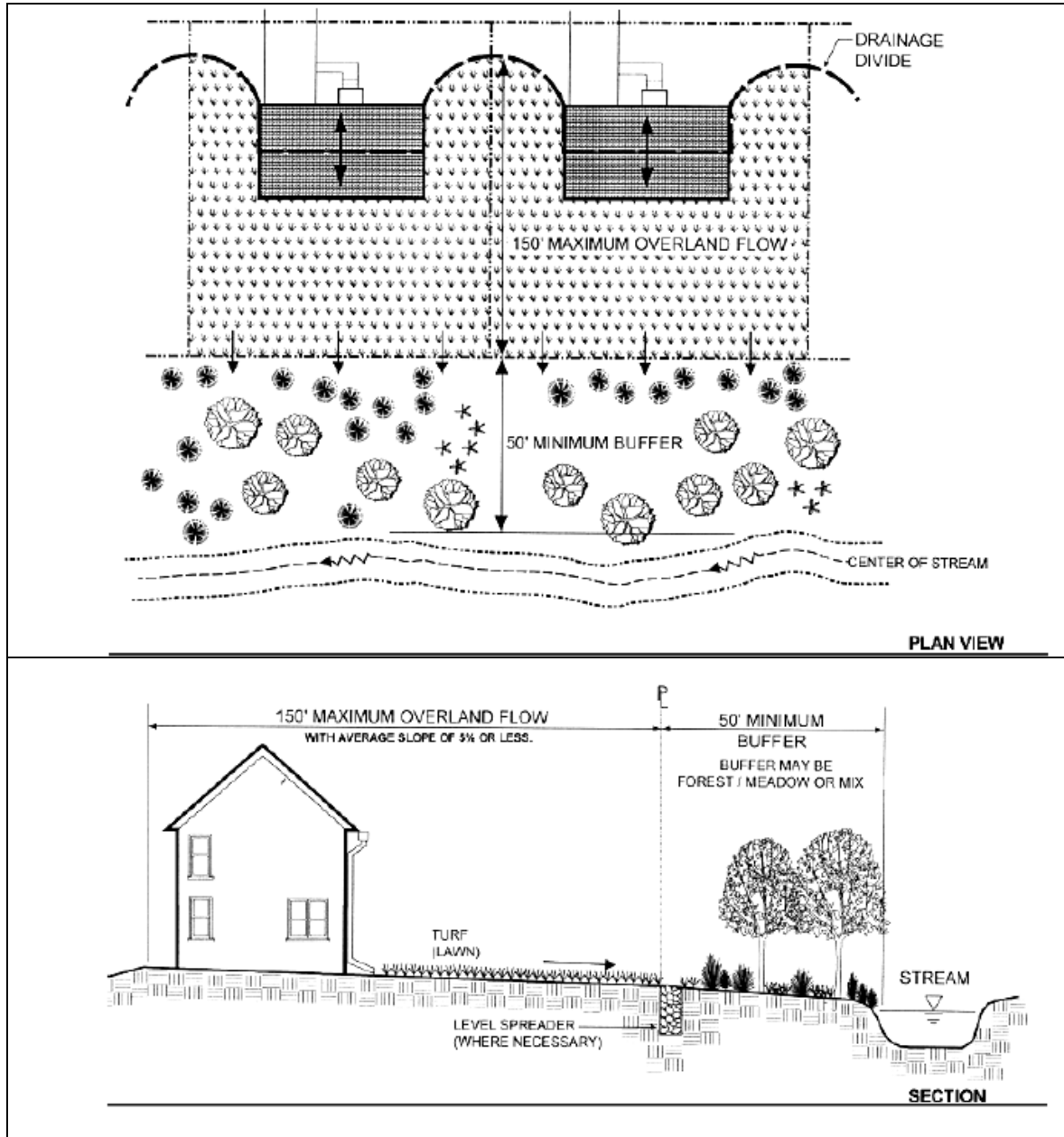
Criteria for Sheetflow to Buffers Credit

The credit is subject to the following conditions:

- *The minimum buffer width shall be 50 feet as measured from bankfull elevation or centerline of the buffer.*
- *The maximum contributing length shall be 150 feet for pervious surfaces and 75 feet for impervious surfaces.*
- *Runoff shall enter the buffer as sheet flow. Either the average contributing overland slope shall be 5.0% or less, or a concrete level spreading device shall be used where sheet flow can no longer be maintained.*
- *Not applicable if rooftop or non rooftop disconnection is already provided.*
- *Buffers shall remain unmanaged other than routine debris removal.*
- *Shall be located within an acceptable conservation easement or other enforceable instrument that ensures perpetual protection of the proposed area. The easement must clearly specify how the natural area vegetation shall be managed and boundaries will be marked [Note: managed turf (e.g., playgrounds, regularly maintained open areas) is not an acceptable form of vegetation management].*

Figure O.2 illustrates how a buffer or filter strip can be used to treat stormwater from adjacent pervious and impervious areas.

Figure O.2 Example of Sheetflow to Buffers Credit



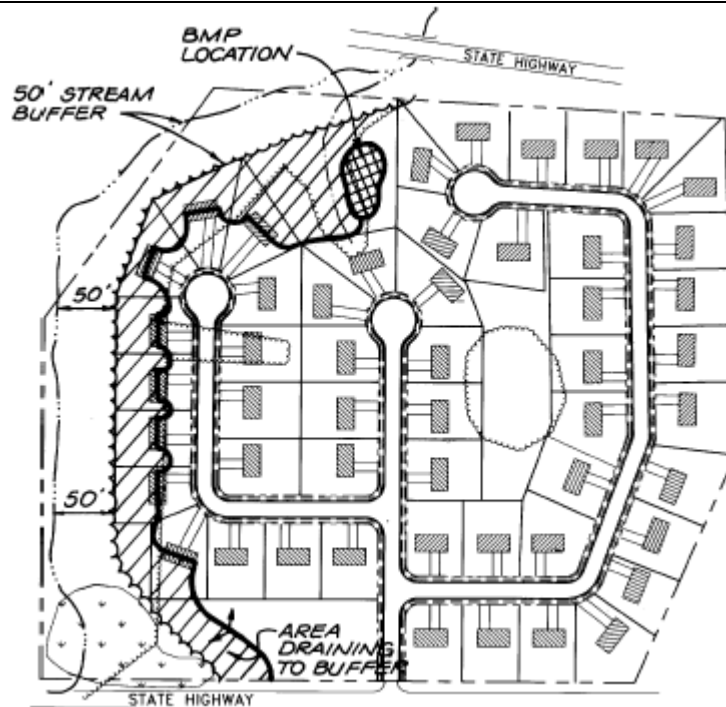
Example of Using the Sheetflow to Buffers Credit

Site Data - 51 Single Family
 Area = 38.0 ac
 Original Impervious Area =
 13.8 ac = 36.3%
 Original $R_v = .38$
 Post-dev. CN = 78

Original $WQ_v = 1.44$ ac-ft
 Original $Re_v = 0.24$ ac-ft
 Original $Cp_v = 1.65$ ac-ft

Credit

5.0 ac draining to buffer/filter strip
 Rooftops represent 3% of site
 imperviousness = 0.41 ac



Computation of Stormwater Credits

New drainage area = 38 ac - 5 ac = 33.0 ac
 R_v remains unchanged to BMP; $R_v = 0.05 + 0.009(36.3) = 0.38$

$$WQ_v = [(P)(R_v)(A)]/12$$

$$= [(1.2)(0.38)(33.0 \text{ ac.})]/12$$

$$= 1.25 \text{ ac-ft}$$

Required Re_v (Percent Area Method)

$$Re_v = 21.8\% \times 13.8 \text{ ac.} = 3.01 \text{ acres}$$

Re_v treated by disconnection = 0.41 acres

Re_v remaining for treatment = 2.60 acres non structurally or 0.207 ac-ft structurally

CN is reduced slightly

O.6 Grass Channel Credit (in lieu of Curb and Gutter)

Credit may be given when open grass channels are used to reduce the volume of runoff and pollutants during smaller storms (e.g., < 1 inch). The schematic of the grass channel is provided in Figure O.3.

Use of a grass channel will automatically meet the Re_v for impervious areas draining into the channel. However, Re_v for impervious areas not draining to grass channels must still be addressed. If designed according to the following criteria, the grass channel will meet the WQ_v as well.

CNs for channel protection or peak flow control (Cp_v or Q_p) will not change.

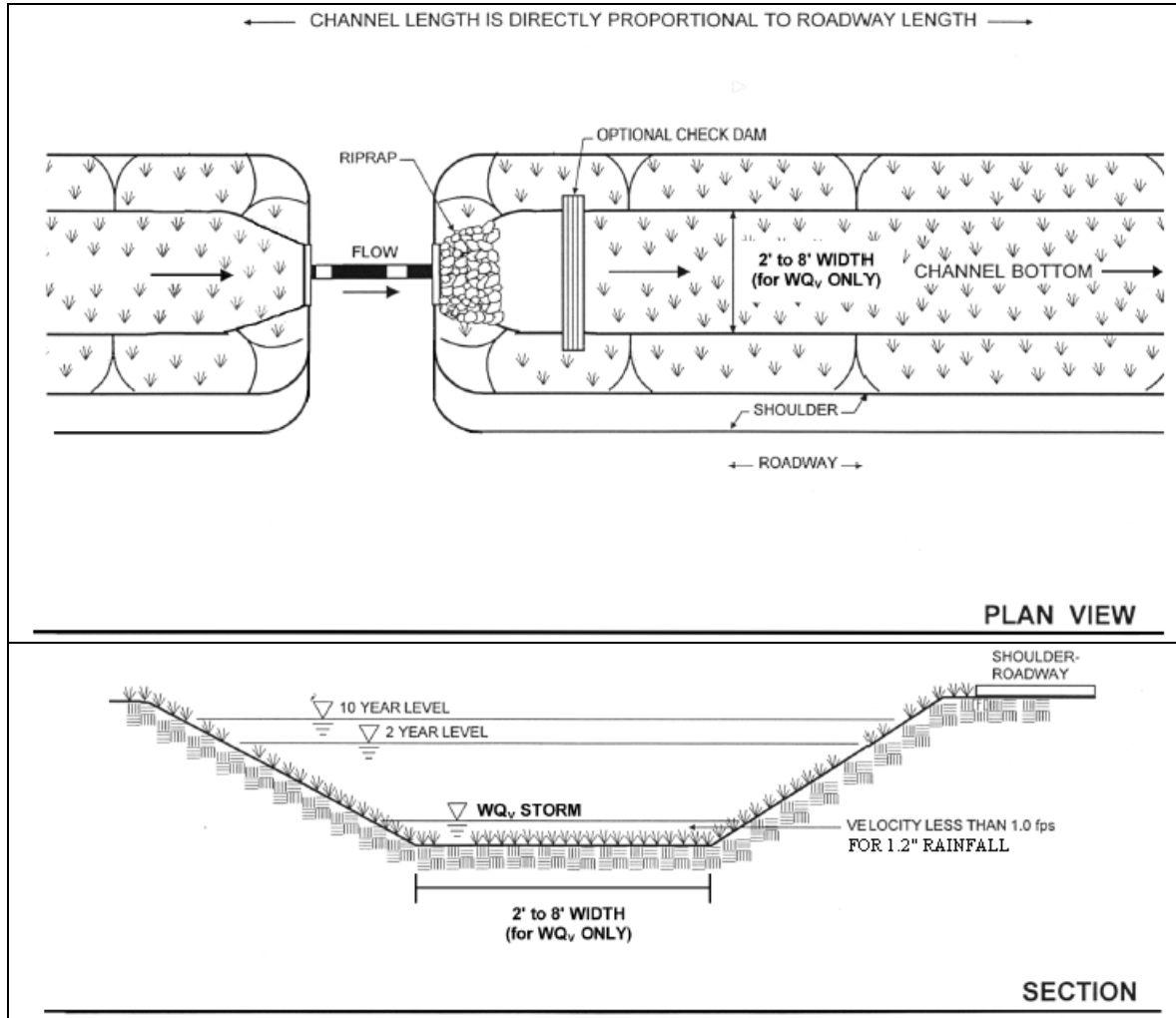
Criteria for the Grass Channel Credit

The WQ_v credit is obtained if a grass channel meets the following criteria:

- *The maximum flow velocity for runoff from the 1.2 inch rainfall shall be less than or equal to 1.0 fps (see Appendix L for methodology to compute flowrate).*
- *The maximum flow velocity for runoff from the 10-year design event shall be non-erosive.*
- *The bottom width shall be 2 feet minimum and 8 feet maximum.*
- *The side slopes shall be 3:1 or flatter.*
- *The channel slope shall be less than or equal to 4.0%.*
- *Not applicable if rooftop disconnection is already provided (see Credit O.2).*

An example of a grass channel is provided in Figure O.3.

Figure O.3 Example of Grass Channel

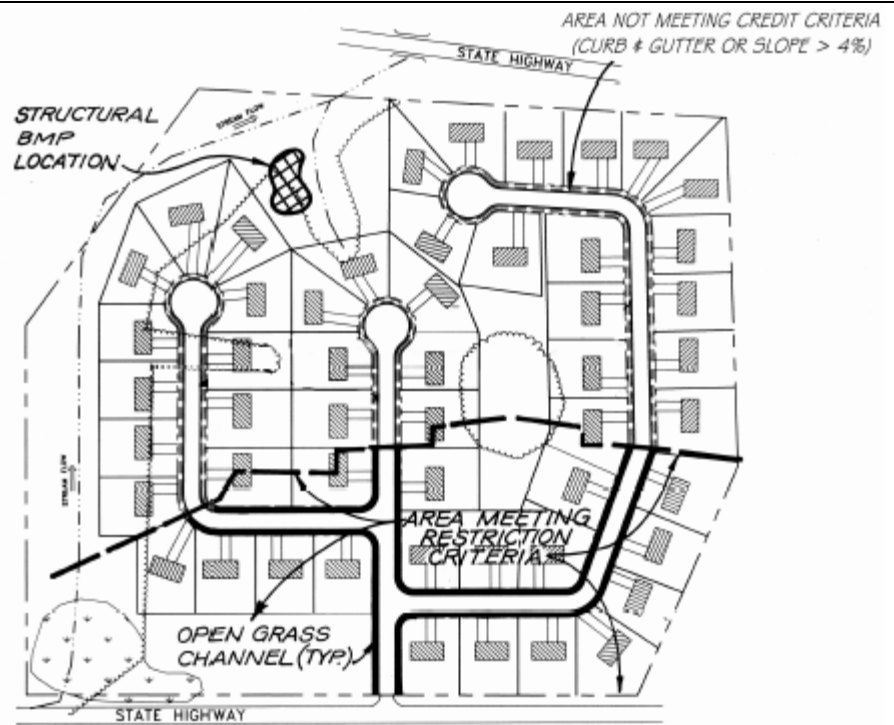


Example of Grass Channel Credit

Site Data - 51 Single Family Residences
 Area = 38.0 ac
 Original Impervious Area = 13.8 = 36.3%
 $R_v = 0.38$
 $CN = 78$

Original $WQ_v = 1.44$ ac-ft
 Original $Re_v = 0.25$ ac-ft
 Original $Cp_v = 1.65$ ac-ft

Credit
 12.5 ac meet grass channel criteria



Computation of Stormwater Credits

New WQ_v Area = 38 ac - 12.5 ac = 25.5 ac
 $WQ_v = [(1.2)(0.38)(25.5 \text{ ac})]/12$
 = 0.97 ac-ft

Required Re_v (Percent Area Method)

$Re_v = 21.8\% \times 13.8 \text{ ac} = 3.01 \text{ ac}$
 4.5 ac of imperviousness lie within area drained by grass channels, and
 4.5 ac > 3.01 ac
 Re_v requirement is met
 Cp_v and Q_p : No change

O.7 Environmentally Sensitive Development Credit

Credit is given when a group of environmental site design techniques are applied to low density or residential development. The credit eliminates the need for structural practices to treat both the Re_v and WQ_v and is intended for use on large lots.

Criteria for Environmentally Sensitive Development Credit

These criteria can be met without the use of structural practices in certain low density residential developments when the following conditions are met:

For Single Lot Development:

- *Total site impervious cover is less than 15%.*
- *Lot size shall be at least two acres.*
- *Rooftop runoff is disconnected in accordance with the criteria outlined in Section O.3.*
- *Grass channels are used to convey runoff versus curb and gutter.*

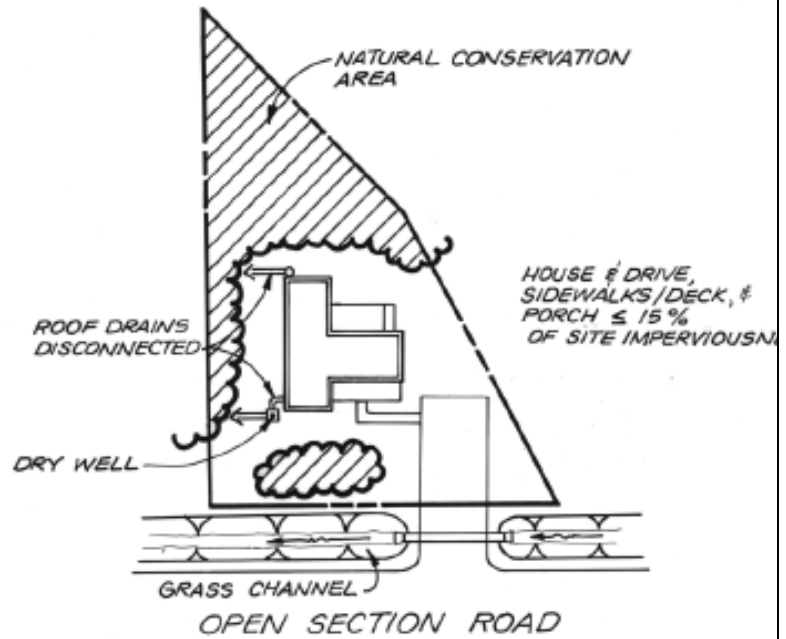
For Multiple Lot Development:

- *Total site impervious cover is less than 15%.*
- *Lot size shall be at least two acres if clustering techniques are not used.*
- *If clustering techniques are used, the average lot size shall not be greater than 50% of the minimum lot size as identified in the appropriate local zoning ordinance and shall be at least one half acre.*
- *Rooftop runoff is disconnected in accordance with the criteria outlined in Section O.3.*
- *Grass channels are used to convey runoff versus curb and gutter.*
- *A minimum of 25% of the site is protected in natural conservation areas (by permanent easement or other similar measure).*
- *The design shall address stormwater (Re_v , WQ_v , Cp_v , and extreme events) for all roadway and connected impervious surfaces.*

Example of Environmentally Sensitive Development Credit

Site Data - 1 Single Family Lot
 Area = 2.5 ac
 Conservation Area = 0.6 ac
 Impervious Area = .35 ac (includes adjacent road surface) = 14%
 B soils
 $R_v = 0.05 + 0.009(14) = 0.18$
 CN = 65

WQ_v : Use $P=0.2$ as $I < 15\%$
 $WQ_v = [(0.2)(A)]/12$
 $= [(0.2)(2.5)]/12 \times (43560 \text{ ft}^2/\text{ac})$
 $= 1,815 \text{ ft}^3$
 $Re_v = [(S)(R_v)(A)]/12$
 $= [(0.27)(0.18)(2.5)]/12 \times (43,560 \text{ ft}^2/\text{ac})$
 $= 441.0 \text{ ft}^3$



Computation of Stormwater Credits:

WQ_v is met by site design
 Re_v is met by site design
 Cp_v : No change in CN, t_c may be longer which would reduce Q_p requirements