TRAINING MODULE 2

Calculations & Examples For RPv Compliance

DELAWARE DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL

Introduction

This Training Module will cover methods designers may use to demonstrate RPv compliance under the 2019 Delaware Sediment & Stormwater Regulations (DSSR). These methods include use of the Delaware Urban Runoff Management Model (DURMM) covered in Module 1, as well as external proprietary models such as HydroCAD. The examples include analyses of infiltrating retention practices, surface recharge practices and detention practices. Methods covered include:

- Compliance using DURMM only
- Compliance using DURMM + HydroCAD
- Compliance using DURMM + criteria from the BMP Standards & Specifications

Alternative BMP scenarios are covered under these 3 general methodologies.

NOTE: Effective with the 2019 DSSR, the maximum volume of runoff that is required to be managed for the RPv event is 1”. DURMM will automatically account for this in the RPv calculations as reflected in the examples included in this module.

Examples

RPv Compliance Using DURMM Only

Examples – Compliance Using DURMM Only

The first set of examples covers determining RPv requirements and verifying compliance using only DURMM under 3 different development scenarios.

Example 2a

New Development - DURMM Only

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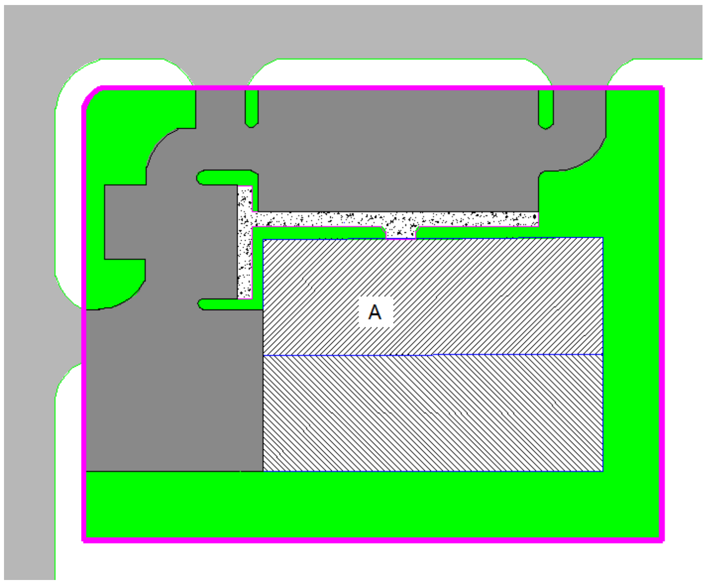
<u>Example 2a – New Development (DURMM Only)</u>
This example illustrates the new development scenario.

Small Commercial – New Development



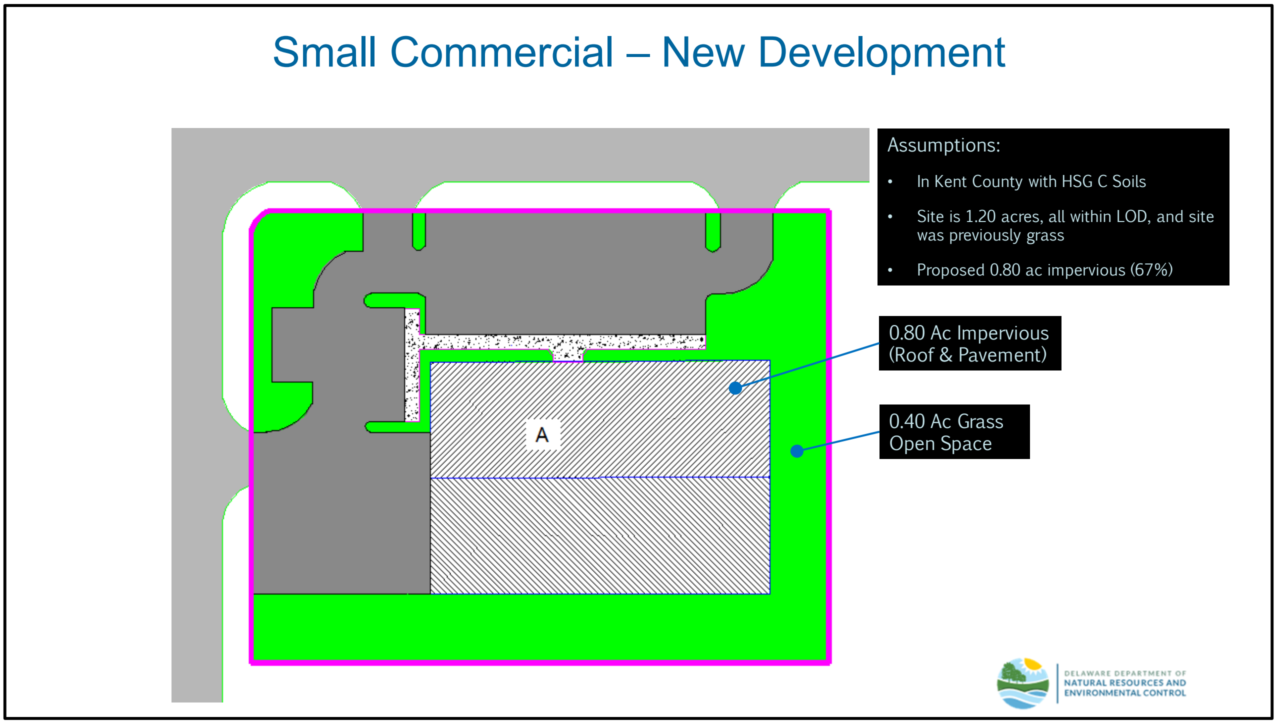
Assumptions:

- In Kent County with HSG C Soils
- Site is 1.20 acres, all within LOD, and site was previously grass

<u>Example 2a – New Development (DURMM Only)</u>

For this example, a new small commercial site located in Kent County is proposed. The following site assumptions apply:

- Total site area = 1.20 acres
- Soil type is Hydrologic Soil Group (HSG) C
- Entire site will be disturbed
- Existing condition is grassed open space



<u>Example 2a – New Development (DURMM Only)</u>

The following assumptions apply for the proposed development:

- Total impervious area from roof and pavement = 0.80 acres
- Total site imperviousness = 67%
- Remaining 0.40 acres is assumed as grassed open space*

*Although a portion of the grassed open space will ultimately also include the bioretention facilities, for compliance purposes this area can still be assumed to be grassed open space in the DURMM calculations.

1		PROJECT:	Example 1, Small Commercial								
2		DRAINAGE SUBAREA ID:									
3		LOCATION (County):	Kent								
4		UNIT HYDROGRAPH:	DMV								
5	CONTRIBUTING AREA RUNOFF CURVE NUMBER (C.A. RCN) WORKSHEET			Curve Numbers for Hydrologic Soil Type							
6	**Cover Type**	**Treatment**	**Hydrologic Condition**	**A**		**B**		**C**		**D**	
7				*Acres*	*RCN*	*Acres*	*RCN*	*Acres*	*RCN*	*Acres*	*RCN*
59	**FULLY DEVELOPED URBAN AREAS (Veg Established)**										
60	Open space (Lawns,parks etc.)										
61		Poor condition; grass cover < 50%			68		79		86		89
62		Fair condition; grass cover 50% to 75 %			49		69		79		84
63		Good condition; grass cover > 75%			39		61	0.4	74		80
64	Impervious Areas										
65		Paved parking lots, roofs, driveways			98		98	0.8	98		98
66		Streets and roads									
67		Paved; curbs and storm sewers			98		98		98		98
68		Paved; open ditches (w/right-of-way)			83		89		92		93
69		Gravel (w/ right-of-way)			76		85		89		91
70		Dirt (w/ right-of-way)			72		82		87		89
71	Urban Districts		Avg % impervious								
72		Commercial & business	85		89		92		94		95
73		Industrial	72		81		88		91		93

Example 2a – New Development (DURMM Only)

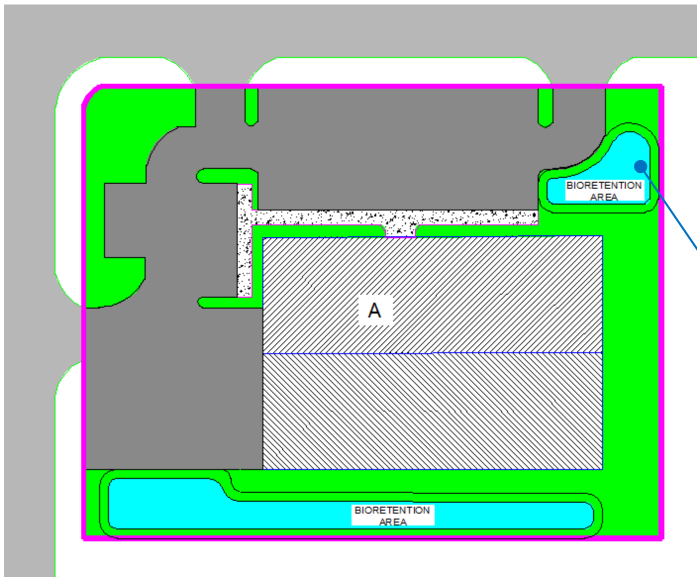
The post-developed site conditions are entered into the DURMM "C.A. RCN" sheet as shown above.

PROJECT:	Example 1, Small Commercial			
DRAINAGE SUBAREA ID:	0			
LOCATION (County):	Kent			
UNIT HYDROGRAPH:	DMV			
LIMIT OF DISTURBANCE (LOD) WORKSHEET				
Step 1 - Subarea LOD Data	**HSG A**	**HSG B**	**HSG C**	**HSG D**
1.1 HSG Area Within LOD (ac)			1.2	
1.2 Pre-Developed Woods/Meadow Within LOD (ac)				
1.3 Pre-Developed Impervious Within LOD (ac)				
1.4.a Post-Developed Imperviousness Within LOD, Option #1 (ac); ***<u>OR</u>***			0.8	
1.4.b Post-Developed Imperviousness Within LOD, Option #2 (%)	0%	0%	67%	0%
Step 2 - Subarea LOD Runoff Calculations				
2.1 RCN per HSG	0.00	0.00	90.00	0.00
2.2 RPv per HSG (in.)	0.00	0.00	1.86	0.00
2.3 Target RCN per HSG	0.00	0.00	74.00	0.00
2.4 Target Runoff per HSG (in.)	0.00	0.00	1.06	0.00
2.5 Subarea LOD (ac)	1.20			
2.6 Subarea Weighted RCN	90.00			

<u>Example 2a – New Development (DURMM Only)</u>

The post-developed site conditions are entered into the DURMM “LOD” sheet as shown above

Small Commercial – New Development



Assumptions:

- In Kent County with HSG C Soils
- Site is 1.20 acres, all within LOD, and site was previously grass
- Proposed 0.80 ac impervious (67%)
- Entire site drains to 1 of 2 Bioretention Areas that are Interconnected

Bioretention:

How much volume is needed to meet RPv?

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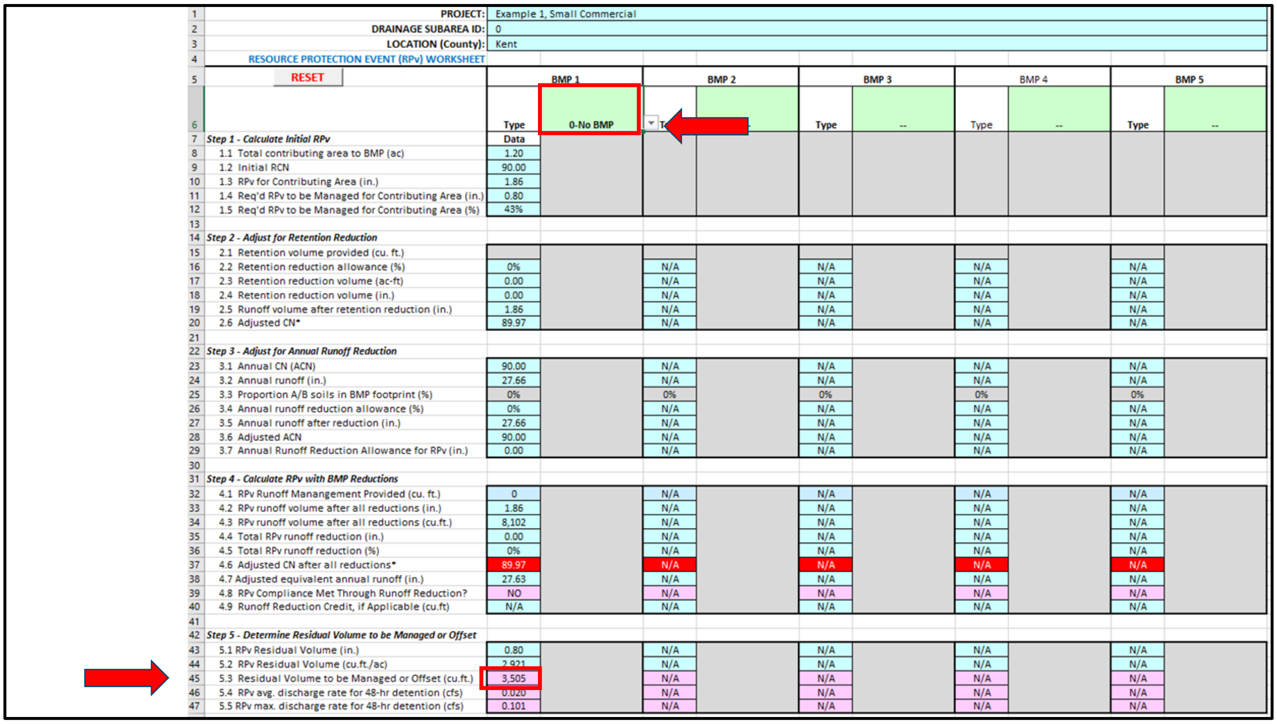
<u>Example 2a – New Development (DURMM Only)</u>

For the purposes of this example, it is assumed that the entire site drains to 1 of 2 Bioretention facilities with underdrains that are interconnected.

The DURMM "RPv" sheet will be used to determine the combined storage capacity of the 2 bioretention areas required for RPv compliance.



		BMP 1 Type	BMP 1	BMP 2 Type	BMP 2	BMP 3 Type	BMP 3	BMP 4 Type	BMP 4	BMP 5 Type	BMP 5
1	PROJECT:	Example 1, Small Commercial									
2	DRAINAGE SUBAREA ID:	0									
3	LOCATION (County):	Kent									
4	RESOURCE PROTECTION EVENT (RPv) WORKSHEET										
5	RESET	BMP 1		BMP 2		BMP 3		BMP 4		BMP 5	
6		Type	0-No BMP	T		Type	--	Type	--	Type	--
7	*Step 1 - Calculate Initial RPv*	Data									
8	1.1 Total contributing area to BMP (ac)	1.20									
9	1.2 Initial RCN	90.00									
10	1.3 RPv for Contributing Area (in.)	1.86									
11	1.4 Req'd RPv to be Managed for Contributing Area (in.)	0.80									
12	1.5 Req'd RPv to be Managed for Contributing Area (%)	43%									
13											
14	*Step 2 - Adjust for Retention Reduction*										
15	2.1 Retention volume provided (cu. ft.)										
16	2.2 Retention reduction allowance (%)	0%		N/A		N/A		N/A		N/A	
17	2.3 Retention reduction volume (ac-ft)	0.00		N/A		N/A		N/A		N/A	
18	2.4 Retention reduction volume (in.)	0.00		N/A		N/A		N/A		N/A	
19	2.5 Runoff volume after retention reduction (in.)	1.86		N/A		N/A		N/A		N/A	
20	2.6 Adjusted CN*	89.97		N/A		N/A		N/A		N/A	
21											
22	*Step 3 - Adjust for Annual Runoff Reduction*										
23	3.1 Annual CN (ACN)	90.00		N/A		N/A		N/A		N/A	
24	3.2 Annual runoff (in.)	27.66		N/A		N/A		N/A		N/A	
25	3.3 Proportion A/B soils in BMP footprint (%)	0%		0%		0%		0%		0%	
26	3.4 Annual runoff reduction allowance (%)	0%		N/A		N/A		N/A		N/A	
27	3.5 Annual runoff after reduction (in.)	27.66		N/A		N/A		N/A		N/A	
28	3.6 Adjusted ACN	90.00		N/A		N/A		N/A		N/A	
29	3.7 Annual Runoff Reduction Allowance for RPv (in.)	0.00		N/A		N/A		N/A		N/A	
30											
31	*Step 4 - Calculate RPv with BMP Reductions*										
32	4.1 RPv Runoff Manangement Provided (cu. ft.)	0		N/A		N/A		N/A		N/A	
33	4.2 RPv runoff volume after all reductions (in.)	1.86		N/A		N/A		N/A		N/A	
34	4.3 RPv runoff volume after all reductions (cu.ft.)	8,102		N/A		N/A		N/A		N/A	
35	4.4 Total RPv runoff reduction (in.)	0.00		N/A		N/A		N/A		N/A	
36	4.5 Total RPv runoff reduction (%)	0%		N/A		N/A		N/A		N/A	
37	4.6 Adjusted CN after all reductions*	89.97		N/A		N/A		N/A		N/A	
38	4.7 Adjusted equivalent annual runoff (in.)	27.63		N/A		N/A		N/A		N/A	
39	4.8 RPv Compliance Met Through Runoff Reduction?	NO		N/A		N/A		N/A		N/A	
40	4.9 Runoff Reduction Credit, if Applicable (cu.ft)	N/A		N/A		N/A		N/A		N/A	
41											
42	*Step 5 - Determine Residual Volume to be Managed or Offset*										
43	5.1 RPv Residual Volume (in.)	0.80		N/A		N/A		N/A		N/A	
44	5.2 RPv Residual Volume (cu.ft./ac)	2,921		N/A		N/A		N/A		N/A	
45	5.3 Residual Volume to be Managed or Offset (cu.ft.)	3,505		N/A		N/A		N/A		N/A	
46	5.4 RPv avg. discharge rate for 48-hr detention (cfs)	0.020		N/A		N/A		N/A		N/A	
47	5.5 RPv max. discharge rate for 48-hr detention (cfs)	0.101		N/A		N/A		N/A		N/A	

<u>Example 2a – New Development (DURMM Only)</u>

Although a designer could determine the required storage for the combined bioretention areas using an iterative approach by entering trial volumes at Step 2.1 on the "RPv" sheet, DURMM provides a quicker method by using the "No BMP" option, as follows:

1. Select the "No BMP" option from the dropdown menu for BMP 1
2. DURMM calculates the residual volume that needs to be managed
3. Results for the residual volume* are shown at Step 5.3

Using this approach, DURMM has calculated the residual volume that needs to be managed is 3,505 CF.

*DURMM uses the term "residual volume" to denote the portion of runoff volume that is <u>not</u> infiltrated or recharged through a permeable surface.

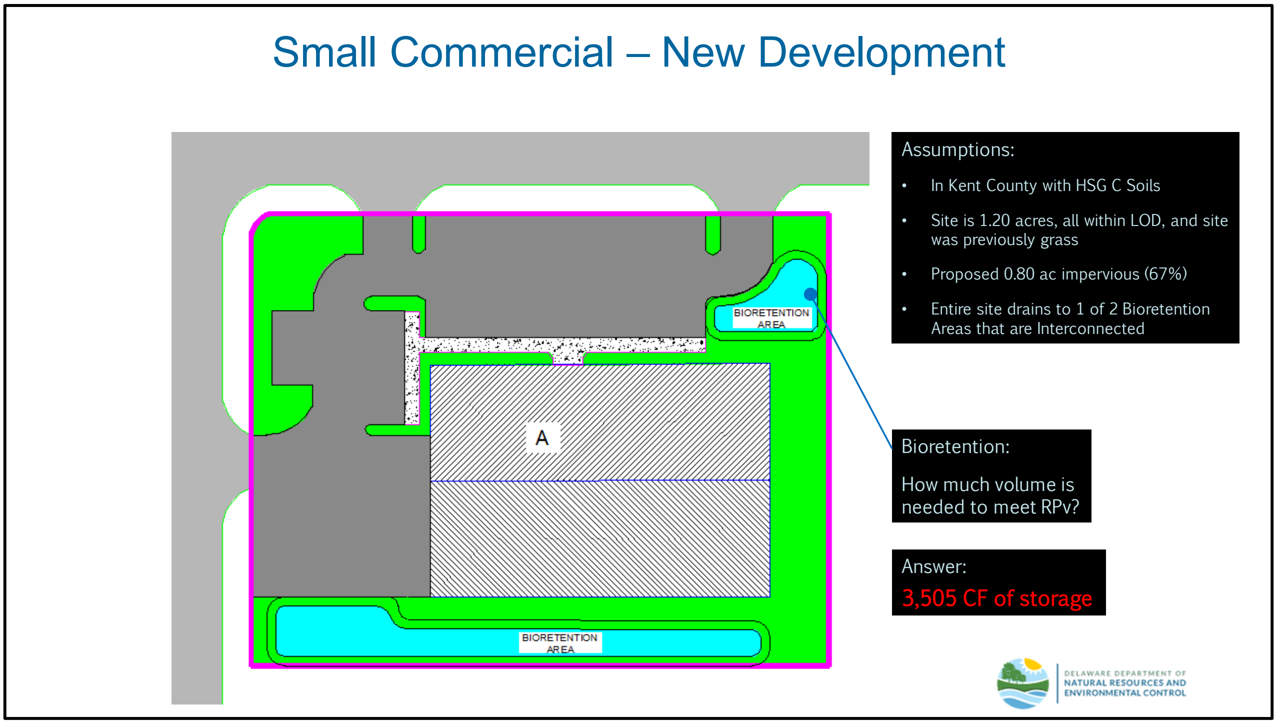
#		BMP 1		BMP 2		BMP 3		BMP 4		BMP 5	
1	PROJECT:	Example 1, Small Commercial									
2	DRAINAGE SUBAREA ID:	0									
3	LOCATION (County):	Kent									
4	RESOURCE PROTECTION EVENT (RPv) WORKSHEET										
5	RESET	BMP 1		BMP 2		BMP 3		BMP 4		BMP 5	
6		Type	2-A Traditional Bioretention - Underdrain		--	Type	--	Type	--	Type	--
7	*Step 1 - Calculate Initial RPv*	Data									
8	1.1 Total contributing area to BMP (ac)	1.20									
9	1.2 Initial RCN	90.00									
10	1.3 RPv for Contributing Area (in.)	1.86									
11	1.4 Req'd RPv to be Managed for Contributing Area (in.)	0.80									
12	1.5 Req'd RPv to be Managed for Contributing Area (%)	43%									
13											
14	*Step 2 - Adjust for Retention Reduction*										
15	2.1 Retention volume provided (cu. ft.)	3505									
16	2.2 Retention reduction allowance (%)	100%		N/A		N/A		N/A		N/A	
17	2.3 Retention reduction volume (ac-ft)	0.08		N/A		N/A		N/A		N/A	
18	2.4 Retention reduction volume (in.)	0.80		N/A		N/A		N/A		N/A	
19	2.5 Runoff volume after retention reduction (in.)	1.06		N/A		N/A		N/A		N/A	
20	2.6 Adjusted CN*	74.00		N/A		N/A		N/A		N/A	
21											
22	*Step 3 - Adjust for Annual Runoff Reduction*										
23	3.1 Annual CN (ACN)	90.00		N/A		N/A		N/A		N/A	
24	3.2 Annual runoff (in.)	27.66		N/A		N/A		N/A		N/A	
25	3.3 Proportion A/B soils in BMP footprint (%)	0%		0%		0%		0%		0%	
26	3.4 Annual runoff reduction allowance (%)	0%		N/A		N/A		N/A		N/A	
27	3.5 Annual runoff after reduction (in.)	27.66		N/A		N/A		N/A		N/A	
28	3.6 Adjusted ACN	90.00		N/A		N/A		N/A		N/A	
29	3.7 Annual Runoff Reduction Allowance for RPv (in.)	0.00		N/A		N/A		N/A		N/A	
30											
31	*Step 4 - Calculate RPv with BMP Reductions*										
32	4.1 RPv Runoff Manangement Provided (cu. ft.)	3505		N/A		N/A		N/A		N/A	
33	4.2 RPv runoff volume after all reductions (in.)	1.06		N/A		N/A		N/A		N/A	
34	4.3 RPv runoff volume after all reductions (cu.ft.)	4,597		N/A		N/A		N/A		N/A	
35	4.4 Total RPv runoff reduction (in.)	0.80		N/A		N/A		N/A		N/A	
36	4.5 Total RPv runoff reduction (%)	43%		N/A		N/A		N/A		N/A	
37	4.6 Adjusted CN after all reductions*	74.00		N/A		N/A		N/A		N/A	
38	4.7 Adjusted equivalent annual runoff (in.)	13.94		N/A		N/A		N/A		N/A	
39	4.8 RPv Compliance Met Through Runoff Reduction?	YES		N/A		N/A		N/A		N/A	
40	4.9 Runoff Reduction Credit, if Applicable (cu.ft)	-0.08		N/A		N/A		N/A		N/A	
41											
42	*Step 5 - Determine Residual Volume to be Managed or Offset*										
43	5.1 RPv Residual Volume (in.)	N/A		N/A		N/A		N/A		N/A	
44	5.2 RPv Residual Volume (cu.ft./ac)	N/A		N/A		N/A		N/A		N/A	
45	5.3 Residual Volume to be Managed or Offset (cu.ft.)	N/A		N/A		N/A		N/A		N/A	
46	5.4 RPv avg. discharge rate for 48-hr detention (cfs)	N/A		N/A		N/A		N/A		N/A	
47	5.5 RPv max. discharge rate for 48-hr detention (cfs)	N/A		N/A		N/A		N/A		N/A	

Example 2a – New Development (DURMM Only)

The designer must verify the “No BMP” calculated storage, as follows:

1. Select “2-A Traditional Bioretention – Underdrain” from the dropdown menu for BMP-1
2. Enter “3505” for BMP-1 at Step 2.1
3. Verify RPv compliance; “YES” will be shown at Step 4.8 if compliance is met

NOTE: In some cases, the residual volume calculated using the “No BMP” option may not meet compliance at the verification step due to computational rounding. The error will usually be within a few CF and can be corrected iteratively at this point.



<u>Example 2a – New Development (DURMM Only)</u>
The site will meet the RPv requirements of the DSSR if the 2 bioretention facilities have a combined storage volume of 3,505 CF. The designer must then apportion the volumes of the 2 facilities accordingly and demonstrate they have the necessary capacity through a combination of void space in the media and surface ponding in accordance with the BMP Standards & Specifications for Bioretention.

The DURMM calculations and verification of storage volume provided are submitted with the SWM Report to demonstrate compliance. (It is not necessary to include the “No BMP” calculations for estimating the required runoff volume to be managed.)

Example 2b

Redevelopment - DURMM Only

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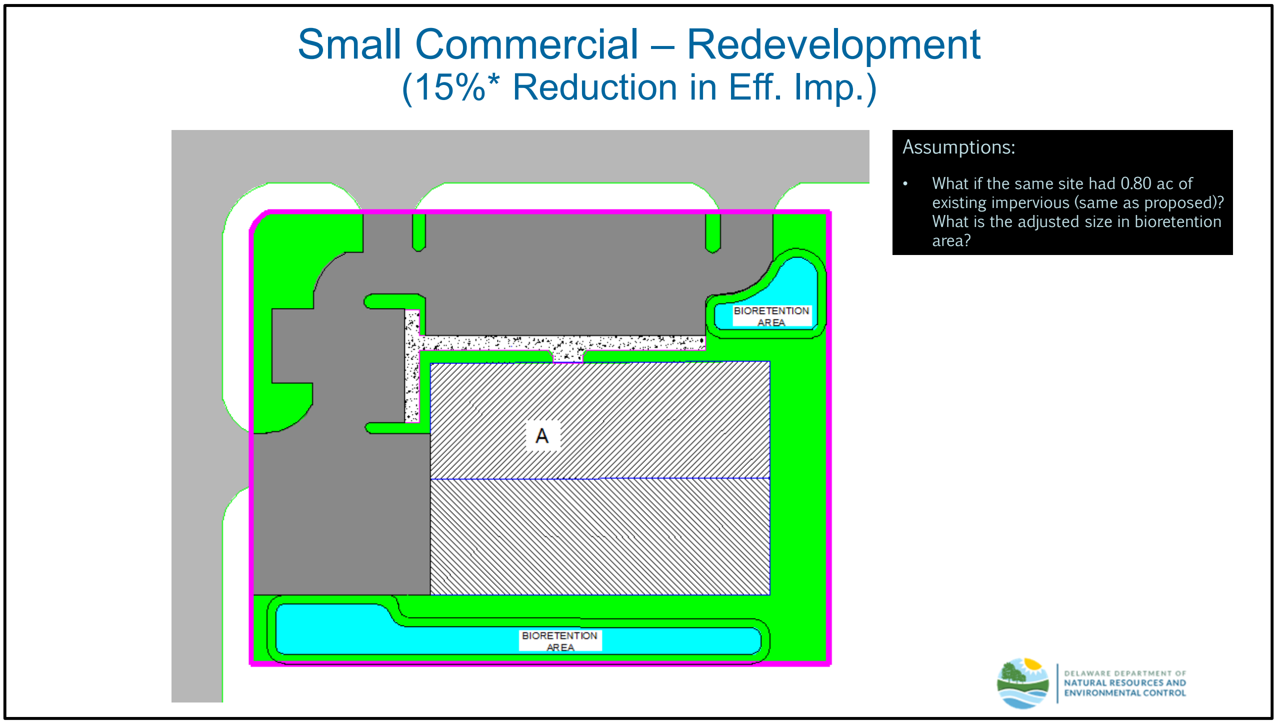
<u>Example 2b – ReDevelopment (DURMM Only)</u>

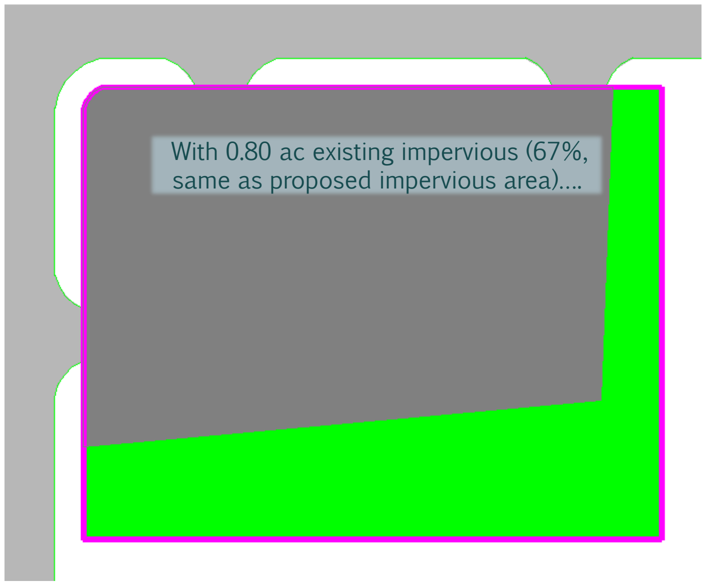


<u>Example 2b – ReDevelopment (DURMM Only)</u>

The next example will use the same proposed small commercial site from Example 2a, but the predeveloped condition will be assumed to have existing impervious area. This then falls under the 15%* reduction in effective imperviousness redevelopment requirements under the DSSR.

*New Castle County requires some redevelopment projects within their jurisdiction to reduce the effective imperviousness by 50%. A special version of DURMM is available from the DNREC Sediment & Stormwater Program website with modified calculations to be used for such projects.

Small Commercial – Redevelopment
(15% Reduction in Eff. Imp.)



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<u>Example 2b – ReDevelopment (DURMM Only)</u>

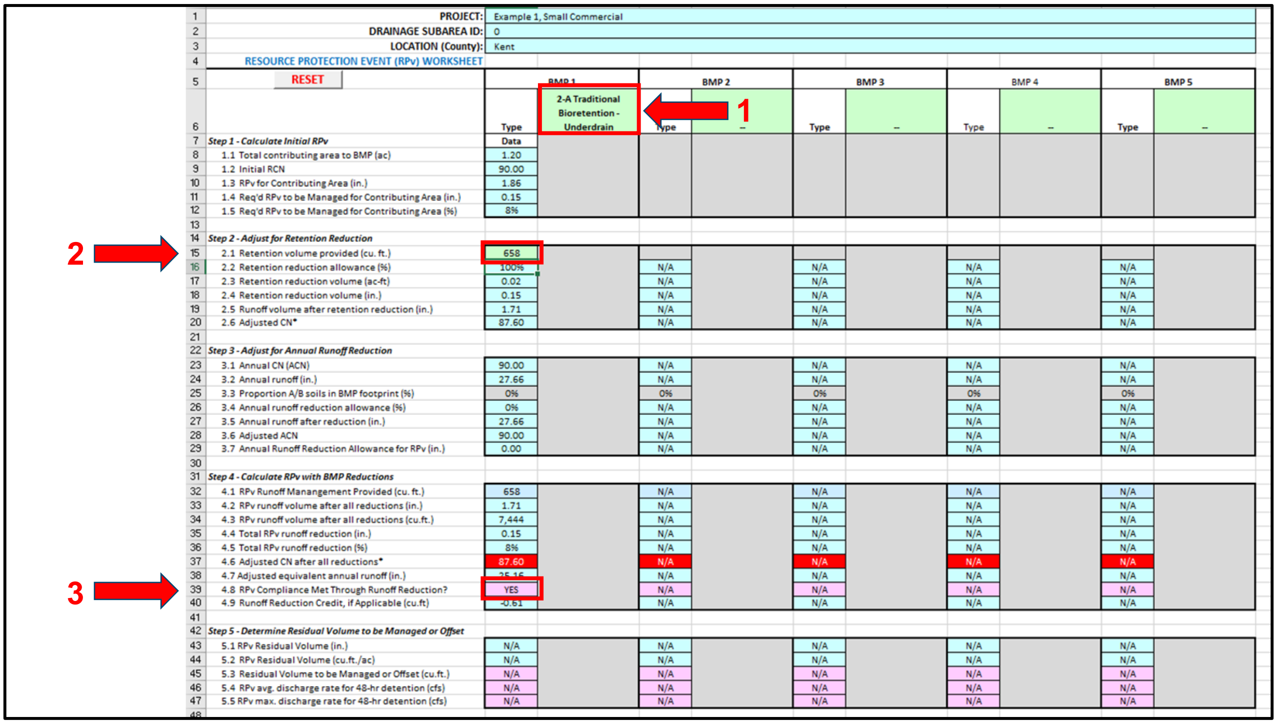
The following site assumptions apply:

- Total site area = 1.20 acres
- Soil type is Hydrologic Soil Group (HSG) C
- Entire site will be disturbed
- Existing condition is:
    - 0.80 acres impervious area
    - 0.40 acres grassed open space

1	**PROJECT:**	Example 1, Small Commercial			
2	**DRAINAGE SUBAREA ID:**	0			
3	**LOCATION (County):**	Kent			
4	**UNIT HYDROGRAPH:**	DMV			
5	**LIMIT OF DISTURBANCE (LOD) WORKSHEET**				
6	**Step 1 - Subarea LOD Data**	**HSG A**	**HSG B**	**HSG C**	**HSG D**
7	1.1 HSG Area Within LOD (ac)			1.2	
8	1.2 Pre-Developed Woods/Meadow Within LOD (ac)				
9	1.3 Pre-Developed Impervious Within LOD (ac)			0.8	
10	1.4.a Post-Developed Imperviousness Within LOD, Option #1 (ac); ***OR***			0.8	
11	1.4.b Post-Developed Imperviousness Within LOD, Option #2 (%)	0%	0%	67%	0%
12					
13	**Step 2 - Subarea LOD Runoff Calculations**				
14	2.1 RCN per HSG	0.00	0.00	90.00	0.00
15	2.2 RPv per HSG (in.)	0.00	0.00	1.86	0.00
16	2.3 Target RCN per HSG	0.00	0.00	87.60	0.00
17	2.4 Target Runoff per HSG (in.)	0.00	0.00	1.71	0.00
18					
19	2.5 Subarea LOD (ac)	1.20			
20	2.6 Subarea Weighted RCN	90.00			

<u>Example 2b – ReDevelopment (DURMM Only)</u>

Since the proposed development is the same as Example 2a, the “C.A. RCN” worksheet is filled out the same way. The post-developed site conditions showing the existing impervious area are entered into the DURMM “LOD” sheet as shown above



1	PROJECT:	Example 1, Small Commercial									
2	DRAINAGE SUBAREA ID:	0									
3	LOCATION (County):	Kent									
4	RESOURCE PROTECTION EVENT (RPv) WORKSHEET										
5	RESET	BMP 1		BMP 2		BMP 3		BMP 4		BMP 5	
6		Type	2-A Traditional Bioretention - Underdrain	Type	--	Type	--	Type	--	Type	--
7	*Step 1 - Calculate Initial RPv*	Data									
8	1.1 Total contributing area to BMP (ac)	1.20									
9	1.2 Initial RCN	90.00									
10	1.3 RPv for Contributing Area (in.)	1.86									
11	1.4 Req'd RPv to be Managed for Contributing Area (in.)	0.15									
12	1.5 Req'd RPv to be Managed for Contributing Area (%)	8%									
13											
14	*Step 2 - Adjust for Retention Reduction*										
15	2.1 Retention volume provided (cu. ft.)	658									
16	2.2 Retention reduction allowance (%)	100%		N/A		N/A		N/A		N/A	
17	2.3 Retention reduction volume (ac-ft)	0.02		N/A		N/A		N/A		N/A	
18	2.4 Retention reduction volume (in.)	0.15		N/A		N/A		N/A		N/A	
19	2.5 Runoff volume after retention reduction (in.)	1.71		N/A		N/A		N/A		N/A	
20	2.6 Adjusted CN*	87.60		N/A		N/A		N/A		N/A	
21											
22	*Step 3 - Adjust for Annual Runoff Reduction*										
23	3.1 Annual CN (ACN)	90.00		N/A		N/A		N/A		N/A	
24	3.2 Annual runoff (in.)	27.66		N/A		N/A		N/A		N/A	
25	3.3 Proportion A/B soils in BMP footprint (%)	0%		0%		0%		0%		0%	
26	3.4 Annual runoff reduction allowance (%)	0%		N/A		N/A		N/A		N/A	
27	3.5 Annual runoff after reduction (in.)	27.66		N/A		N/A		N/A		N/A	
28	3.6 Adjusted ACN	90.00		N/A		N/A		N/A		N/A	
29	3.7 Annual Runoff Reduction Allowance for RPv (in.)	0.00		N/A		N/A		N/A		N/A	
30											
31	*Step 4 - Calculate RPv with BMP Reductions*										
32	4.1 RPv Runoff Manangement Provided (cu. ft.)	658		N/A		N/A		N/A		N/A	
33	4.2 RPv runoff volume after all reductions (in.)	1.71		N/A		N/A		N/A		N/A	
34	4.3 RPv runoff volume after all reductions (cu.ft.)	7,444		N/A		N/A		N/A		N/A	
35	4.4 Total RPv runoff reduction (in.)	0.15		N/A		N/A		N/A		N/A	
36	4.5 Total RPv runoff reduction (%)	8%		N/A		N/A		N/A		N/A	
37	4.6 Adjusted CN after all reductions*	87.60		N/A		N/A		N/A		N/A	
38	4.7 Adjusted equivalent annual runoff (in.)	25.16		N/A		N/A		N/A		N/A	
39	4.8 RPv Compliance Met Through Runoff Reduction?	YES		N/A		N/A		N/A		N/A	
40	4.9 Runoff Reduction Credit, if Applicable (cu.ft)	-0.61		N/A		N/A		N/A		N/A	
41											
42	*Step 5 - Determine Residual Volume to be Managed or Offset*										
43	5.1 RPv Residual Volume (in.)	N/A		N/A		N/A		N/A		N/A	
44	5.2 RPv Residual Volume (cu.ft./ac)	N/A		N/A		N/A		N/A		N/A	
45	5.3 Residual Volume to be Managed or Offset (cu.ft.)	N/A		N/A		N/A		N/A		N/A	
46	5.4 RPv avg. discharge rate for 48-hr detention (cfs)	N/A		N/A		N/A		N/A		N/A	
47	5.5 RPv max. discharge rate for 48-hr detention (cfs)	N/A		N/A		N/A		N/A		N/A	

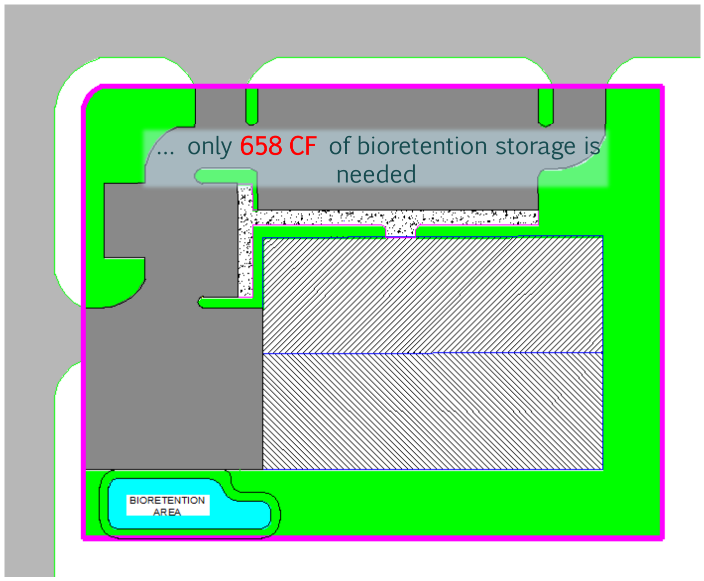
<u>Example 2b – ReDevelopment (DURMM Only)</u>

Using the "No BMP" option as in Example 2a, it was determined that a bioretention facility with 658 CF of storage will meet the RPv requirements of the DSSR. The verification process is performed also as in Example 2a:

1. Select "2-A Traditional Bioretention – Underdrain" from the dropdown menu for BMP-1
2. Enter "658" for BMP-1 at Step 2.1
3. Verify RPv compliance; "YES" will be shown at Step 4.8 if compliance is met

NOTE: In some cases, the residual volume calculated using the "No BMP" option may not meet compliance at the verification step due to computational rounding. The error will usually be within a few CF and can be corrected iteratively at this point.

Small Commercial – Redevelopment
(15% Reduction in Eff. Imp.)



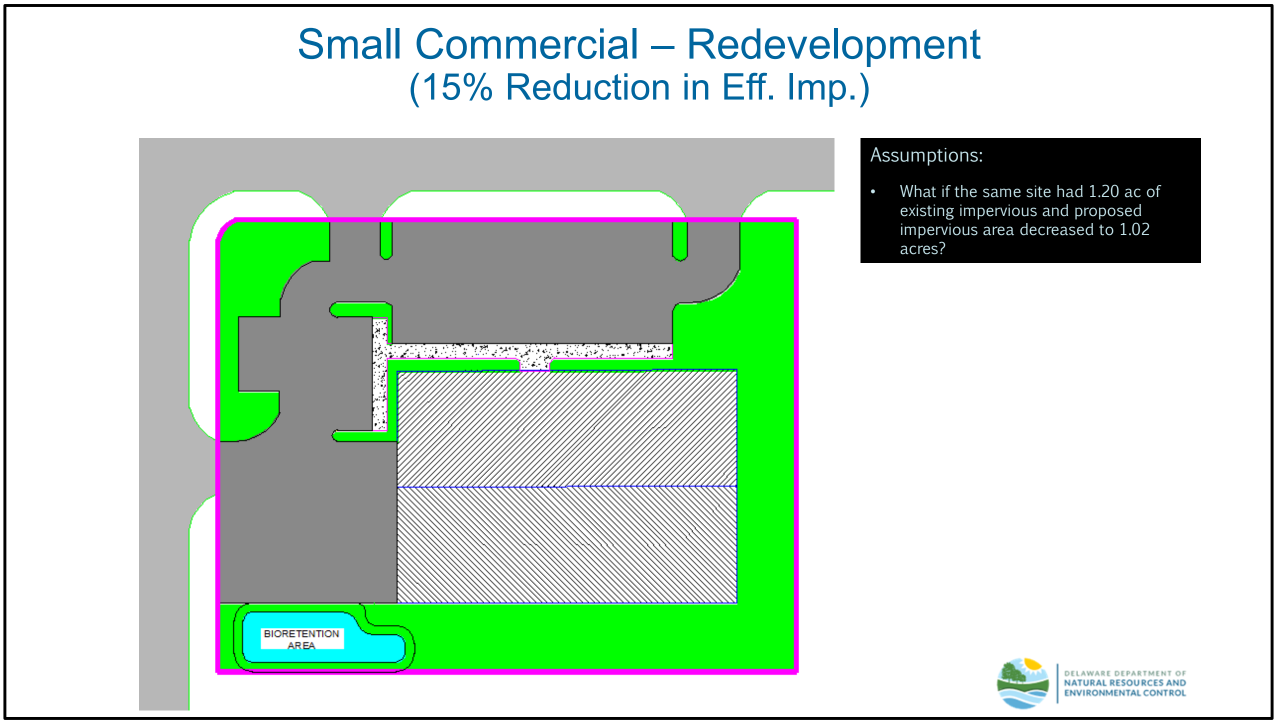
Example 2b – ReDevelopment (DURMM Only)
This example illustrates the fact that the RPv runoff reduction requirements are significantly reduced for redevelopment projects, incentivizing these types of projects over converting undeveloped areas.

Example 2c

Redevelopment of 100% Impervious Site
DURMM Only

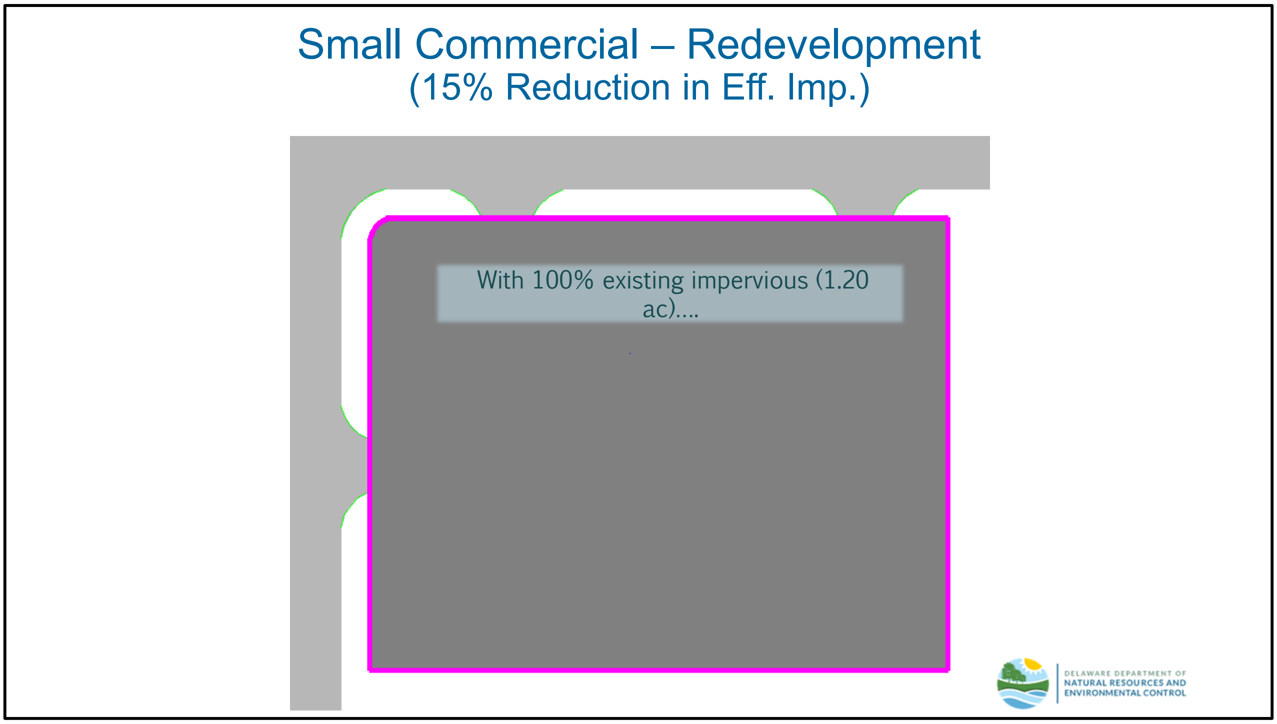
DELAWARE DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL

Example 2c – ReDevelopment of 100% Impervious Site (DURMM Only)



<u>Example 2c – ReDevelopment of 100% Impervious Site (DURMM Only)</u>

The next example takes the redevelopment scenario even farther by assuming the existing condition is a site with 100% impervious area.



<u>Example 2c – ReDevelopment of 100% Impervious Site (DURMM Only)</u>

The following site assumptions apply:

- Total site area = 1.20 acres
- Soil type is Hydrologic Soil Group (HSG) C
- Entire site will be disturbed
- Existing condition = 1.20 acres impervious area

1	**PROJECT:**	Example 1, Small Commercial				
2	**DRAINAGE SUBAREA ID:**	0				
3	**LOCATION (County):**	Kent				
4	**UNIT HYDROGRAPH:**	DMV				
5	**LIMIT OF DISTURBANCE (LOD) WORKSHEET**					
6	**Step 1 - Subarea LOD Data**	**HSG A**	**HSG B**	**HSG C**	**HSG D**	
7	1.1 HSG Area Within LOD (ac)			1.2		
8	1.2 Pre-Developed Woods/Meadow Within LOD (ac)					
9	1.3 Pre-Developed Impervious Within LOD (ac)			1.2		
10	1.4.a Post-Developed Imperviousness Within LOD, Option #1 (ac); ***OR***			1.02		
11	1.4.b Post-Developed Imperviousness Within LOD, Option #2 (%)	0%	0%	85%	0%	
12						
13	**Step 2 - Subarea LOD Runoff Calculations**					
14	2.1 RCN per HSG	0.00	0.00	94.40	0.00	
15	2.2 RPv per HSG (in.)	0.00	0.00	2.18	0.00	
16	2.3 Target RCN per HSG	0.00	0.00	94.40	0.00	
17	2.4 Target Runoff per HSG (in.)	0.00	0.00	2.18	0.00	
18						
19	2.5 Subarea LOD (ac)	1.20				
20	2.6 Subarea Weighted RCN	94.40				

<u>Example 2c – ReDevelopment of 100% Impervious Site (DURMM Only)</u>

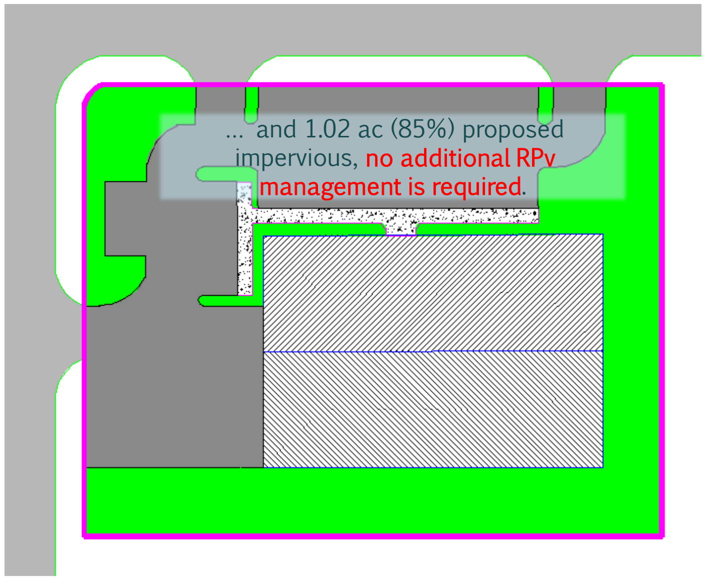
Since the proposed development is the same as examples 2a and 2b, the "C.A. RCN" worksheet is filled out the same way. The post-developed site conditions showing 1.2 acres of existing impervious area are entered into the DURMM "LOD" sheet as shown above. The proposed post-developed impervious area of 1.02 acres is entered at Step 1.4a. DURMM has calculated that the post-developed imperviousnessis 85%.

		BMP 1		BMP 2		BMP 3		BMP 4		BMP 5	
1	PROJECT:	Example 1, Small Commercial									
2	DRAINAGE SUBAREA ID:	0									
3	LOCATION (County):	Kent									
4	RESOURCE PROTECTION EVENT (RPv) WORKSHEET										
5	RESET	BMP 1		BMP 2		BMP 3		BMP 4		BMP 5	
6		Type	0-No BMP	Type	--	Type	--	Type	--	Type	--
7	***Step 1 - Calculate Initial RPv***	Data									
8	1.1 Total contributing area to BMP (ac)	1.20									
9	1.2 Initial RCN	90.00									
10	1.3 RPv for Contributing Area (in.)	1.86									
11	1.4 Req'd RPv to be Managed for Contributing Area (in.)	-0.32									
12	1.5 Req'd RPv to be Managed for Contributing Area (%)	-17%									
13											
14	***Step 2 - Adjust for Retention Reduction***										
15	2.1 Retention volume provided (cu. ft.)										
16	2.2 Retention reduction allowance (%)	0%		N/A		N/A		N/A		N/A	
17	2.3 Retention reduction volume (ac-ft)	0.00		N/A		N/A		N/A		N/A	
18	2.4 Retention reduction volume (in.)	0.00		N/A		N/A		N/A		N/A	
19	2.5 Runoff volume after retention reduction (in.)	1.86		N/A		N/A		N/A		N/A	
20	2.6 Adjusted CN*	89.97		N/A		N/A		N/A		N/A	
21											
22	***Step 3 - Adjust for Annual Runoff Reduction***										
23	3.1 Annual CN (ACN)	90.00		N/A		N/A		N/A		N/A	
24	3.2 Annual runoff (in.)	27.66		N/A		N/A		N/A		N/A	
25	3.3 Proportion A/B soils in BMP footprint (%)	0%		0%		0%		0%		0%	
26	3.4 Annual runoff reduction allowance (%)	0%		N/A		N/A		N/A		N/A	
27	3.5 Annual runoff after reduction (in.)	27.66		N/A		N/A		N/A		N/A	
28	3.6 Adjusted ACN	90.00		N/A		N/A		N/A		N/A	
29	3.7 Annual Runoff Reduction Allowance for RPv (in.)	0.00		N/A		N/A		N/A		N/A	
30											
31	***Step 4 - Calculate RPv with BMP Reductions***										
32	4.1 RPv Runoff Manangement Provided (cu. ft.)	0		N/A		N/A		N/A		N/A	
33	4.2 RPv runoff volume after all reductions (in.)	1.86		N/A		N/A		N/A		N/A	
34	4.3 RPv runoff volume after all reductions (cu.ft.)	8,102		N/A		N/A		N/A		N/A	
35	4.4 Total RPv runoff reduction (in.)	0.00		N/A		N/A		N/A		N/A	
36	4.5 Total RPv runoff reduction (%)	0%		N/A		N/A		N/A		N/A	
37	4.6 Adjusted CN after all reductions*	89.97		N/A		N/A		N/A		N/A	
38	4.7 Adjusted equivalent annual runoff (in.)	27.63		N/A		N/A		N/A		N/A	
39	4.8 RPv Compliance Met Through Runoff Reduction?	YES		N/A		N/A		N/A		N/A	
40	4.9 Runoff Reduction Credit, if Applicable (cu.ft)	-1415.48		N/A		N/A		N/A		N/A	
41											
42	***Step 5 - Determine Residual Volume to be Managed or Offset***										
43	5.1 RPv Residual Volume (in.)	N/A		N/A		N/A		N/A		N/A	
44	5.2 RPv Residual Volume (cu.ft./ac)	N/A		N/A		N/A		N/A		N/A	
45	5.3 Residual Volume to be Managed or Offset (cu.ft.)	N/A		N/A		N/A		N/A		N/A	
46	5.4 RPv avg. discharge rate for 48-hr detention (cfs)	N/A		N/A		N/A		N/A		N/A	
47	5.5 RPv max. discharge rate for 48-hr detention (cfs)	N/A		N/A		N/A		N/A		N/A	

<u>Example 2c – ReDevelopment of 100% Impervious Site (DURMM Only)</u>

In this case, selecting the “No BMP” option also verifies that the physical reduction of impervious area meets the redevelopment requirements for RPv compliance under the DSSR.

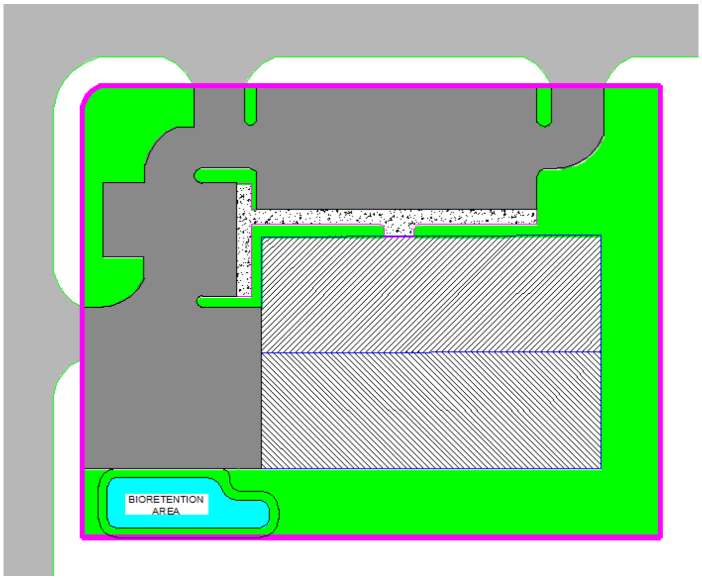
Small Commercial – Redevelopment
(15% Reduction in Eff. Imp.)



Example 2c – ReDevelopment of 100% Impervious Site (DURMM Only)
No additional RPv management is therefore required in this case.*

*Some redevelopment projects location within the jurisdictional area of New Castle County have a requirement of 50% reduction of effective impervious for RPv compliance. Under a situation similar to this example, additional management of RPv as calculated in the modified New Castle County version of DURMM would be required.

Small Commercial Example
Summary



Summary:

- New Development: 3,505 CF storage
- Redevelopment (IMP_{dev}=IMP_{ex}): 658 CF storage
- Redevelopment (IMP_{dev}=0.85IMP_{ex}): 0 CF storage

<u>Summary (DURMM Only)</u>

Summarizing the RPv compliance requirements for the 3 scenarios of development of a small commercial site in Kent County:

- New Development of "Green Space": 3,505 CF runoff management
- Redevelopment (15% Reduction of Effective IMP): 657 CF management
- Redevelopment (Existing IMP reduced by 15%): 0 CF management

NOTE: The "DURMM Only" method is a simplified, though conservative solution. Routing bioretention facilities would typically result in more optimal sizing, with the trade-off being a requirement for additional calculations. Examples of routing solutions are included later in this module.

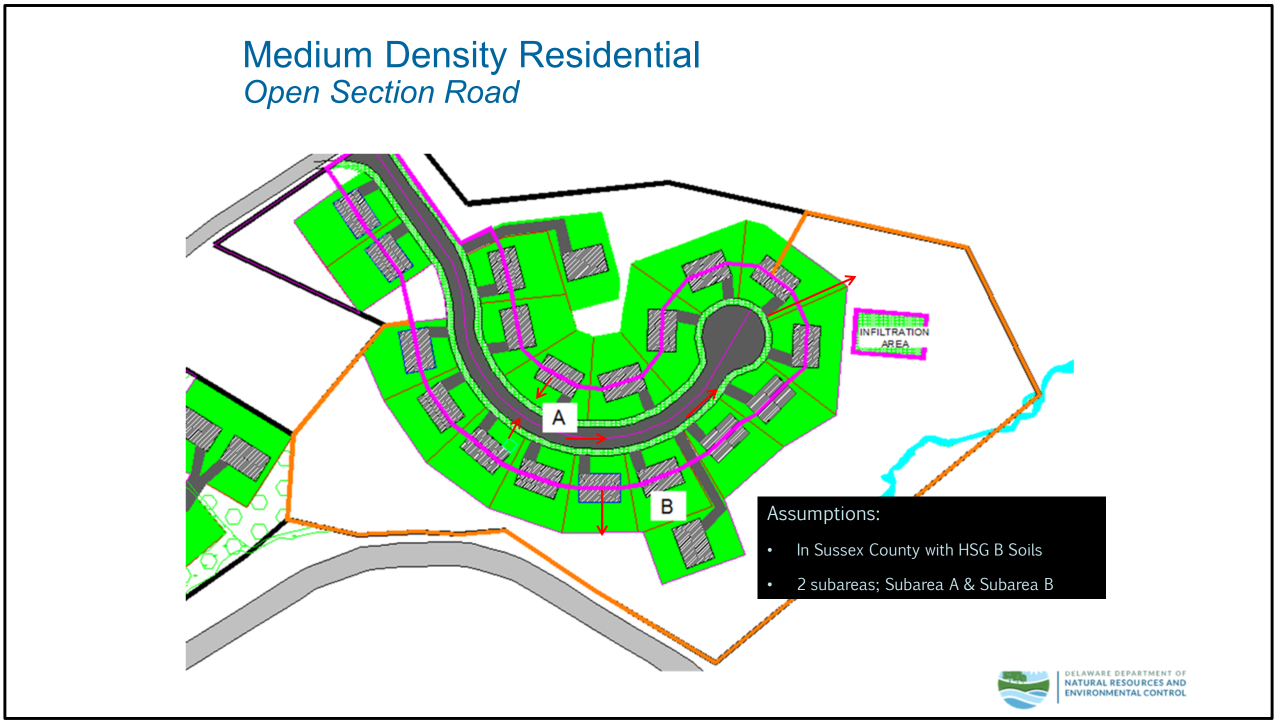
Example 2d

RPv Compliance using
DURMM + HydroCAD

DELAWARE DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL

Example 2d – DURMM + HydroCAD

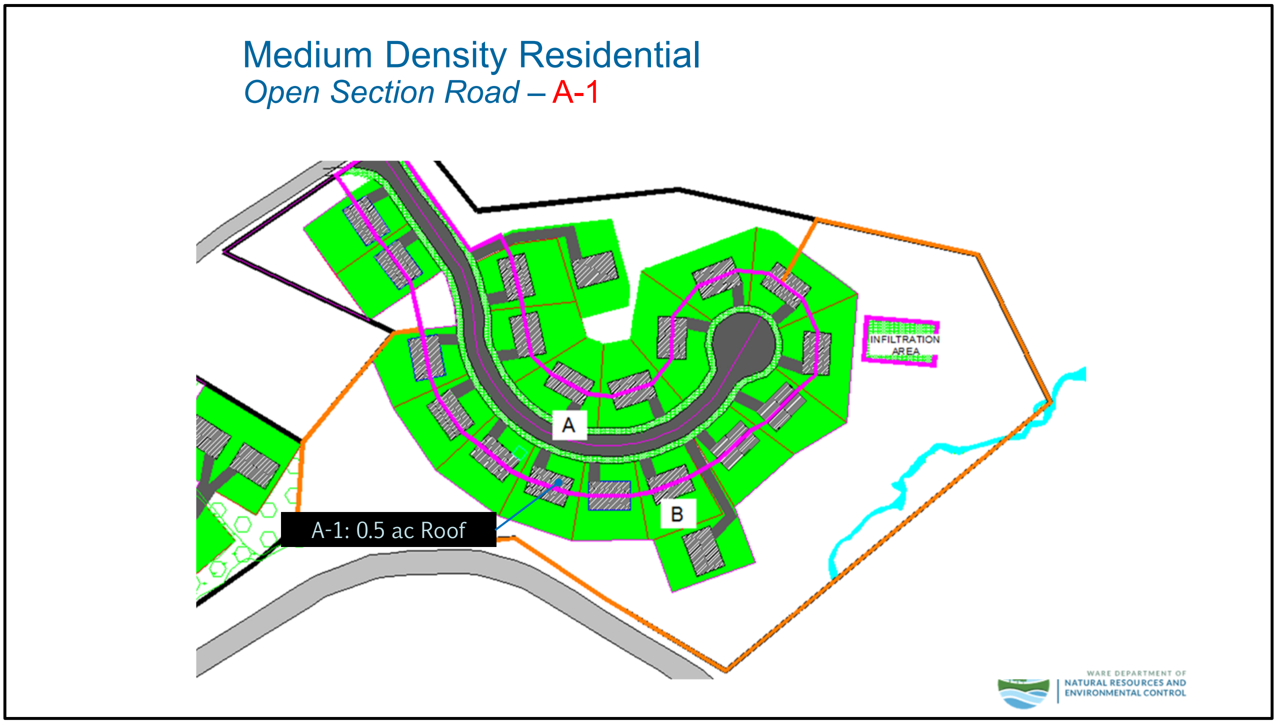
The next example covers the use of DURMM to determine the RPv runoff management requirements and the use of an external hydrologic software package to verify compliance. In this case, HydroCAD will be used as the external hydrologic software package. The Sediment & Stormwater Program web site maintains a list of approved proprietary and non-proprietary hydrologic software that can be used to meet the requirements of the DSSR. As before, different scenarios will be used to illustrate varying pre-developed and/or post-developed conditions.



<u>Example 2d – DURMM + HydroCAD</u>

For this example, a medium density single family residential development with open section road is proposed in Sussex County. Stormwater runoff will be directed to a proposed infiltration basin. The following site assumptions apply:

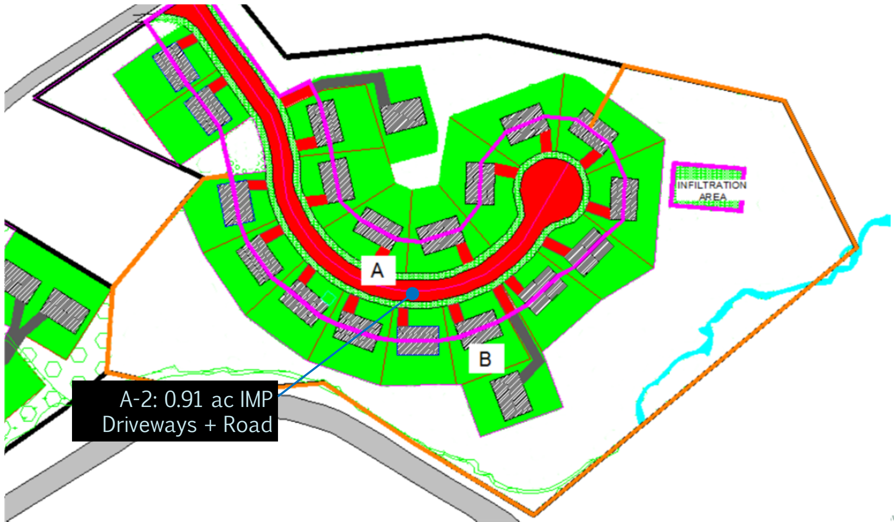
- Soil type is Hydrologic Soil Group (HSG) B
- 2 subareas within the LOD
    - Subarea A: Fronts of lots/roofs, driveways and open section road
    - Subarea B: Backs of lots/roofs



Example 2d – DURMM + HydroCAD
Additional site conditions:

- A-1 consists of 0.5 acres of roof area

Medium Density Residential
Open Section Road – A-2



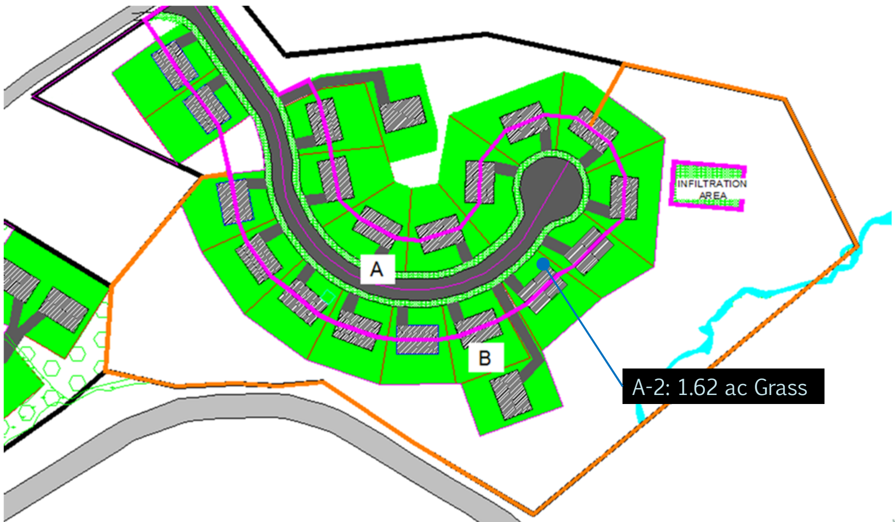
<u>Example 2d – DURMM + HydroCAD</u>

Additional site conditions:

- A-2 consists of 0.91 acres of impervious area comprised of the driveways and road

Medium Density Residential

Open Section Road – A-2

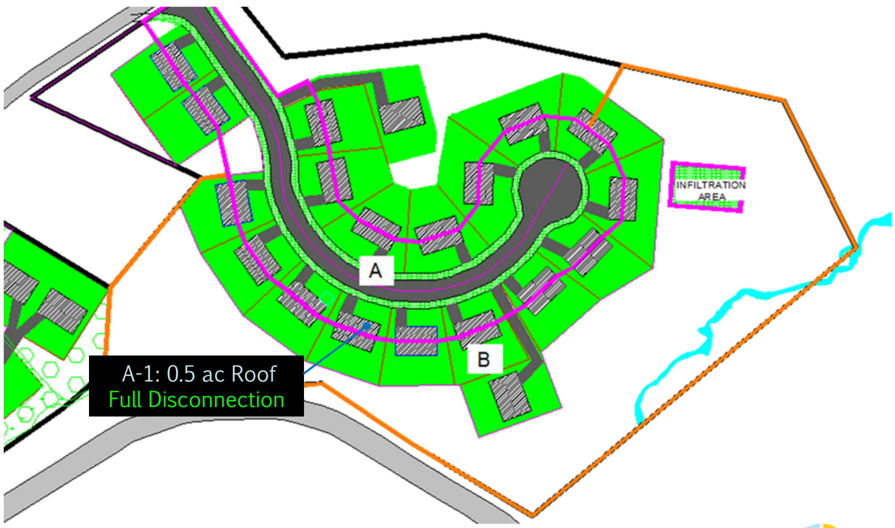


Example 2d – DURMM + HydroCAD

Additional site conditions:

- The remaining area in A-2 consists of 1.62 acres of grassed open space

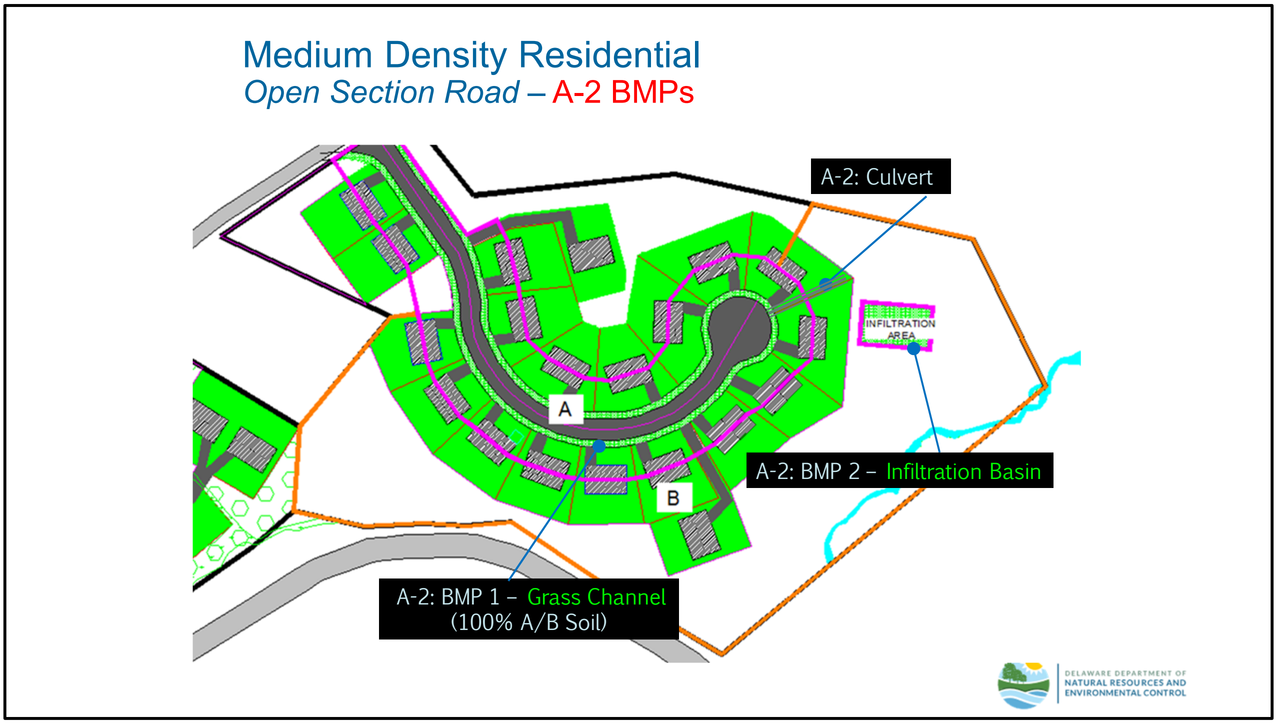
Medium Density Residential
Open Section Road – A-1 BMP



DELAWARE DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL

Example 2d – DURMM + HydroCAD
The proposed BMP for A-1 consists of:

- Full rooftop disconnection



<u>Example 2d – DURMM + HydroCAD</u>

Runoff from the road channel is collected at the end of the cul-de-sac. It was determined that there is not enough length of flow between the property lines to construct a Bioswale, so the runoff will be conveyed to an infiltration basin through a culvert. The proposed BMP treatment train for A-2 consists of:

- BMP 1 – Grassed channel; 100% HSG A/B soil
- BMP 2 – Infiltration basin

Medium Density Residential
Open Section Road – A-1

	PROJECT:	MDR								
	DRAINAGE SUBAREA ID:	A-1								
	LOCATION (County):	Sussex								
	UNIT HYDROGRAPH:	DMV								
CONTRIBUTING AREA RUNOFF CURVE NUMBER (C.A. RCN) WORKSHEET			Curve Numbers for Hydrologic Soil Type							
Cover Type	Treatment	Hydrologic Condition	A		B		C		D	
			Acres	RCN	Acres	RCN	Acres	RCN	Acres	RCN
FULLY DEVELOPED URBAN AREAS (Veg Established)										
Open space (Lawns,parks etc.)										
	Poor condition; grass cover < 50%			68		79		86		89
	Fair condition; grass cover 50% to 75 %			49		69		79		84
	Good condition; grass cover > 75%			39		61		74		80
Impervious Areas										
	Paved parking lots, roofs, driveways			98	0.5	98		98		98
	Streets and roads									
	Paved; curbs and storm sewers			98		98		98		98
	Paved; open ditches (w/right-of-way)			83		89		92		93
	Gravel (w/ right-of-way)			76		85		89		91
	Dirt (w/ right-of-way)			72		82		87		89
Urban Districts		Avg % impervious								
	Commercial & business	85		89		92		94		95
	Industrial	72		81		88		91		93
Residential districts by average lot size		Avg % impervious								
	1/8 acre (town houses)	65		77		85		90		92
	1/4 acre	38		61		75		83		87
	1/3 acre	30		57		72		81		86
	1/2 acre	25		54		70		80		85
	1 acre	20		51		68		79		84
	2 acre	12		46		65		77		82
DEVELOPING URBAN AREA (No Vegetation)										
	Newly graded area (pervious only)			77		86		91		94
USER DEFINED										
	Subarea Contributing Area per Soil Type (ac)		0		0.5		0		0	
	Subarea Contributing Area (ac)	0.5								
	Subarea Weighted RCN	98								
UPSTREAM CONTRIBUTING AREAS		Subarea ID	Acres	RCN						
	Upstream Contributing Area 1									
	Upstream Contributing Area 2									
	Upstream Contributing Area 3									
	Upstream Contributing Area 4									
	Total Contributing Area w. Upstream Areas (ac)						0.5			
	Weighted Runoff Curve Number (RCN)						98			

DELAWARE DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL

<u>Example 2d – DURMM + HydroCAD</u>

DURMM will be used to determine the required RPv volume to be managed in order to comply with the DSSR, as well as how much runoff reduction the various BMPs are able achieve. The first subarea to be analyzed is Subarea A-1, which represents the impervious area from the front rooftops. The input data for A-1 is entered in the DURMM "C.A. RCN" sheet as shown above.

Medium Density Residential
Open Section Road – A-1

1	PROJECT:	Example 2, MDR			
2	DRAINAGE SUBAREA ID:	A-1			
3	LOCATION (County):	Sussex			
4	UNIT HYDROGRAPH:	DMV			
5	LIMIT OF DISTURBANCE (LOD) WORKSHEET				
6	**Step 1 - Subarea LOD Data**	HSG A	HSG B	HSG C	HSG D
7	1.1 HSG Area Within LOD (ac)		0.5		
8	1.2 Pre-Developed Woods/Meadow Within LOD (ac)				
9	1.3 Pre-Developed Impervious Within LOD (ac)				
10	1.4.a Post-Developed Imperviousness Within LOD, Option #1 (ac); ***OR***				
11	1.4.b Post-Developed Imperviousness Within LOD, Option #2 (%)	0%	100%	0%	0%
12					
13	**Step 2 - Subarea LOD Runoff Calculations**				
14	2.1 RCN per HSG	0.00	98.00	0.00	0.00
15	2.2 RPv per HSG (in.)	0.00	2.50	0.00	0.00
16	2.3 Target RCN per HSG	0.00	61.00	0.00	0.00
17	2.4 Target Runoff per HSG (in.)	0.00	0.65	0.00	0.00
18					
19	2.5 Subarea LOD (ac)	0.50			
20	2.6 Subarea Weighted RCN	98.00			
21	2.7 Subarea Weighted RPv (in.)	2.50			
22	2.8 Subarea Weighted Target Runoff (in.)	0.65			

DELAWARE DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL

<u>Example 2d – DURMM + HydroCAD</u>

The input data for A-1 is entered in the DURMM “LOD” sheet as shown above. In this case, Option #2 is used to enter the rooftops as 100% impervious for the post-developed condition. Alternatively, the user can use Option #1 to enter 0.5 acres. DURMM will then calculate the post-developed imperviousness as 100%.

Medium Density Residential
Open Section Road – A-1

		BMP 1		BMP 2		BMP 3		BMP 4		BMP 5	
1	PROJECT:	Example 2, MDR									
2	DRAINAGE SUBAREA ID:	A-1									
3	LOCATION (County):	Sussex									
4	RESOURCE PROTECTION EVENT (RPv) WORKSHEET										
5	RESET										
6		Type	7-B Full Rooftop Disconnection - HSG B	Type	--	Type	--	Type	--	Type	--
7	***Step 1 - Calculate Initial RPv***	Data									
8	1.1 Total contributing area to BMP (ac)	0.50									
9	1.2 Initial RCN	98.00									
10	1.3 RPv for Contributing Area (in.)	2.50									
11	1.4 Req'd RPv to be Managed for Contributing Area (in.)	1.00									
12	1.5 Req'd RPv to be Managed for Contributing Area (%)	40%									
13											
14	***Step 2 - Adjust for Retention Reduction***										
15	2.1 Retention volume provided (cu. ft.)										
16	2.2 Retention reduction allowance (%)	0%		N/A		N/A		N/A		N/A	
17	2.3 Retention reduction volume (ac-ft)	0.00		N/A		N/A		N/A		N/A	
18	2.4 Retention reduction volume (in.)	0.00		N/A		N/A		N/A		N/A	
19	2.5 Runoff volume after retention reduction (in.)	2.50		N/A		N/A		N/A		N/A	
20	2.6 Adjusted CN*	98.00		N/A		N/A		N/A		N/A	
21											
22	***Step 3 - Adjust for Annual Runoff Reduction***										
23	3.1 Annual CN (ACN)	98.00		N/A		N/A		N/A		N/A	
24	3.2 Annual runoff (in.)	37.27		N/A		N/A		N/A		N/A	
25	3.3 Proportion A/B soils in BMP footprint (%)	100%		0%		0%		0%		0%	
26	3.4 Annual runoff reduction allowance (%)	81%		N/A		N/A		N/A		N/A	
27	3.5 Annual runoff after reduction (in.)	7.09		N/A		N/A		N/A		N/A	
28	3.6 Adjusted ACN	61.00		N/A		N/A		N/A		N/A	
29	3.7 Annual Runoff Reduction Allowance for RPv (in.)	1.85		N/A		N/A		N/A		N/A	
30											
31	***Step 4 - Calculate RPv with BMP Reductions***										
32	4.1 RPv Runoff Manangement Provided (cu. ft.)	3358		N/A		N/A		N/A		N/A	
33	4.2 RPv runoff volume after all reductions (in.)	0.65		N/A		N/A		N/A		N/A	
34	4.3 RPv runoff volume after all reductions (cu.ft.)	1,180		N/A		N/A		N/A		N/A	
35	4.4 Total RPv runoff reduction (in.)	1.85		N/A		N/A		N/A		N/A	
36	4.5 Total RPv runoff reduction (%)	74%		N/A		N/A		N/A		N/A	
37	4.6 Adjusted CN after all reductions*	61.00		N/A		N/A		N/A		N/A	
38	4.7 Adjusted equivalent annual runoff (in.)	7.09		N/A		N/A		N/A		N/A	
39	4.8 RPv Compliance Met Through Runoff Reduction?	YES		N/A		N/A		N/A		N/A	
40	4.9 Runoff Reduction Credit, if Applicable (cu.ft)	0.00		N/A		N/A		N/A		N/A	
41											
42	***Step 5 - Determine Residual Volume to be Managed or Offset***										
43	5.1 RPv Residual Volume (in.)	N/A		N/A		N/A		N/A		N/A	
44	5.2 RPv Residual Volume (cu.ft./ac)	N/A		N/A		N/A		N/A		N/A	
45	5.3 Residual Volume to be Managed or Offset (cu.ft.)	N/A		N/A		N/A		N/A		N/A	
46	5.4 RPv avg. discharge rate for 48-hr detention (cfs)	N/A		N/A		N/A		N/A		N/A	
47	5.5 RPv max. discharge rate for 48-hr detention (cfs)	N/A		N/A		N/A		N/A		N/A	

DELAWARE DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL

<u>Example 2d – DURMM + HydroCAD</u>

Input data for the DURMM “RPv” sheet is as follows:

- BMP 1 drop down menu: “7-B Full Rooftop Connection – HSG B”
- Step 3.3 Proportion A/B soils in BMP footprint: 100%

DURMM calculates the runoff reduction based on the inputs.

Medium Density Residential

Open Section Road – A-1

1	**PROJECT:**	Example 2, MDR
2	**DRAINAGE SUBAREA ID:**	A-1
3	**COUNTY:**	Sussex
4	**TMDL Watershed:**	0
5	**DURMM OUTPUT WORKSHEET**	
42	C.A. RPv avg. discharge rate (cfs)	0.00
43	C.A. RPv max. discharge rate (cfs)	0.00
44	TN Pollutant Load (lb/yr)	2.25
45	TP Pollutant Load (lb/yr)	0.39
46	TSS Pollutant Load (lb/yr)	72
47		
48	***Conveyance Event (Cv)***	
49	Cv runoff volume (in.)	5.06
50	Adjusted RCN for H&H Modeling (CN*)	94.75
51		
52	***Flooding Event (Fv)***	
53	Fv runoff volume (in.)	8.96
54	Equivalent RCN for H&H Modeling (CN*)	97.48
55		
56	***Adjusted Subarea Data for Downstream DURMM Modeling***	
57	Subarea ID	A-1
58	Contributing Area (ac.)	0.50
59	Weighted Target Runoff (in.)	0.65
60	Adjusted CN after all reductions	61.00
61	Adjusted RPv (in.)	0.65
62	Adjusted Cv (in.)	4.69
63	Adjusted Fv (in.)	8.90
64		

DELAWARE DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL

Example 2d – DURMM + HydroCAD

The "DURMM Report" sheet contains a summary of the results for all the selected BMPs for the RPv, Cv and Fv. The information from the "Adjusted Subarea Data for DURMM Downstream Modeling" section contains information that will be used for subsequent calculations for analyzing subarea A-2.

Medium Density Residential
Open Section Road – A-1 + A-2

1		PROJECT:	MDR								
2		DRAINAGE SUBAREA ID:	A1 + A2								
3		LOCATION (County):	Sussex								
4		UNIT HYDROGRAPH:	DMV								
5		CONTRIBUTING AREA RUNOFF CURVE NUMBER (C.A. RCN) WORKSHEET		Curve Numbers for Hydrologic Soil Type							
6	Cover Type	Treatment	Hydrologic Condition	A		B		C		D	
7				*Acres*	*RCN*	*Acres*	*RCN*	*Acres*	*RCN*	*Acres*	*RCN*
58											
59	FULLY DEVELOPED URBAN AREAS (Veg Established)										
60	Open space (Lawns,parks etc.)										
61		Poor condition; grass cover < 50%			68		79		86		89
62		Fair condition; grass cover 50% to 75 %			49		69		79		84
63		Good condition; grass cover > 75%			39	1.62	61		74		80
64	Impervious Areas										
65		Paved parking lots, roofs, driveways			98	0.91	98		98		98
66		Streets and roads									
67		Paved; curbs and storm sewers			98		98		98		98
68		Paved; open ditches (w/right-of-way)			83		89		92		93
69		Gravel (w/ right-of-way)			76		85		89		91
70		Dirt (w/ right-of-way)			72		82		87		89
71	Urban Districts		Avg % impervious								
72		Commercial & business	85		89		92		94		95
73		Industrial	72		81		88		91		93
74	Residential districts by average lot size		Avg % impervious								
75		1/8 acre (town houses)	65		77		85		90		92
76		1/4 acre	38		61		75		83		87
77		1/3 acre	30		57		72		81		86
78		1/2 acre	25		54		70		80		85
79		1 acre	20		51		68		79		84
80		2 acre	12		46		65		77		82
81											
83	DEVELOPING URBAN AREA (No Vegetation)										
84		Newly graded area (pervious only)			77		86		91		94
85											
86	USER DEFINED										
87											
88											
89											
90		**Subarea Contributing Area per Soil Type (ac)**		0		2.53		0		0	
91		**Subarea Contributing Area (ac)**	2.53								
92		**Subarea Weighted RCN**	74								
93											
94	UPSTREAM CONTRIBUTING AREAS		*Subarea ID*	*Acres*	*RCN*						
95		Upstream Contributing Area 1	A-1	0.5	61						
96		Upstream Contributing Area 2									
97		Upstream Contributing Area 3									
98		Upstream Contributing Area 4									
99											
100		**Total Contributing Area w. Upstream Areas (ac)**						3.03			

DELAWARE DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL

<u>Example 2d – DURMM + HydroCAD</u>

The input data for A-2 is entered in the DURMM “C.A. RCN” sheet as shown above. However, since A-2 also receives the residual runoff from the roofs after the disconnection is accounted for, the area and adjusted CN for A-1 from the “DURMM Report” for subarea A-1 must be included as an upstream contributing area as shown. Thus the analysis is effectively for a combined A-1 + A-2 subarea.

Medium Density Residential
Open Section Road – A-1 + A-2

1	**PROJECT:**	Example 2, MDR			
2	**DRAINAGE SUBAREA ID:**	A-1 + A-2			
3	**LOCATION (County):**	Sussex			
4	**UNIT HYDROGRAPH:**	DMV			
5	**LIMIT OF DISTURBANCE (LOD) WORKSHEET**				
6	**Step 1 - Subarea LOD Data**	**HSG A**	**HSG B**	**HSG C**	**HSG D**
7	1.1 HSG Area Within LOD (ac)		2.53		
8	1.2 Pre-Developed Woods/Meadow Within LOD (ac)				
9	1.3 Pre-Developed Impervious Within LOD (ac)				
10	1.4.a Post-Developed Imperviousness Within LOD, Option #1 (ac); ***OR***		0.91		
11	1.4.b Post-Developed Imperviousness Within LOD, Option #2 (%)	0%	36%	0%	0%
12					
13	**Step 2 - Subarea LOD Runoff Calculations**				
14	2.1 RCN per HSG	0.00	74.31	0.00	0.00
15	2.2 RPv per HSG (in.)	0.00	1.07	0.00	0.00
16	2.3 Target RCN per HSG	0.00	61.00	0.00	0.00
17	2.4 Target Runoff per HSG (in.)	0.00	0.65	0.00	0.00

DELAWARE DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL

Example 2d – DURMM + HydroCAD

The input data for A-2 is entered in Step 1 of the DURMM “LOD” sheet as shown above.

Medium Density Residential
Open Section Road – A-1 + A-2

1	PROJECT:	Example 2, MDR			
2	DRAINAGE SUBAREA ID:	A-1 + A-2			
3	LOCATION (County):	Sussex			
4	UNIT HYDROGRAPH:	DMV			
5	LIMIT OF DISTURBANCE (LOD) WORKSHEET				
6	**Step 1 - Subarea LOD Data**	HSG A	HSG B	HSG C	HSG D
7	1.1 HSG Area Within LOD (ac)		2.53		
8	1.2 Pre-Developed Woods/Meadow Within LOD (ac)				
9	1.3 Pre-Developed Impervious Within LOD (ac)				
10	1.4.a Post-Developed Imperviousness Within LOD, Option #1 (ac); ***OR***		0.91		
11	1.4.b Post-Developed Imperviousness Within LOD, Option #2 (%)	0%	36%	0%	0%
12					
13	**Step 2 - Subarea LOD Runoff Calculations**				
14	2.1 RCN per HSG	0.00	74.31	0.00	0.00
15	2.2 RPv per HSG (in.)	0.00	1.07	0.00	0.00
16	2.3 Target RCN per HSG	0.00	61.00	0.00	0.00
17	2.4 Target Runoff per HSG (in.)	0.00	0.65	0.00	0.00
18					
19	2.5 Subarea LOD (ac)	2.53			
20	2.6 Subarea Weighted RCN	74.31			
21	2.7 Subarea Weighted RPv (in.)	1.07			
22	2.8 Subarea Weighted Target Runoff (in.)	0.65			

DELAWARE DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL

<u>Example 2d – DURMM + HydroCAD</u>

DURMM has calculated the total runoff for subarea A-1 + A-2 as 1.07 watershed inches at Step 2.7 on the “LOD” sheet. The target runoff for compliance is calculated as 0.65 watershed inches at Step 2.8 on the “LOD” sheet. That is, the treatment train of stormwater management BMPs must bring the total site runoff down from 1.07 watershed inches to 0.65 watershed inches or less in order for subarea A-1 + A-2 to comply with the DSSR.

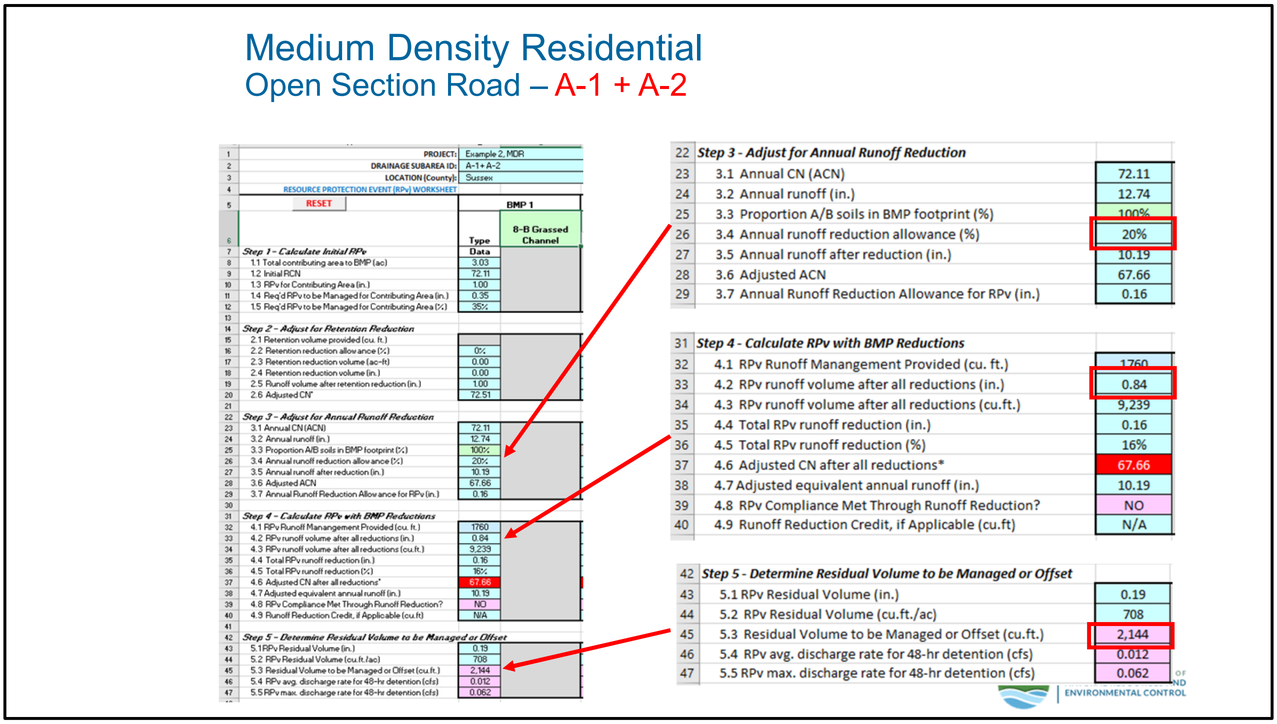
Medium Density Residential
Open Section Road – A-1 + A-2

1	PROJECT:	Example 2, MDR			
2	DRAINAGE SUBAREA ID:	A-1 + A-2			
3	LOCATION (County):	Sussex			
4	UNIT HYDROGRAPH:	DMV			
5	LIMIT OF DISTURBANCE (LOD) WORKSHEET				
6	**Step 1 - Subarea LOD Data**	HSG A	HSG B	HSG C	HSG D
7	1.1 HSG Area Within LOD (ac)		2.53		
8	1.2 Pre-Developed Woods/Meadow Within LOD (ac)				
9	1.3 Pre-Developed Impervious Within LOD (ac)				
10	1.4.a Post-Developed Imperviousness Within LOD, Option #1 (ac); OR		0.91		
11	1.4.b Post-Developed Imperviousness Within LOD, Option #2 (%)	0%	36%	0%	0%
12					
13	**Step 2 - Subarea LOD Runoff Calculations**				
14	2.1 RCN per HSG	0.00	74.31	0.00	0.00
15	2.2 RPv per HSG (in.)	0.00	1.07	0.00	0.00
16	2.3 Target RCN per HSG	0.00	61.00	0.00	0.00
17	2.4 Target Runoff per HSG (in.)	0.00	0.65	0.00	0.00
18					
19	2.5 Subarea LOD (ac)	2.53			
20	2.6 Subarea Weighted RCN	74.31			
21	2.7 Subarea Weighted RPv (in.)	1.07			
22	2.8 Subarea Weighted Target Runoff (in.)	0.65			
23					
24	**Step 3 - Upstream LOD Areas** *(from previous DURMM Report as applicable)*	Area 1	Area 2	Area 3	Area 4
25	3.1 Upstream Sub-Area ID	A1			
26	3.2 Upstream Contributing Area (ac)	0.50			
27	3.3 Target Runoff for Upstream Area (in.)	0.65			
28	3.4 Adjusted CN after all reductions	61.00			
29	3.5 Adjusted RPv (in.)	0.65			
30	3.6 Adjusted Cv (in.)	4.69			
31	3.7 Adjusted Fv (in.)	8.90			

DELAWARE DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL

Example 2d – DURMM + HydroCAD

The results from the “DURMM Report” for A-1 are entered in Step 3 of the DURMM “LOD” sheet as shown above.



22	***Step 3 - Adjust for Annual Runoff Reduction***	
23	3.1 Annual CN (ACN)	72.11
24	3.2 Annual runoff (in.)	12.74
25	3.3 Proportion A/B soils in BMP footprint (%)	100%
26	3.4 Annual runoff reduction allowance (%)	20%
27	3.5 Annual runoff after reduction (in.)	10.19
28	3.6 Adjusted ACN	67.66
29	3.7 Annual Runoff Reduction Allowance for RPv (in.)	0.16

31	***Step 4 - Calculate RPv with BMP Reductions***	
32	4.1 RPv Runoff Manangement Provided (cu. ft.)	1760
33	4.2 RPv runoff volume after all reductions (in.)	0.84
34	4.3 RPv runoff volume after all reductions (cu.ft.)	9,239
35	4.4 Total RPv runoff reduction (in.)	0.16
36	4.5 Total RPv runoff reduction (%)	16%
37	4.6 Adjusted CN after all reductions*	67.66
38	4.7 Adjusted equivalent annual runoff (in.)	10.19
39	4.8 RPv Compliance Met Through Runoff Reduction?	NO
40	4.9 Runoff Reduction Credit, if Applicable (cu.ft)	N/A

42	***Step 5 - Determine Residual Volume to be Managed or Offset***	
43	5.1 RPv Residual Volume (in.)	0.19
44	5.2 RPv Residual Volume (cu.ft./ac)	708
45	5.3 Residual Volume to be Managed or Offset (cu.ft.)	2,144
46	5.4 RPv avg. discharge rate for 48-hr detention (cfs)	0.012
47	5.5 RPv max. discharge rate for 48-hr detention (cfs)	0.062

<u>Example 2d – DURMM + HydroCAD</u>

Since the rooftop disconnection is already accounted for from area A-1, the next BMP in the treatment train is the grass channel provided by the open section road. Input data for the DURMM "RPv" sheet is as follows:

- BMP 1 drop down menu: "8-B Grassed Channel"
- Step 3.3 Proportion A/B soils in BMP footprint: 100%

DURMM automatically inputs the allowable runoff reduction allowance of 20% for grassed channel on HSG B soils and calculates the runoff reduction. The analysis indicates that the residual runoff from the combined suabareas A-1 + A-2 after accounting for full rooftop disconnection and runoff reduction in the open road section grassed channels is 0.84 watershed inches.

DURMM has calculated at Step 5.3 that an additional 2,144 cubic feet of residual runoff must be managed in order to comply with the RPv requirements of the DSSR. At this point the designer could simply provide an infiltration basin with 2,144 cubic feet of storage. However, the design could be optimized by using a routing method. Since DURMM is not capable of performing a routing, an external software package, such as HydroCAD, can be used. The next series of slides will illustrate how surface recharge practices can be modeled using HydroCAD so that they can then be used as inputs in the routing of a BMP.

Medium Density Residential
Open Section Road – A-1 + A-2

- Problem:
  - Optimized design of infiltration basin
- Determine:
  - Runoff reduction for open section road channels using Std & Specification 8.0 Vegetated Channels and HydroCAD

DELAWARE DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL

<u>Example 2d – DURMM + HydroCAD</u>

In order to optimize the design of the infiltration basin, the credit for the grassed channels in the open section road using HydroCAD is illustrated in the next series of slides.

Medium Density Residential
Open Section Road – A-2

BMP Standards and Specifications — Vegetated Channels

8.0 **Vegetated Channels**

Definition: **Vegetated channels are open conveyances planted with grass or other suitable vegetation and having a shallow depth of flow to allow runoff to be filtered and recharged along the length of the channel.**

Design variants include:

- 8-A **Bioswale**
- 8-B **Grassed Channel**

Vegetated channels systems are not typically designed to provide stormwater detention. Vegetated channels can provide a modest amount of runoff filtering and volume attenuation within the stormwater conveyance system resulting in the delivery of less runoff and pollutants than a traditional system of curb and gutter, storm drain inlets, and pipes. The performance of vegetated channels will vary depending on the underlying soil permeability. Their runoff reduction performance can be boosted when compost amendments are added to the bottom of the channel. Where development density, topography, soils, and water table permit, vegetated channels are a preferable alternative to both curb and gutter and storm drains as a stormwater conveyance system.

8-1 Effective February 2019

DELAWARE DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL

Example 2d – DURMM + HydroCAD

Information for the grassed channels of the open section road is contained in Section 8.0 Vegetated Channels specification from the Post Construction Stormwater BMP Standards & Specifications.

Medium Density Residential
Open Section Road – A-2

Table 8.1 Vegetated Channel Performance Credits

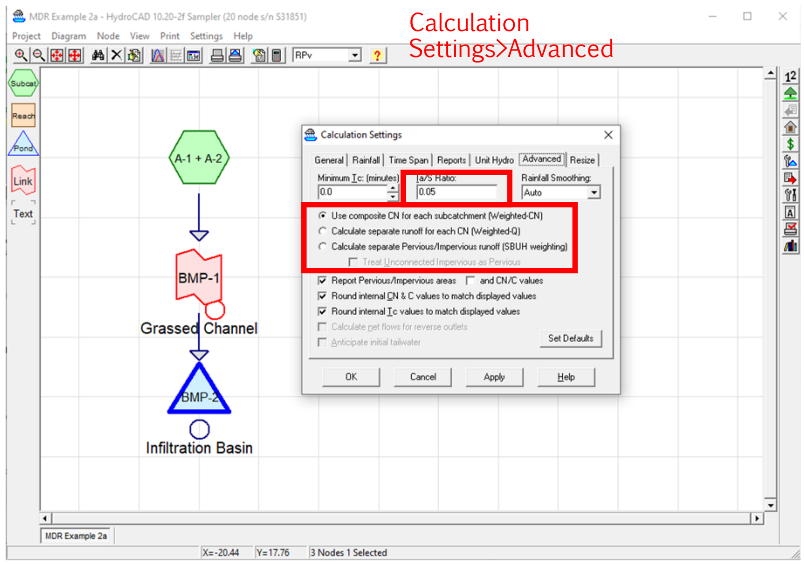
Runoff Reduction*	
Retention Allowance	0%
RPv - A/B Soil or Compost Amended C Soil	**Bioswale : 50% Annual Runoff Reduction Grassed Channel: 20% Annual Runoff Reduction**
RPv - C/D Soil	**Bioswale: 25% Annual Runoff Reduction Grassed Channel: 10% Annual Runoff Reduction**
Cv	**10% of RPv Allowance**
Fv	**1% of RPv Allowance**
Pollutant Reduction	
TN Reduction	**100% of Load Reduction**
TP Reduction	**100% of Load Reduction**
TSS Reduction	**100% of Load Reduction**

DELAWARE DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL

Example 2d – DURMM + HydroCAD

Table 8.1 indicates that a grassed channel on HSG A/B soil gets a 20% runoff reduction credit for the RPv event. This can then be used to set up the HydroCAD model for the grassed channels of the open section road.

Medium Density Residential
Open Section Road –
A-1 + A-2

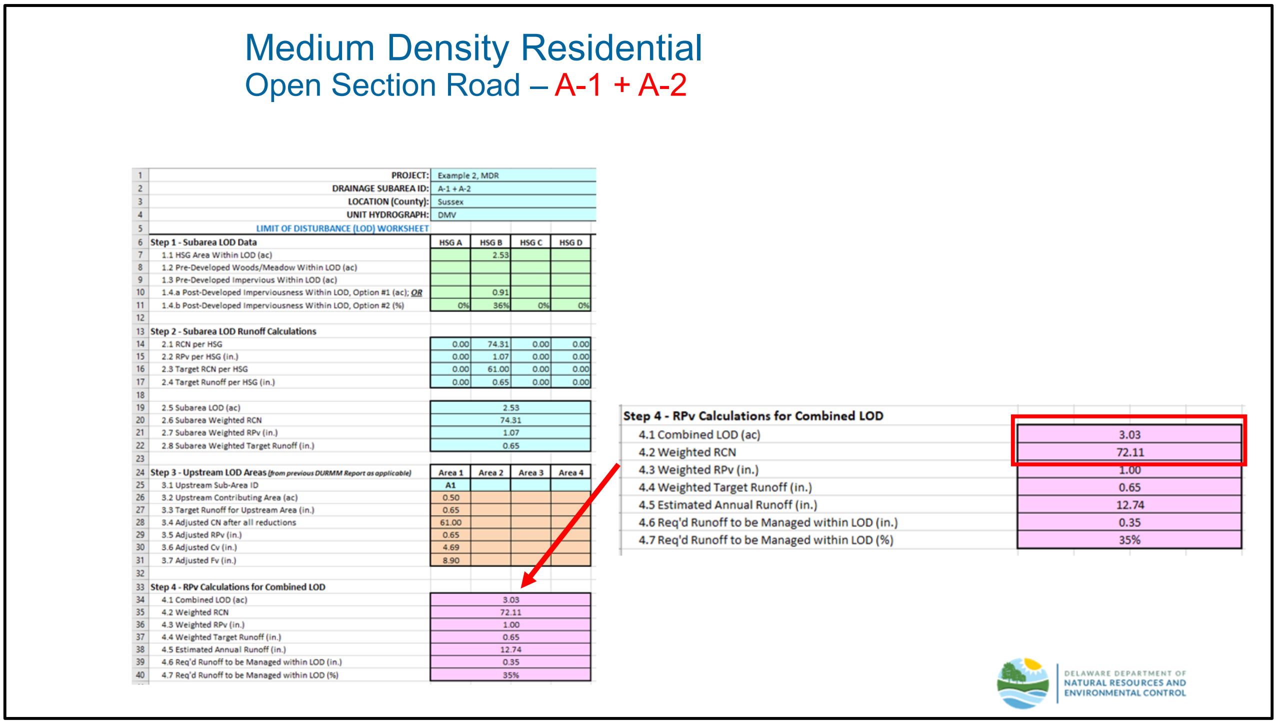


__Example 2d – DURMM + HydroCAD__

In order to use HydroCAD for RPv compliance under the DSSR, the following steps must be taken to ensure the RPv computations are consistent with those that are calculated in DURMM:

1. Go to “Calculation Settings>Advanced” under the “Settings” menu
2. Change the default setting for “Ia/S Ratio” to 0.05
3. Click the radio button for “Use composite CN for each subcatchment (Weighted CN)”

NOTE: The adjustment of the Ia/S ratio in HydroCAD is only necessary for modeling the RPv event. Modeling for the Cv and Fv events should continue to use the NRCS Runoff Equation default value of 0.20.

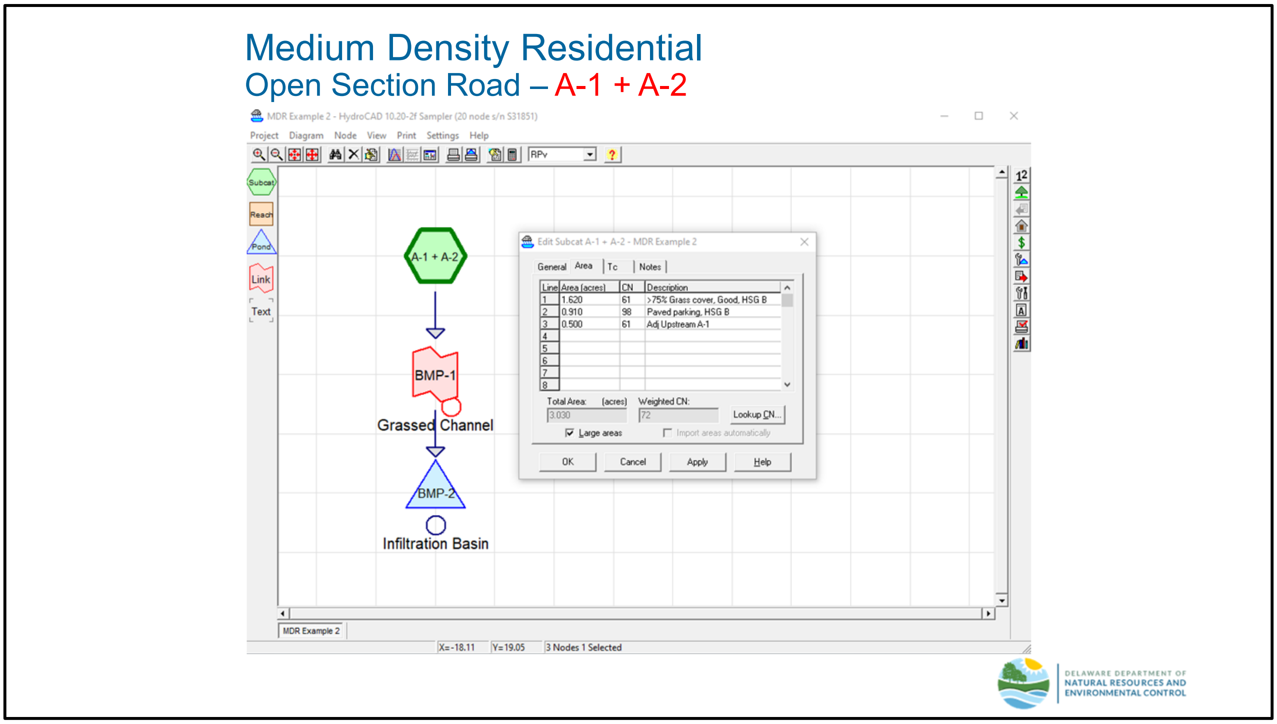


1	PROJECT:	Example 2, MDR			
2	DRAINAGE SUBAREA ID:	A-1 + A-2			
3	LOCATION (County):	Sussex			
4	UNIT HYDROGRAPH:	DMV			
5	LIMIT OF DISTURBANCE (LOD) WORKSHEET				
6	**Step 1 - Subarea LOD Data**	HSG A	HSG B	HSG C	HSG D
7	1.1 HSG Area Within LOD (ac)		2.53		
8	1.2 Pre-Developed Woods/Meadow Within LOD (ac)				
9	1.3 Pre-Developed Impervious Within LOD (ac)				
10	1.4.a Post-Developed Imperviousness Within LOD, Option #1 (ac); ***OR***		0.91		
11	1.4.b Post-Developed Imperviousness Within LOD, Option #2 (%)	0%	36%	0%	0%
12					
13	**Step 2 - Subarea LOD Runoff Calculations**				
14	2.1 RCN per HSG	0.00	74.31	0.00	0.00
15	2.2 RPv per HSG (in.)	0.00	1.07	0.00	0.00
16	2.3 Target RCN per HSG	0.00	61.00	0.00	0.00
17	2.4 Target Runoff per HSG (in.)	0.00	0.65	0.00	0.00
18					
19	2.5 Subarea LOD (ac)	2.53			
20	2.6 Subarea Weighted RCN	74.31			
21	2.7 Subarea Weighted RPv (in.)	1.07			
22	2.8 Subarea Weighted Target Runoff (in.)	0.65			
23					
24	**Step 3 - Upstream LOD Areas** *(from previous DURMM Report as applicable)*	Area 1	Area 2	Area 3	Area 4
25	3.1 Upstream Sub-Area ID	A1			
26	3.2 Upstream Contributing Area (ac)	0.50			
27	3.3 Target Runoff for Upstream Area (in.)	0.65			
28	3.4 Adjusted CN after all reductions	61.00			
29	3.5 Adjusted RPv (in.)	0.65			
30	3.6 Adjusted Cv (in.)	4.69			
31	3.7 Adjusted Fv (in.)	8.90			
32					
33	**Step 4 - RPv Calculations for Combined LOD**				
34	4.1 Combined LOD (ac)	3.03			
35	4.2 Weighted RCN	72.11			
36	4.3 Weighted RPv (in.)	1.00			
37	4.4 Weighted Target Runoff (in.)	0.65			
38	4.5 Estimated Annual Runoff (in.)	12.74			
39	4.6 Req'd Runoff to be Managed within LOD (in.)	0.35			
40	4.7 Req'd Runoff to be Managed within LOD (%)	35%			

Step 4 - RPv Calculations for Combined LOD	
4.1 Combined LOD (ac)	3.03
4.2 Weighted RCN	72.11
4.3 Weighted RPv (in.)	1.00
4.4 Weighted Target Runoff (in.)	0.65
4.5 Estimated Annual Runoff (in.)	12.74
4.6 Req'd Runoff to be Managed within LOD (in.)	0.35
4.7 Req'd Runoff to be Managed within LOD (%)	35%

<u>Example 2d – DURMM + HydroCAD</u>

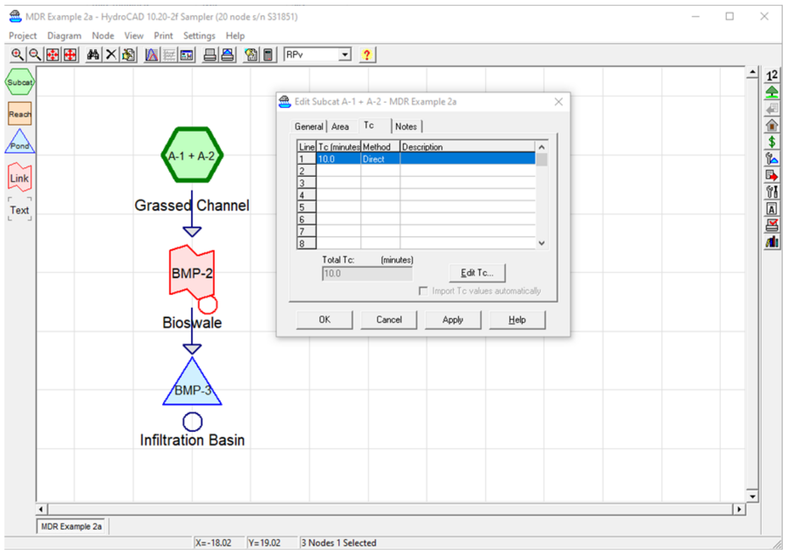
The DURMM "LOD" sheet for the combined A-1 + A-2 subarea will be used for inputs to the HydroCAD model.



<u>Example 2d – DURMM + HydroCAD</u>

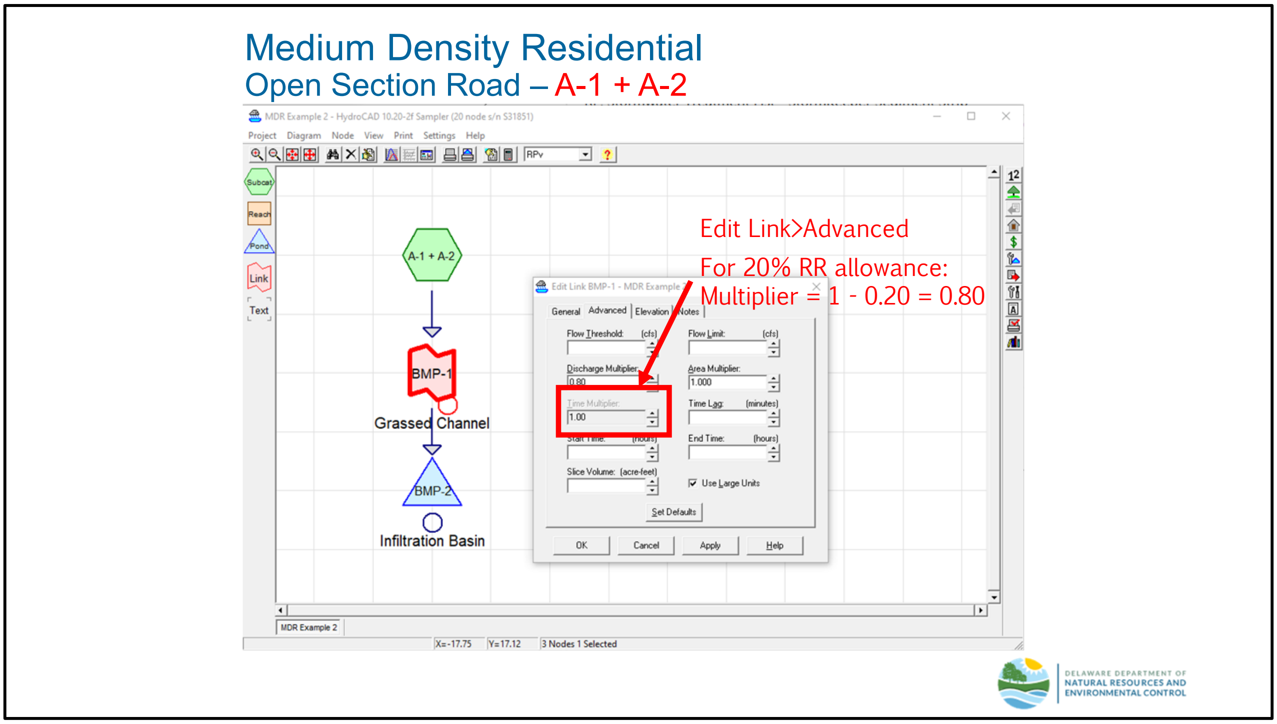
The 3.03 acre drainage area and Curve Number of 72 are entered on the "Area" tab for Subcatchment A-1+A-2.

Medium Density Residential
Open Section Road – A-1 + A-2



Example 2d – DURMM + HydroCAD

The time of concentration was determined to be the minimum of 10 minutes, which is entered on the “Tc” tab for the subcatchment.



<u>Example 2d – DURMM + HydroCAD</u>

Surface recharge practices are modeled in HydroCAD using a flow factor (or discharge multiplier in HydroCAD terms) with a Link Node. It is important to note that the multiplier as used in HydroCAD represents the percentage of flow that continues to be discharged, not the percentage of runoff reduction (RR). It is therefore necessary to calculate the appropriate multiplier as follows:

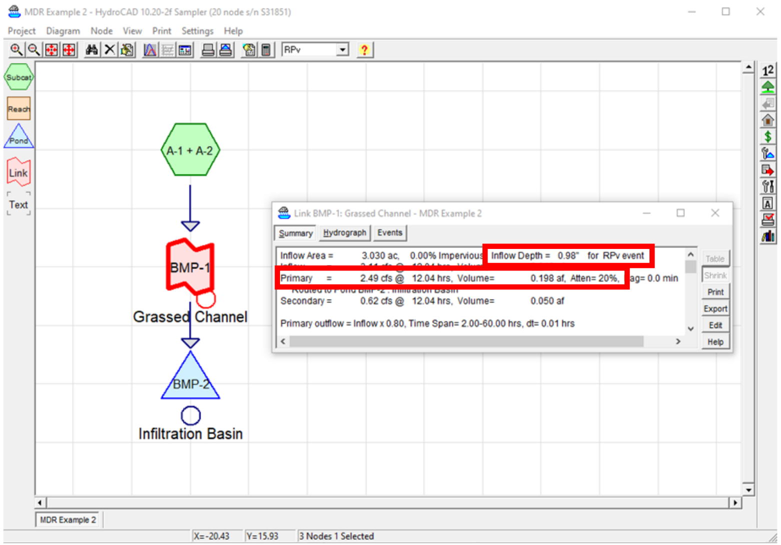
HydroCAD Discharge Multiplier = 1 – RR allowance

In this example, it was determined that the RR allowance for grassed channel on HSG A/B soil is 20% (0.20). Thus:

HydroCAD Discharge Multiplier = 1 – 0.20 = 0.80

To enter the multiplier, right click the “BMP-1” node>Edit>Advanced

Medium Density Residential
Open Section Road – A-1 + A-2



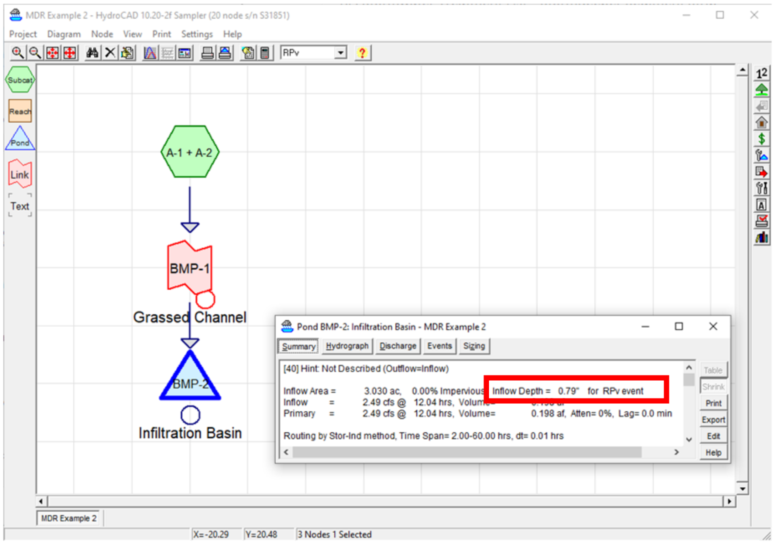
DELAWARE DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL

Example 2d – DURMM + HydroCAD

Running the RPv event in HydroCAD for the Grassed Channel shows that the total runoff entering the Infiltration Basin is 0.98 watershed inches and that the discharge multiplier has correctly reduced (or attenuated in HydroCAD terms) the flow by 20%.

NOTE: The calculated runoff volume of 0.98 watershed inches is slightly less than the 1.0 watershed inches calculated in DURMM due to differing internal rounding and calculation precision settings. However, showing compliance using either DURMM or an approved external program such as HydroCAD is acceptable under the DSSR.

Medium Density Residential
Open Section Road – A-1 + A-2



DELAWARE DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL

Example 2d – DURMM + HydroCAD

Running RPv event at the Infiltration Basin (BMP-2) shows that the inflow is 0.79 watershed inches. This is still more than the target of 0.65 watershed inches.

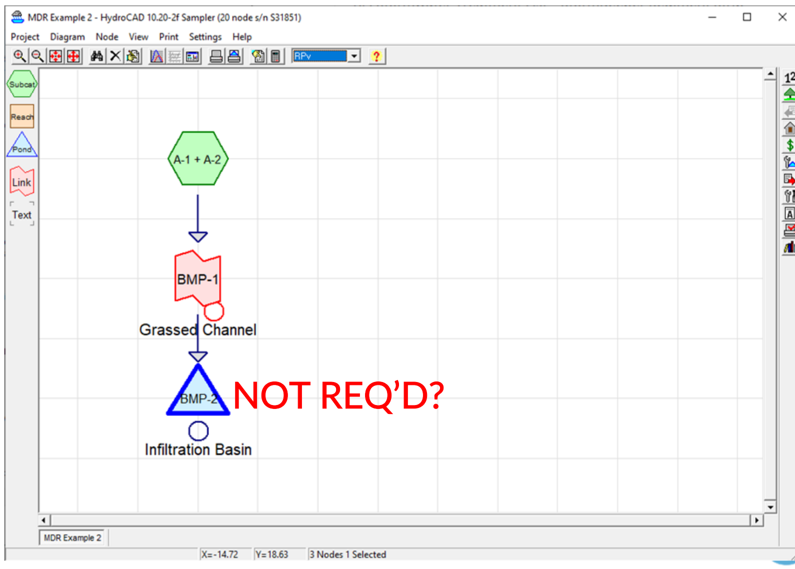
0.79” > 0.65”

∴ **DOES NOT COMPLY**

Thus additional BMPs are required for subarea A-1 + A-2 to comply with the DSSR. Since the soils are classified as HSG B, an infiltration basin would be a logical choice to manage the residual runoff required for compliance.

Medium Density Residential

Open Section Road – A-1 + A-2



DELAWARE DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL

<u>Example 2d – DURMM + HydroCAD</u>

For this example, full disconnection of the front rooftops and use of an open road section with grassed channels did not quite provide enough runoff reduction for subarea A-1 + A-2 to comply with the DSSR without the need for additional BMPs. However, the additional runoff that must be managed is only 0.14 watershed inches, which may not warrant construction of a BMP as large as an infiltration basin. Although it was determined that there was not enough length of flow between the lot lines at the end of the cul-de-sac to provide a Bioswale, the Post Construction Stormwater BMP Standards & Specifications include procedures for determining partial credit for some of the surface recharge practices, including Bioswales. Module 3 will demonstrate how to model partial credit using the Link Node method in HydroCAD which might confirm that an infiltration basin would not be required for this example.

Examples

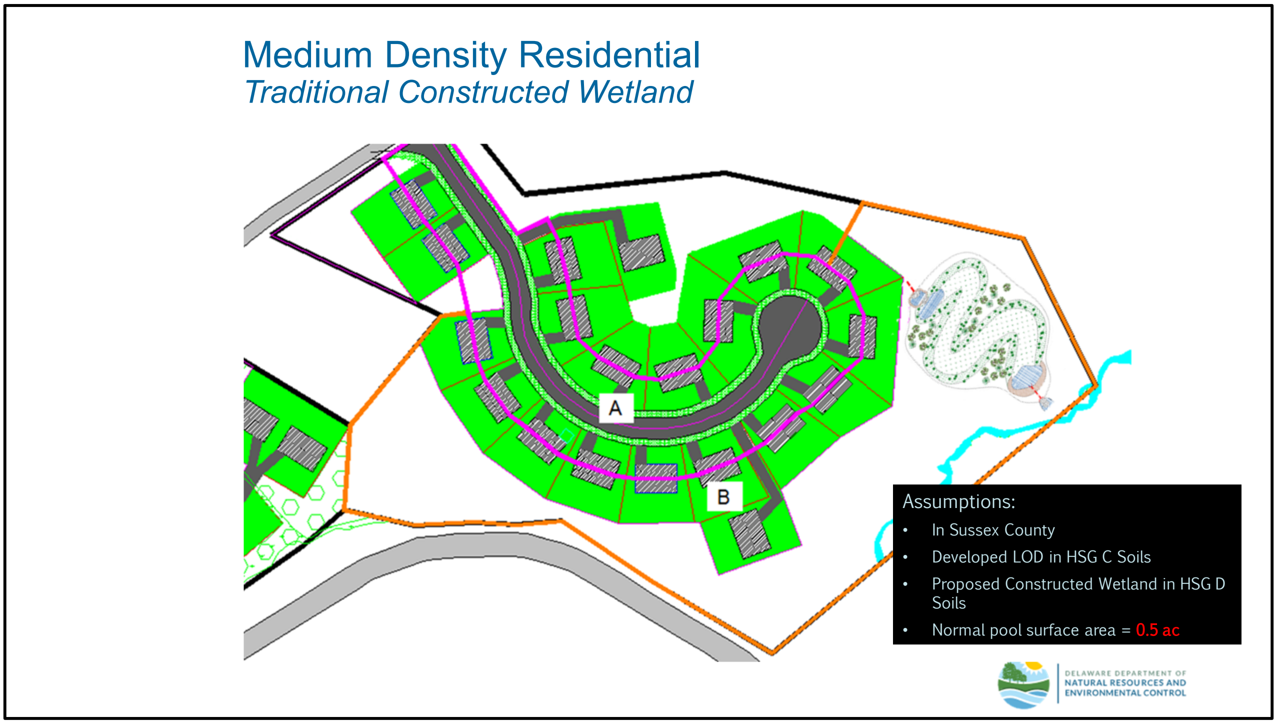
DURMM + Spec Criteria

Examples – DURMM + Spec Criteria

The next set of examples will illustrate how DURMM is used to determine the required runoff reduction for a project, as before. However, the demonstration of RPv compliance under the DSSR will be based on criteria contained in the Standards and Specifications for Post Construction Stormwater BMPs.

Example 2e – DURMM + Spec Criteria

The first example in this series will cover a Traditional Constructed Wetland from BMP 12.0 in the Standards and Specifications for Post Construction Stormwater BMPs.



<u>Example 2e – DURMM + Spec Criteria</u>

The site will be the same medium density residential project located in Sussex County as used in Example 2d with some slightly modified conditions, as follows:

- Soil type is Hydrologic Soil Group (HSG) C
- 2 subareas within the LOD, Subarea A and Subarea B
    - Subarea A: Fronts of lots/roofs, driveways and closed section road with storm drains
        - Open space, good condition, HSG C: 1.62 acres
        - Impervious area: 1.41 acres
- Drainage from Subarea A is collected in a storm drain along lot lines that then discharges directly into a proposed Traditional Constructed Wetland with a normal pool surface area of 0.5 acres.
- Although Subarea A is the focus of this example, Subarea B would also need to be analyzed to complete the verification of compliance for the site as a whole.

Medium Density Residential
Traditional Constructed Wetland

PROJECT: Example 3, MDR
DRAINAGE SUBAREA ID: A
LOCATION (County): Sussex
RESOURCE PROTECTION EVENT (RPv) WORKSHEET
RESET

	BMP 1		BMP 2		BMP 3		BMP 4		BMP 5	
	Type	12-A Traditional Constructed Wetlands	Type	--	Type	--	Type	--	Type	--
Step 1 - Calculate Initial RPv	Data									
1.1 Total contributing area to BMP (ac)	3.03									
1.2 Initial RCN	85.17									
1.3 RPv for Contributing Area (in.)	1.57									
1.4 Req'd RPv to be Managed for Contributing Area (in.)	0.51									
1.5 Req'd RPv to be Managed for Contributing Area (%)	33%									
Step 2 - Adjust for Retention Reduction										
2.1 Retention volume provided (cu. ft.)										
2.2 Retention reduction allowance (%)	[illegible]		N/A		N/A		N/A		N/A	
2.3 Retention reduction volume (ac-ft)	0.00		N/A		N/A		N/A		N/A	
2.4 Retention reduction volume (in.)	0.00		N/A		N/A		N/A		N/A	
2.5 Runoff volume after retention reduction (in.)	1.57		N/A		N/A		N/A		N/A	
2.6 Adjusted CN*	85.21		N/A		N/A		N/A		N/A	
Step 3 - Adjust for Annual Runoff Reduction										
3.1 Annual CN (ACN)	85.17		N/A		N/A		N/A		N/A	
3.2 Annual runoff (in.)	[illegible]		N/A		N/A		N/A		N/A	
3.3 Proportion A/B soils in BMP footprint (%)			0%		0%		0%		0%	
3.4 Annual runoff reduction allowance (%)	[illegible]		N/A		N/A		N/A		N/A	
3.5 Annual runoff after reduction (in.)	22.81		N/A		N/A		N/A		N/A	
3.6 Adjusted ACN	85.17		N/A		N/A		N/A		N/A	
3.7 Annual Runoff Reduction Allowance for RPv (in.)	0.00		N/A		N/A		N/A		N/A	
Step 4 - Calculate RPv with BMP Reductions										
4.1 RPv Runoff Manangement Provided (cu. ft.)	0		N/A		N/A		N/A		N/A	
4.2 RPv runoff volume after all reductions (in.)	1.57		N/A		N/A		N/A		N/A	
4.3 RPv runoff volume after all reductions (cu.ft.)	17,268		N/A		N/A		N/A		N/A	
4.4 Total RPv runoff reduction (in.)	0.00		N/A		N/A		N/A		N/A	
4.5 Total RPv runoff reduction (%)	0%		N/A		N/A		N/A		N/A	
4.6 Adjusted CN after all reductions*	85.17		N/A		N/A		N/A		N/A	
4.7 Adjusted equivalent annual runoff (in.)	22.81		N/A		N/A		N/A		N/A	
4.8 RPv Compliance Met Through Runoff Reduction?	NO		N/A		N/A		N/A		N/A	
4.9 Runoff Reduction Credit, if Applicable (cu.ft)	N/A		N/A		N/A		N/A		N/A	
Step 5 - Determine Residual Volume to be Managed or Offset										
5.1 RPv Residual Volume (in.)	0.51		N/A		N/A		N/A		N/A	
5.2 RPv Residual Volume (cu.ft./ac)	1,868		N/A		N/A		N/A		N/A	
5.3 Residual Volume to be Managed or Offset (cu.ft.)	5,660		N/A		N/A		N/A		N/A	
5.4 RPv avg. discharge rate for 48-hr detention (cfs)	0.033		N/A		N/A		N/A		N/A	
5.5 RPv max. discharge rate for 48-hr detention (cfs)	0.164		N/A		N/A		N/A		N/A	

DELAWARE DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL

Example 2e – DURMM + Spec Criteria

Note that on the “RPv” sheet, the input cells for both retention and annual runoff reduction are both grayed-out. This is because Constructed Wetlands do not infiltrate or recharge stormwater runoff. Nevertheless, they can be used for full compliance for the RPv event if designed in accordance with the Post Construction Stormwater BMP Standards and Specifications. The following series of slides will illustrate the procedure for demonstrating compliance for a Traditional Constructed Wetland.

Medium Density Residential
Traditional Constructed Wetland

BMP Standards and Specifications — Constructed Wetlands

12.0 **Constructed Wetlands**

Definition: **Practices that mimic natural wetland areas to treat urban stormwater by incorporating permanent pools with shallow storage areas. Constructed Wetlands may provide stormwater detention for larger storms (Cv and Fv) above the RPv storage.**

Design variants include:

- 12-A **Traditional Constructed Wetlands**
- 12-B **Wetland Swales**
- 12-C **Ephemeral Constructed Wetlands**
- 12-D **Submerged Gravel Wetlands**
- 12-E Floating Wetlands (to be added at a later date)

Constructed Wetlands are shallow depressions that receive stormwater inputs for water quality treatment. The majority of the wetland surface area is covered by shallow (<1-foot deep) wetland area, with greater depths in the forebay and pools within the wetland. Wetlands possess variable microtopography to promote dense and diverse wetland cover. Runoff from each new storm displaces runoff from previous storms, and the long residence time allows multiple pollutant removal processes to operate. The wetland environment provides an ideal environment for gravitational settling, biological uptake, and microbial activity.

Submerged Gravel Wetlands (SGW) treat stormwater runoff primarily through filtration, sedimentation, physical and chemical sorption, microbially mediated transformation, uptake, and attenuation. Sedimentation occurs in the pretreatment forebay as well as above the wetland surface. Filtration, sorption, and transformation occur as the stormwater passes through the gravel substrate via microbe rich environment. While uptake occurs from the wetland vegetation most of the treatment is within the gravel substrate in a "plug flow" type system.

The Constructed Wetlands design variants all share commonalities but are also unique in their performance credits.

12-1 Effective February 2019

DELAWARE DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL

<u>Example 2e – DURMM + Spec Criteria</u>

Section 12.0 contains the Standards and Specifications for Constructed Wetlands.

Medium Density Residential
Traditional Constructed Wetland

Table 12.1-A
Traditional Constructed Wetlands Performance Credits

Runoff Reduction	
RPv	**100%**
Cv	**Not Less Than 1%**
Fv	**Not Less Than 0%**
Pollutant Reduction	
TN Reduction	**Not less than 30% Removal Efficiency**
TP Reduction	**Not less than 40% Removal Efficiency**
TSS Reduction	**Not less than 80% Removal Efficiency**

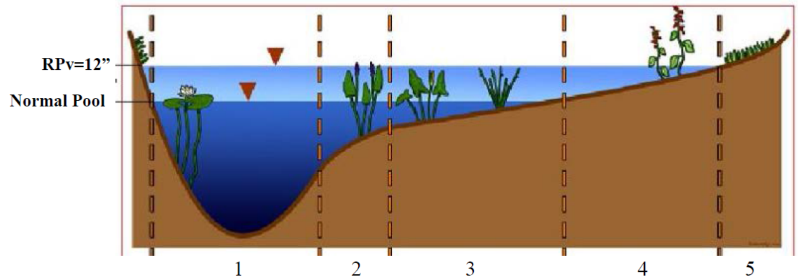
DELAWARE DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL

Example 2e – DURMM + Spec Criteria

Table 12.1-A indicates that a Traditional Constructed Wetland receives full RPv credit when designed in accordance with the specifications.

Medium Density Residential
Traditional Constructed Wetland

Inundation Zones.



1. Deep Pool (depth -36” to -18”)
2. Transition Zone (depth -18” to -6”)
3. Low Marsh Zone (depth -6” to Normal Pool)
4. High Marsh Zone (depth Normal Pool to +12”)
5. Floodplain (depth +12” to +30”)

DELAWARE DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL

<u>Example 2e – DURMM + Spec Criteria</u>

In order to meet the specifications, the Traditional Constructed Wetland must be designed to meet the volume and/or surface area requirements for the various zones, as illustrated in the graphic included with the specifications.

Medium Density Residential
Traditional Constructed Wetland

1			
2	***Design Inputs***		
3	Total contributing drainage area (from DURMM v2.5, RPv Sheet, Step 1.1)	3.03	ac
4	RPv volume to be managed (from DURMM v2.5, RPv Sheet, Step 5.3)	5660	cf
5			
6	***Design Criteria***		
7	Max. contributing drainage area to inlets with < 0.5:1 flow length ratio (20%)	0.606	ac
8	Permanent pool volume (50% RPv)	2830	cf
9	Minimum Planting Zone volumes		
10	Zone 1: Deep Pool volume (min. 20% RPv)	1132	cf
11	Zone 2: Transition Zone volume (min. 20% RPv)	1132	cf
12	Zone 3: Low Marsh Zone volume (min. 10% RPv)	566	cf
13			
14	***Hunt Water Balance Equation***		
15	RFm = Monthly rainfall during drought (assume 1")	1	in
16	EF = Fraction of rainfall that enters the stormwater wetland (Rational eq. "C")	0.4	
17	WS/WL = Ratio of contributing drainage area to normal pool surface area	6.06	
18	ET = Summer evapostranspiration rate (assume 7")	7	in
19	INF = Monthly infiltration loss (assume 7.2")	7.2	in
20	RES = Resevoir of water for factor of safety (assume 6")	6	in
21	DP = Depth of pool	17.776	in
22			

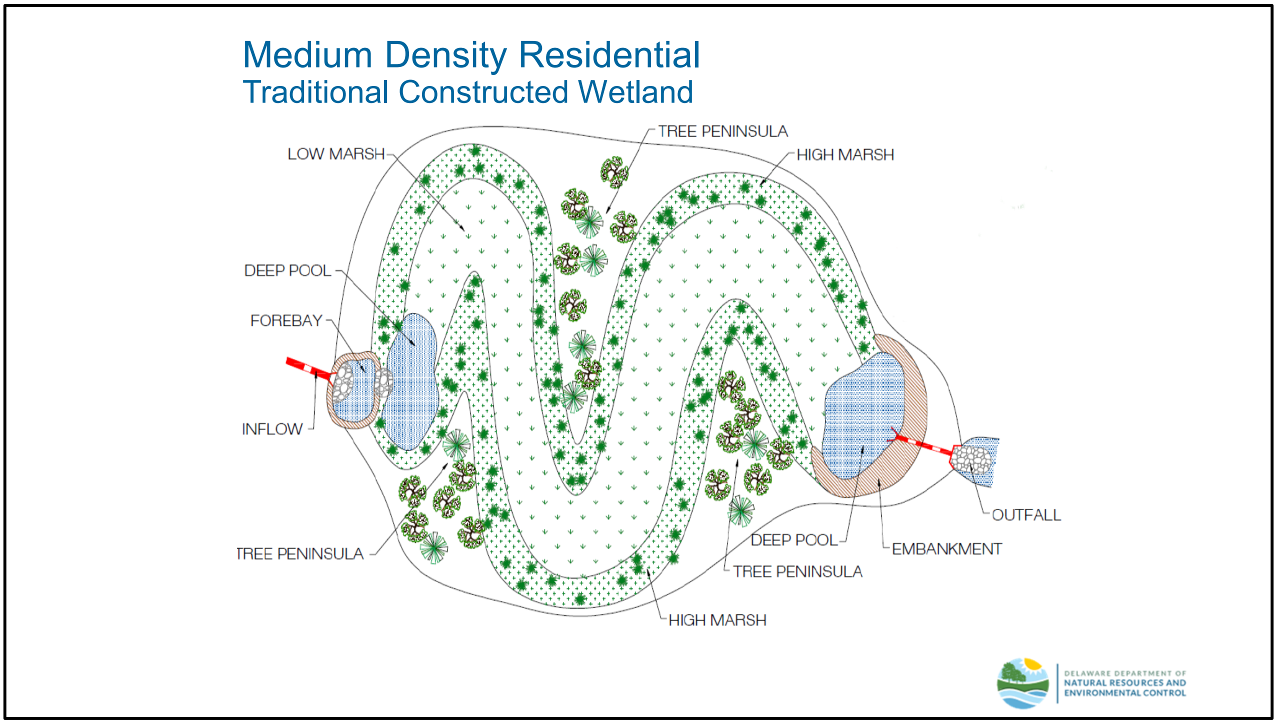
DELAWARE DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL

Example 2e – DURMM + Spec Criteria

The equations for determining the required volumes and/or surface areas for the various zones within the constructed wetland are contained in the specifications. However, the DNREC Sediment & Stormwater Program has developed a spreadsheet that greatly simplifies the process. The "BMP Design Worksheet" can be downloaded from the program website under the "Engineering" resources tab. Input for the "green" shaded cells are as follows:

- Total contributing drainage area (From DURMM RPv Sheet, Step 1.1): 3.03 ac
- RPv volume to be managed (from DURMM RPv Sheet, Step 5.3): 5660 cf
- Fraction of rainfall that enters the stormwater wetland (Rational Eq. "C" factor from BMP Design Worksheet): 0.4
- Ratio of contributing drainage area to normal pool surface area (3.03/0.5): 6.06

The required volumes and surface areas for design of the Traditional Constructed Wetland are calculated in the "magenta" shaded cells.



<u>Example 2e – DURMM + Spec Criteria</u>

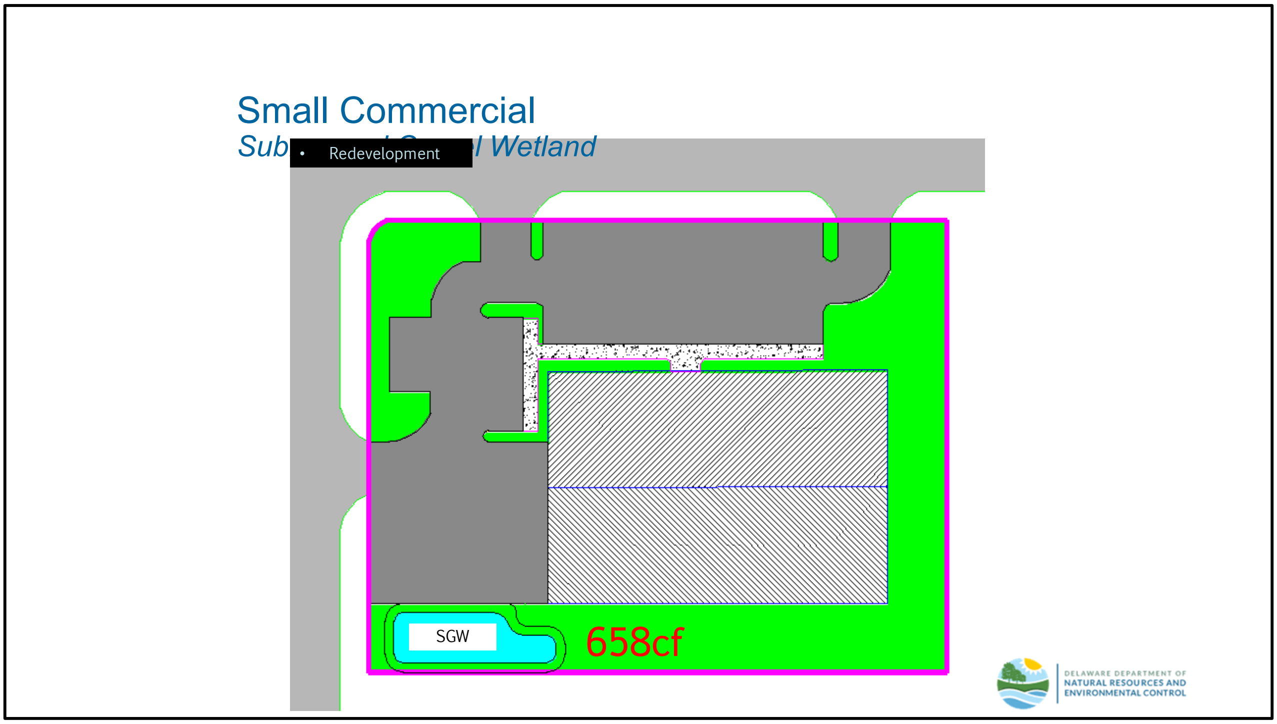
The designer must then demonstrate the required volumes and surface areas for the various zones are provided in order to comply under the DSSR.

Example 2f

Submerged Gravel Wetland

Example 2f – DURMM + Spec Criteria

The next example will cover another type of constructed wetland known as a Submerged Gravel Wetland.



<u>Example 2f – DURMM + Spec Criteria</u>

The proposed project is the small commercial redevelopment project in Kent County. In Example 2b, it was shown that a bioretention facility with 658 cubic feet of storage would comply under the DSSR. For this example, the bioretention facility will be replaced with a Submerged Gravel Wetland (SGW) due to high groundwater conditions. The assumptions and site conditions are the same as for Example 2b. Therefore, the only difference will be the selection of a Submerged Gravel Wetland on the RPv sheet instead of a Traditional Bioretention with Underdrain.

Small Commercial

Submerged Gravel Wetland

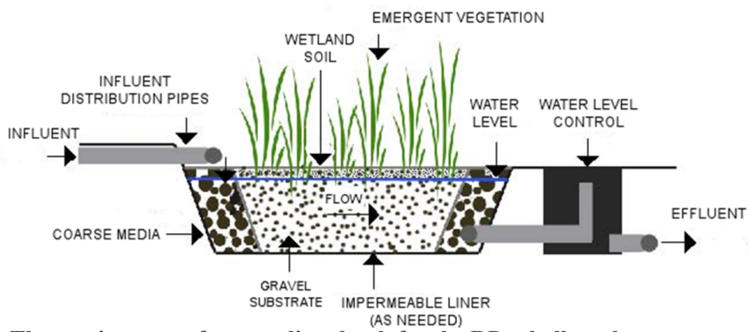
1	PROJECT:	Example 3b, Small Commercial									
2	DRAINAGE SUBAREA ID:	0									
3	LOCATION (County):	Kent									
4	RESOURCE PROTECTION EVENT (RPv) WORKSHEET										
5	RESET	BMP 1		BMP 2		BMP 3		BMP 4		BMP 5	
6		Type	12-D Submerged Gravel Wetlands	Type	--	Type	--	Type	--	Type	--
7	*Step 1 - Calculate Initial RPv*	Data									
8	1.1 Total contributing area to BMP (ac)	1.20									
9	1.2 Initial RCN	90.00									
10	1.3 RPv for Contributing Area (in.)	1.86									
11	1.4 Req'd RPv to be Managed for Contributing Area (in.)	0.15									
12	1.5 Req'd RPv to be Managed for Contributing Area (%)	8%									
13											
14	*Step 2 - Adjust for Retention Reduction*										
15	2.1 Retention volume provided (cu. ft.)										
16	2.2 Retention reduction allowance (%)	[illegible]		N/A		N/A		N/A		N/A	
17	2.3 Retention reduction volume (ac-ft)	0.00		N/A		N/A		N/A		N/A	
18	2.4 Retention reduction volume (in.)	0.00		N/A		N/A		N/A		N/A	
19	2.5 Runoff volume after retention reduction (in.)	1.86		N/A		N/A		N/A		N/A	
20	2.6 Adjusted CN*	89.97		N/A		N/A		N/A		N/A	
21											
22	*Step 3 - Adjust for Annual Runoff Reduction*										
23	3.1 Annual CN (ACN)	90.00		N/A		N/A		N/A		N/A	
24	3.2 Annual runoff (in.)	[illegible]		N/A		N/A		N/A		N/A	
25	3.3 Proportion A/B soils in BMP footprint (%)	0%		0%		0%		0%		0%	
26	3.4 Annual runoff reduction allowance (%)	[illegible]		N/A		N/A		N/A		N/A	
27	3.5 Annual runoff after reduction (in.)	27.66		N/A		N/A		N/A		N/A	
28	3.6 Adjusted ACN	90.00		N/A		N/A		N/A		N/A	
29	3.7 Annual Runoff Reduction Allowance for RPv (in.)	0.00		N/A		N/A		N/A		N/A	
30											
31	*Step 4 - Calculate RPv with BMP Reductions*										
32	4.1 RPv Runoff Manangement Provided (cu. ft.)	0		N/A		N/A		N/A		N/A	
33	4.2 RPv runoff volume after all reductions (in.)	1.86		N/A		N/A		N/A		N/A	
34	4.3 RPv runoff volume after all reductions (cu.ft.)	8,102		N/A		N/A		N/A		N/A	
35	4.4 Total RPv runoff reduction (in.)	0.00		N/A		N/A		N/A		N/A	
36	4.5 Total RPv runoff reduction (%)	0%		N/A		N/A		N/A		N/A	
37	4.6 Adjusted CN after all reductions*	89.97		N/A		N/A		N/A		N/A	
38	4.7 Adjusted equivalent annual runoff (in.)	27.63		N/A		N/A		N/A		N/A	
39	4.8 RPv Compliance Met Through Runoff Reduction?	NO		N/A		N/A		N/A		N/A	
40	4.9 Runoff Reduction Credit, if Applicable (cu.ft)	N/A		N/A		N/A		N/A		N/A	
41											
42	*Step 5 - Determine Residual Volume to be Managed or Offset*										
43	5.1 RPv Residual Volume (in.)	0.15		N/A		N/A		N/A		N/A	
44	5.2 RPv Residual Volume (cu.ft./ac)	548		N/A		N/A		N/A		N/A	
45	5.3 Residual Volume to be Managed or Offset (cu.ft.)	657		N/A		N/A		N/A		N/A	
46	5.4 RPv avg. discharge rate for 48-hr detention (cfs)	0.004		N/A		N/A		N/A		N/A	
47	5.5 RPv max. discharge rate for 48-hr detention (cfs)	0.019		N/A		N/A		N/A		N/A	

DELAWARE DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL

Example 2f – DURMM + Spec Criteria

As with the Traditional Constructed Wetland example, a SGW does not receive a runoff retention or recharge credit. However, Step 5.3 indicates that the residual runoff volume required for RPv compliance is the same 658 cubic feet that was required for the Bioretention facility in Example 2b. Therefore, the design of the SGW must meet the requirements in the specifications for Submerged Gravel Wetlands in order to comply.

Small Commercial
Submerged Gravel Wetland



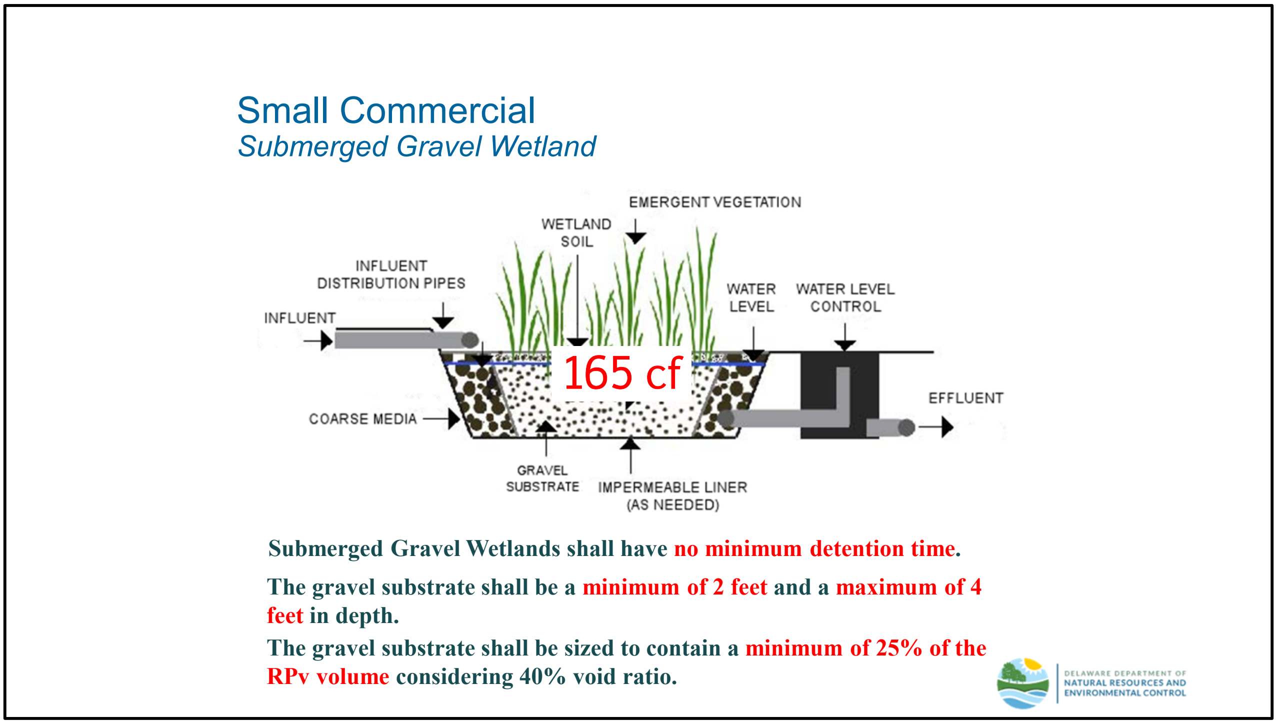
The maximum surface ponding depth for the RPv shall not be greater than the tolerance depths of the wetland plantings selected, or two feet, whichever is less.

The Submerged Gravel Wetland shall store the RPv volume within the gravel substrate and wetland soils and above the soils in surface ponding.

DELAWARE DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL

<u>Example 2f – DURMM + Spec Criteria</u>

One of the design criteria for a SGW is that it must store the RPv volume required for compliance within the gravel substrate, the wetland soils, and any surface ponding above the wetland soils. The maximum allowable ponding depth is the tolerance for ponding of the selected wetland plantings or a maximum of 2 feet.



<u>Example 2f – DURMM + Spec Criteria</u>

SGWs are unique in that they are designed to retain a certain portion of a previous runoff event. This retained runoff volume is then displaced by subsequent runoff events. As such, there is no hydraulic control for their discharge and there is no minimum detention time requirement. Instead, the SGW must meet the following design criteria from the specifications:

- The gravel substrate must be a minimum of 2 feet in depth
- The gravel substrate must be a maximum of 4 feet in depth
- The gravel substrate must have the capacity to store a minimum of 25% of the RPv volume required for compliance

The design for this example must therefore meet the following requirement:

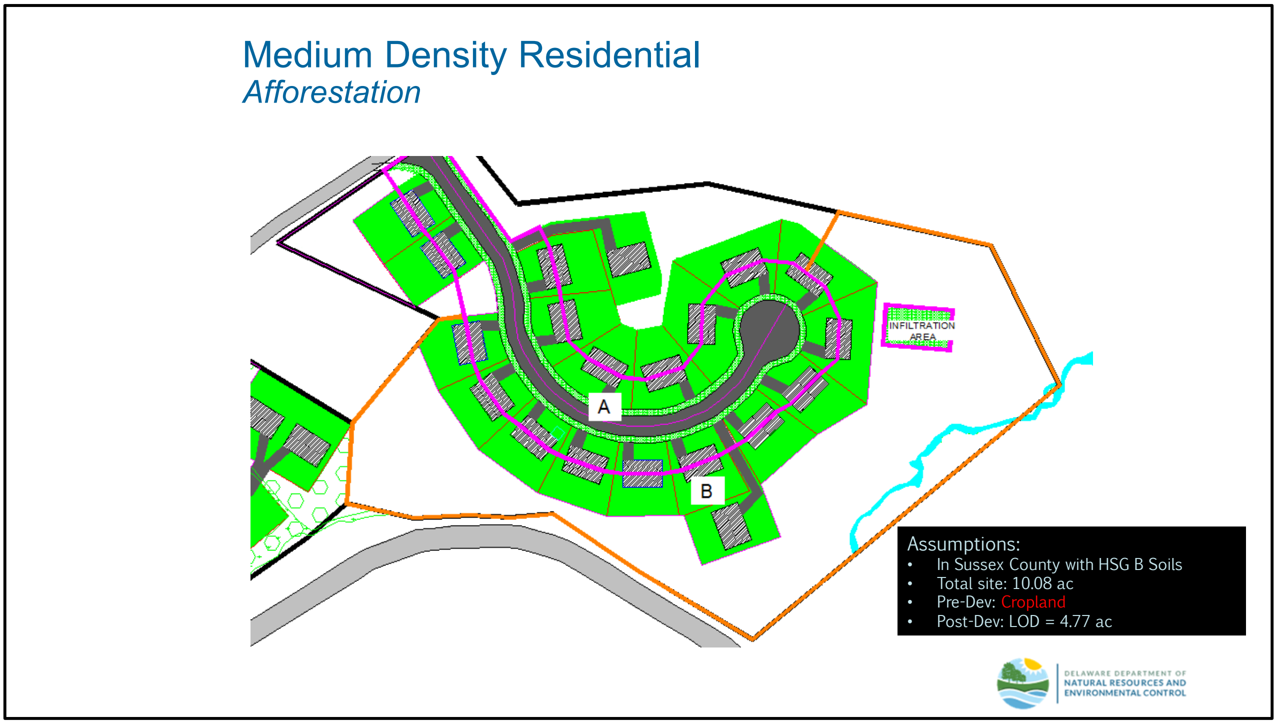
- RPv volume required for compliance = 658 cf
- Minimum RPv volume stored in gravel substrate = 658*0.25 = 165 cf
- Minimum total volume of the gravel substrate assuming 40% void ratio = 165/0.40 = 413 cf
- The 413 cf gravel substrate section must be between 2 feet and 4 feet in depth

Example 2g

Afforestation

Example 2g – DURMM + Spec Criteria

The final example in this module will cover BMP 17 Afforestation from the Post Construction Stormwater BMP Standards and Specifications.



Example 2g – DURMM + Spec Criteria

The medium density residential development in Sussex County from Example 2d will again be used, with the exception that the entire LOD will be evaluated rather than a single subarea. The relevant site details are as follows:

- Entire site is Hydrologic Soils Group (HSG) B
- Total site area: 10.08 ac
- Entire site is cropland for the predeveloped condition
- Post-developed Limit of Disturbance (LOD): 4.77 ac

Medium Density Residential
Afforestation

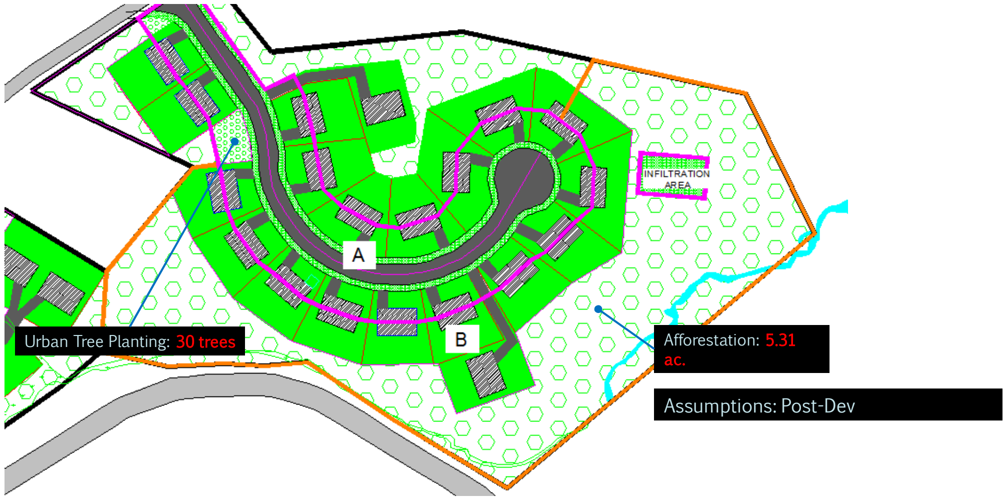
- Problem:
  - Minimize size of infiltration basin
- Determine:
  - Runoff reduction allowance for afforestation of site area outside development LOD & urban tree planting

DELAWARE DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL

Example 2g – DURMM + Spec Criteria

The proposed BMP is a single infiltration facility. However, the developer has proposed to convert the existing cropland areas outside the development LOD to conserved forest area using a combination of afforestation and urban tree plantings. The designer must now determine the RPv runoff reduction allowance from afforestation and urban tree planting so that the final volume for the infiltration facility can be determined.

Medium Density Residential
Afforestation



DELAWARE DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL

Example 2g – DURMM + Spec Criteria

The designer has determined the remaining areas outside the development LOD will allow the following post-developed conditions:

- Afforestation: 5.31 ac
- Urban Tree Planting: 30 trees

Medium Density Residential
Afforestation

BMP Standards and Specifications — Afforestation

17.0 **Afforestation**

Definition: **Afforestation includes practices that mimic the hydrologic benefits of a natural forest utilizing a regeneration process within the landscape by selectively planting tree seedlings (less than 1" DBH) or saplings (greater than 1" DBH). Afforestation can be used as both a runoff reduction practice by converting non-forested areas to forested areas as well as a mitigation practice for offsetting the clearing of forested areas during the development process.**

These areas can be positioned in the landscape for capture of stormwater runoff, retention of sediment and nutrients as well as improving the microclimate, such as providing shade, and habitat complexity. This practice should be conducted on non-compacted soils that are suitable for planting. The minimum soil depth should be 4 feet, based upon soils mapping, to ensure adequate rooting of trees. As illustrated in Figure 17.1, full establishment of a mature forest can take decades. However, even a young forest provides hydrologic benefits which can be realized in a relatively short time.

Design variants include:

- **17-A. Afforestation**
- **17-B. Urban Tree Planting**

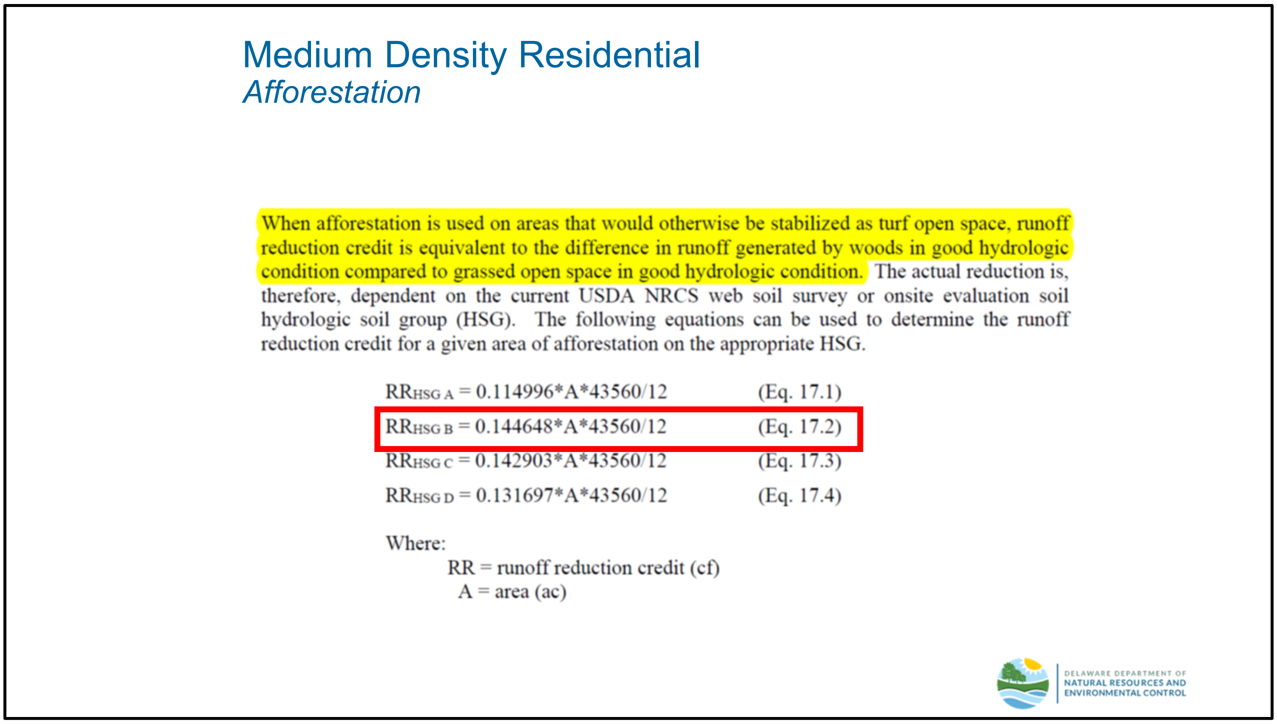
17-1

Effective February 2019

DELAWARE DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL

Example 2g – DURMM + Spec Criteria

Section 17.0 from the Post-Construction Stormwater BMP Standards and Specifications contains the requirements for Afforestation and Urban Tree Planting as well as the allowable runoff reduction credits.



<u>Example 2g – DURMM + Spec Criteria</u>

The Afforestation specification assumes areas that would otherwise be grassed open space in the post-developed condition will instead eventually exhibit the hydrologic conditions of a mature forest. Although this is not the case initially, it is felt that incentivizing the long-term benefits of establishing trees in the urban environment more than makes up for any temporary shortfalls in managing the RPv event. It is anticipated that a brush-like condition will be established in 5 years or less, which can actually outperform a mature forest from a hydrologic standpoint.

The allowable runoff reduction credit for Afforestation depends on the underlying soil HSG. Equations 17.1 through 17.4 are used to calculate the runoff reduction credit. In this case, Equation 17.2 will be used since the entire area to be planted is HSG B.

Medium Density Residential
Afforestation

The minimum size of the afforestation area shall be 10,000 square feet with a minimum width of 50 feet. The long dimension of the area should be perpendicular to the slope where feasible.

For areas planted in trees that do not meet the design criteria for afforestation, credit shall be an equivalent 1/200th of an acre per tree. The equations above under the Urban Tree Planting variant may be used for calculating the credit. These equations may also be used to determine equivalent credit for afforestation used as a mitigation practice.

DELAWARE DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL

Example 2g – DURMM + Spec Criteria

The Afforestation specification states that the afforested area must be a minimum of 10,000 square feet with a minimum width of 50 feet. However, there is also a provision that allows credit for tree plantings that may not meet these areal requirements. In those cases, the credit is equivalent to 1/200th of the per acre credit for each tree planted.

Medium Density Residential
Afforestation

Afforestation Runoff Reduction Calculator

Area Planted IAW Afforestation Stds & Spec

Soil	Coefficient	Area (ac)	RR Credit (cf)	
HSG A	0.114996		0	
HSG B	0.144648	5.31	2788	
HSG C	0.142903		0	
HSG D	0.131697		0	
			2788	TOTAL

AND/OR

Trees Planted IAW An Approved Landscaping Plan

Soil	Coefficient	Trees (no)	RR Credit (cf)	
HSG A	0.114996		0	
HSG B	0.144648	30	79	
HSG C	0.142903		0	
HSG D	0.131697		0	
			79	TOTAL

DELAWARE DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL

Example 2g – DURMM + Spec Criteria

Although DURMM can be used to determine the allowable runoff reduction credit for Afforestation areas, it does not have the capability of calculating credits for Urban Tree Planting since DURMM is based on area calculations. However, the “BMP Design Worksheet” covered in Example 2e (on page 59) also has a worksheet that can be used to facilitate the calculations for RPv credit for both Afforestation areas and individual Urban Tree Plantings.

NOTE: Areas to be planted for Afforestation credit are assumed to be “LOD” areas when using DURMM. Results may vary slightly between DURMM and the BMP Design Worksheet due to rounding and computational differences. However, the results from either application are acceptable for compliance purposes under the DSSR.

Medium Density Residential
Afforestation

- Problem:
  - Minimize size of infiltration basin
- Determine:
  - Runoff reduction allowance for afforestation of site area outside development LOD & urban tree planting
- Solution:
  1. $RR_{HSG\ B}$ = (0.144648)*(5.31)*(43560/12) = 2788 cf
  2. RR_{Trees} = (0.144648)*(30)*(43560/12)*(1/200) = 79 cf
  3. Infiltration Basin size can be reduced by 2867 cf

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Example 2g – DURMM + Spec Criteria

In this case, the credits were calculated as:

- RR credit for 5.31 ac Afforestation (HSG B): 2788 cf
- RR credit for 30 individual Urban Tree Planting (HSG B): 79 cf
- Total RR credit for Afforestation and Urban Tree Planting = 2788 + 79 = 2867 cf

The final design volume of the proposed infiltration basin can therefore be reduced by 2867 cubic feet.

End of Module 2

This concludes Training Module 2, “Calculations & Examples for RPv Compliance”. This module covered various examples using a combination of DURMM, external hydrologic software packages such as HydroCAD and the specifications themselves for meeting full compliance for the RPv event. However, in some cases it may not be possible to meet the requirements for full compliance due to site constraints or other limiting conditions. In other cases, it may be possible to manage more runoff volume than the minimum required for compliance. Module 3 will cover how partial and extra credit can be determined in accordance with the RPv requirements of the DSSR.