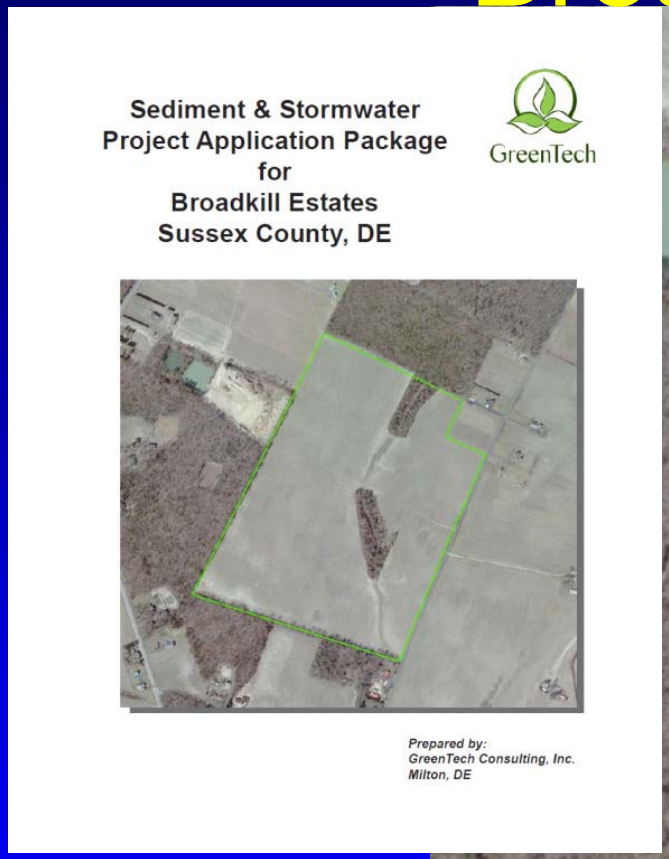
Revisions to the Delaware Sediment & Stormwater Regulations

Training Session 6: Broadkill Estates Example Site Analysis for RPv, Cv & Fv

Broadkill Estates

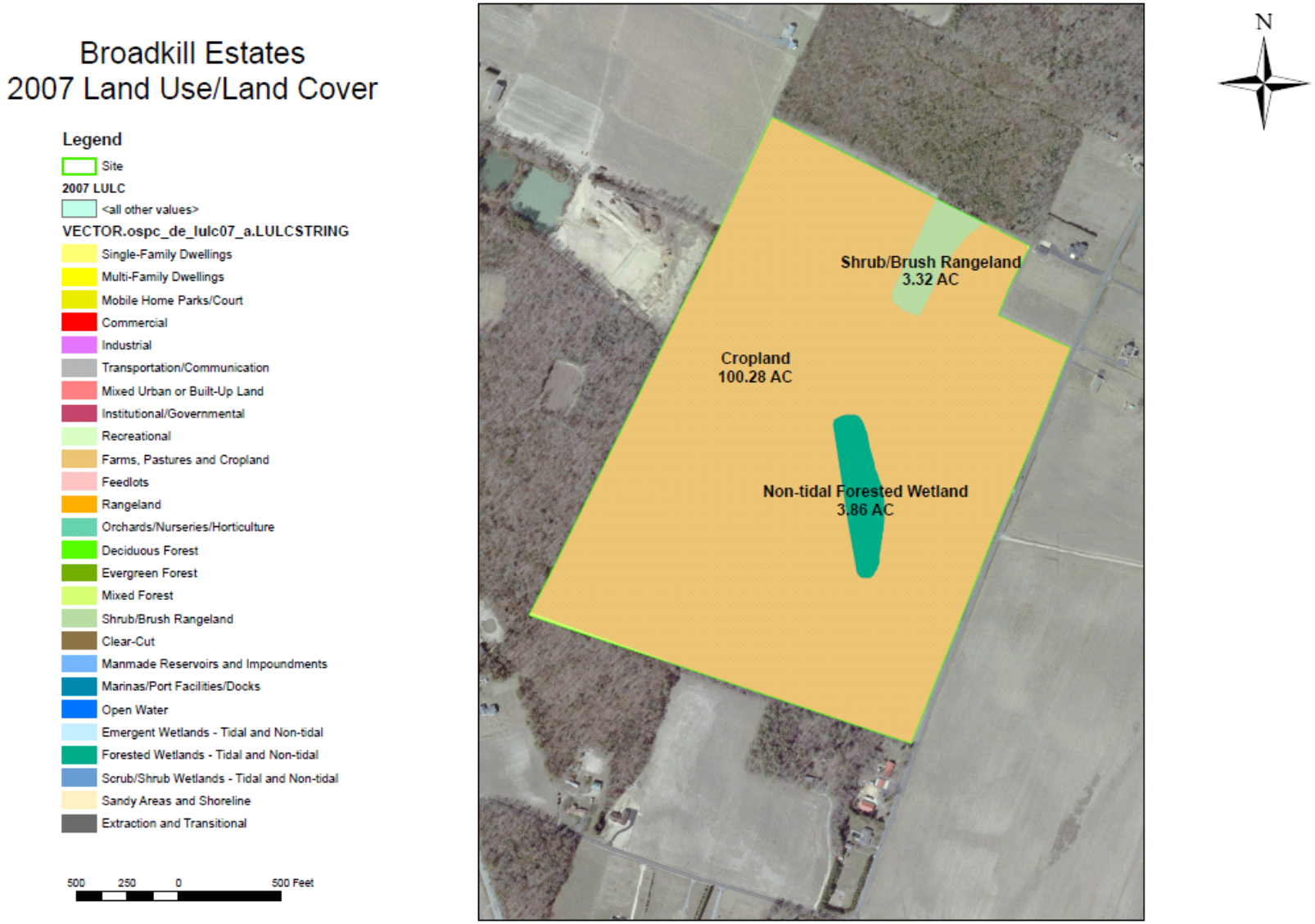


Sediment & Stormwater
Project Application Package
for
Broadkill Estates
Sussex County, DE

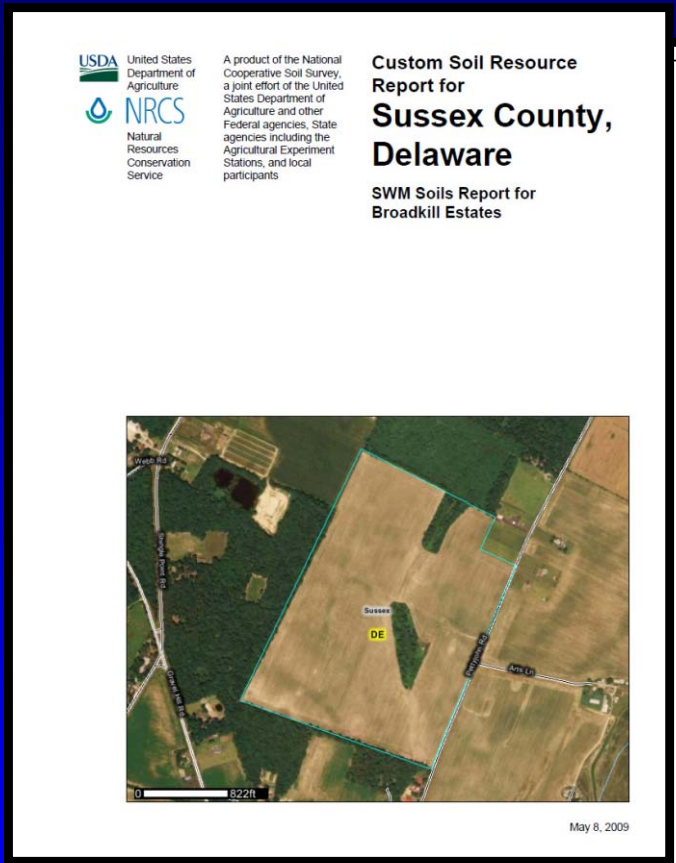
GreenTech

Prepared by:
GreenTech Consulting, Inc.
Milton, DE

Concept Level Analysis



Broadkill Estates Soils Data



USDA United States Department of Agriculture

NRCS Natural Resources Conservation Service

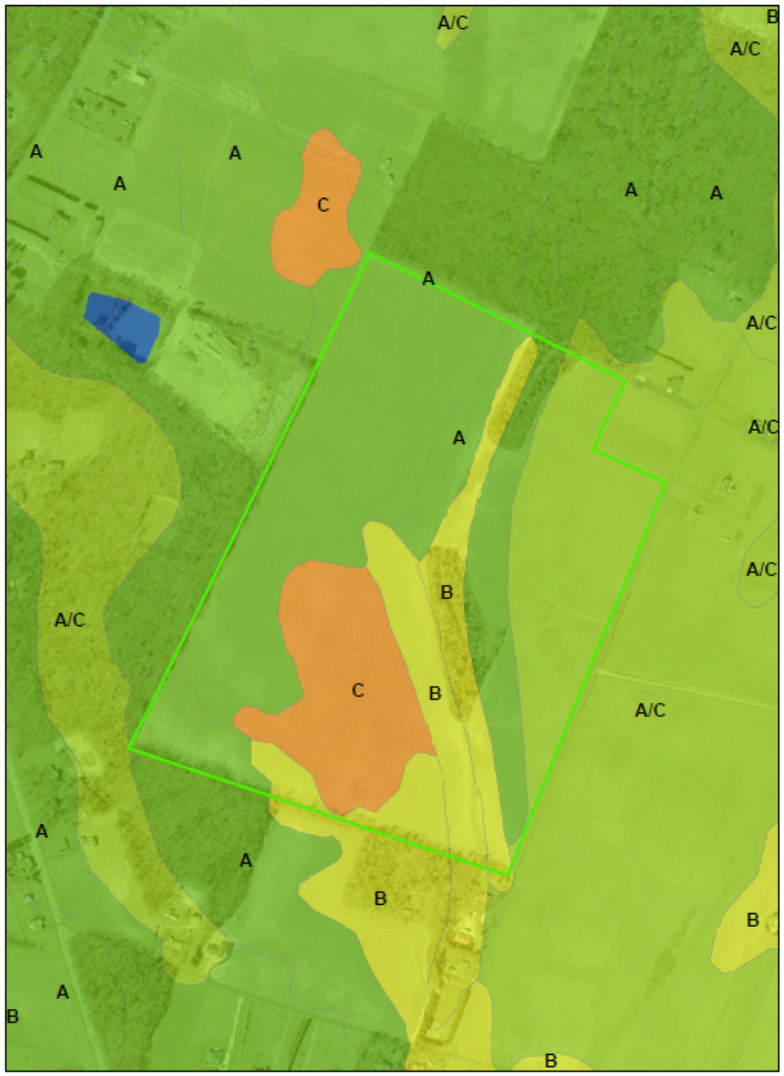
A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for

Sussex County, Delaware

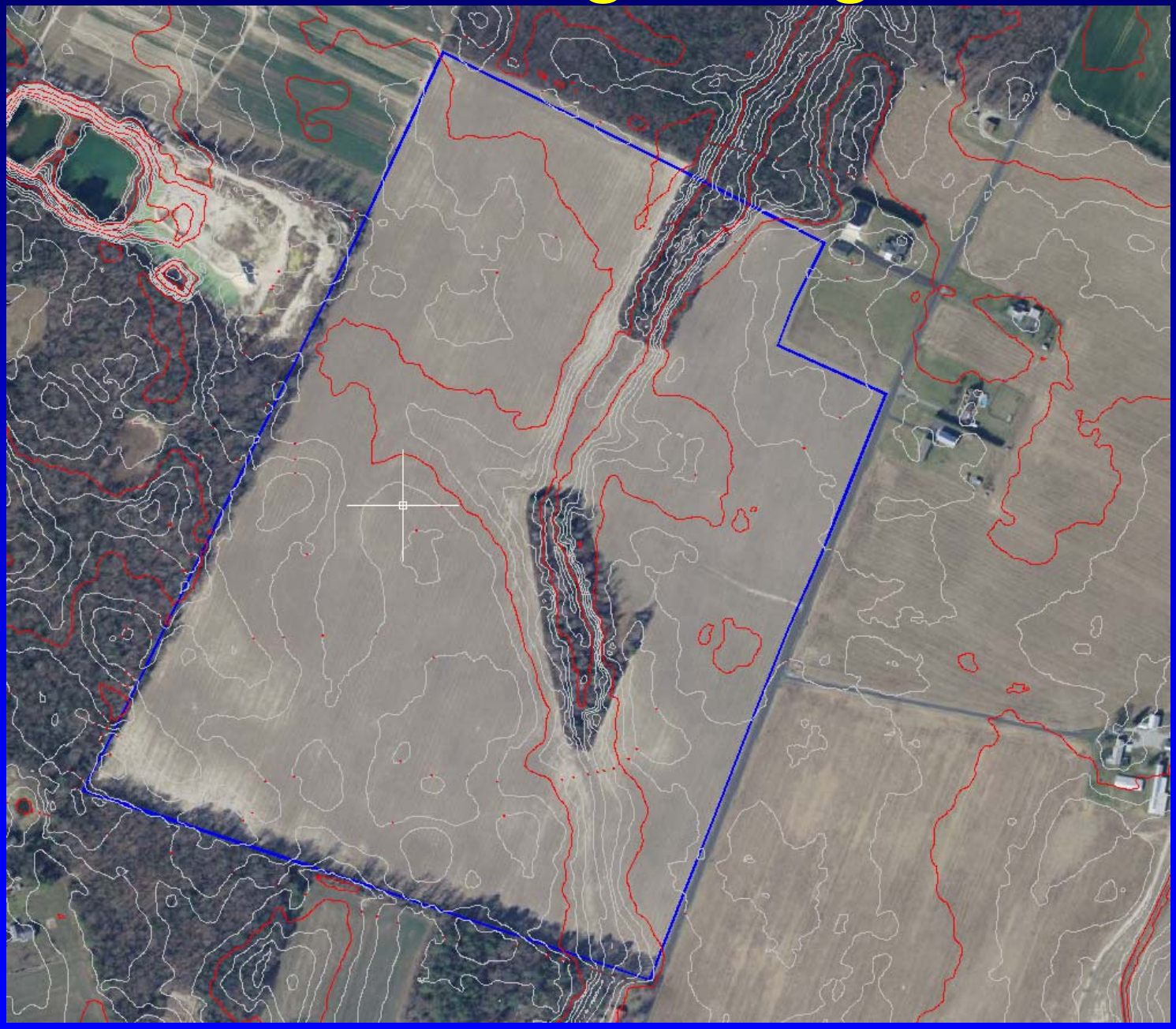
SWM Soils Report for Broadkill Estates

May 8, 2009

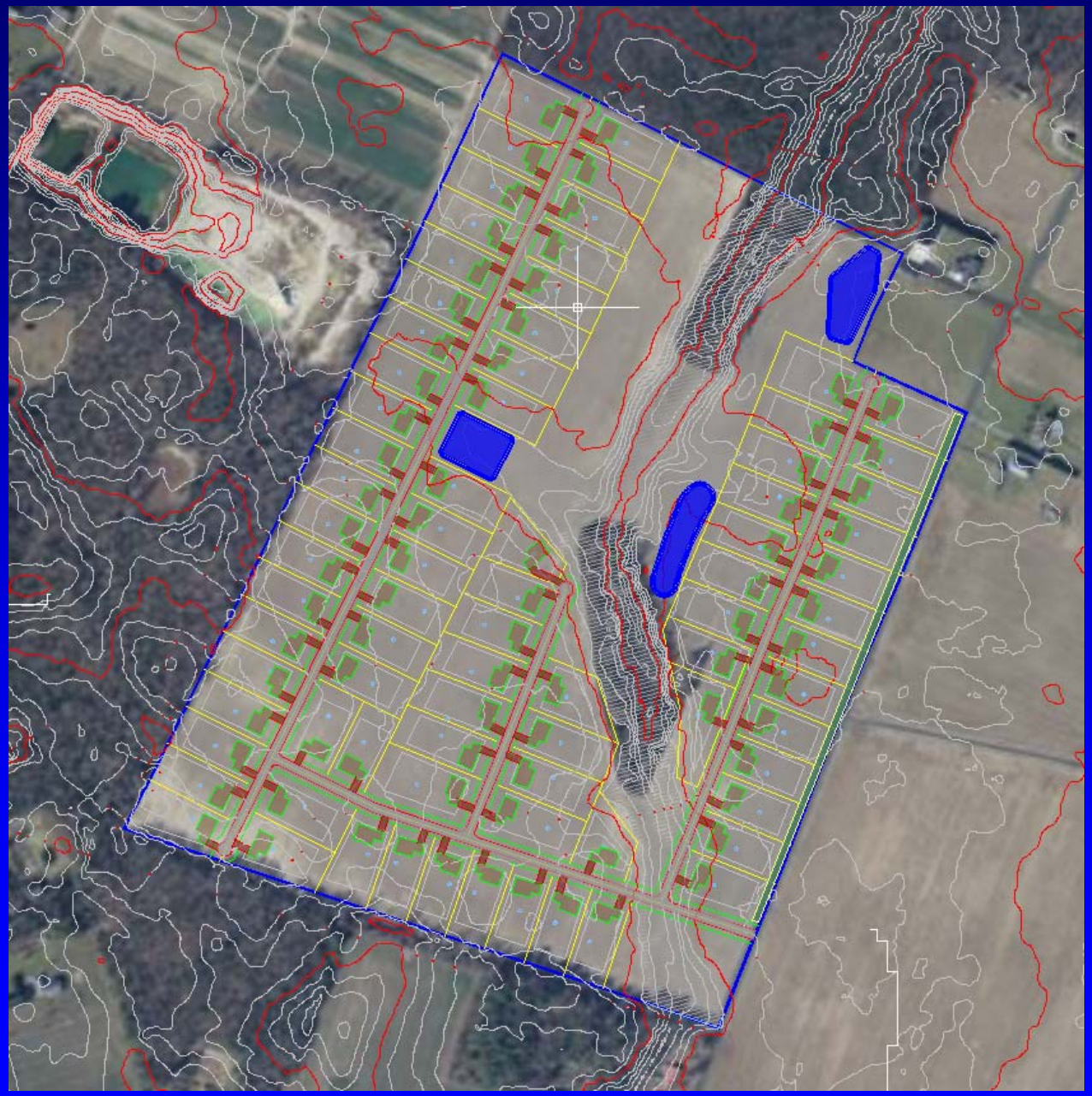


Broadkill Estates – Land Use

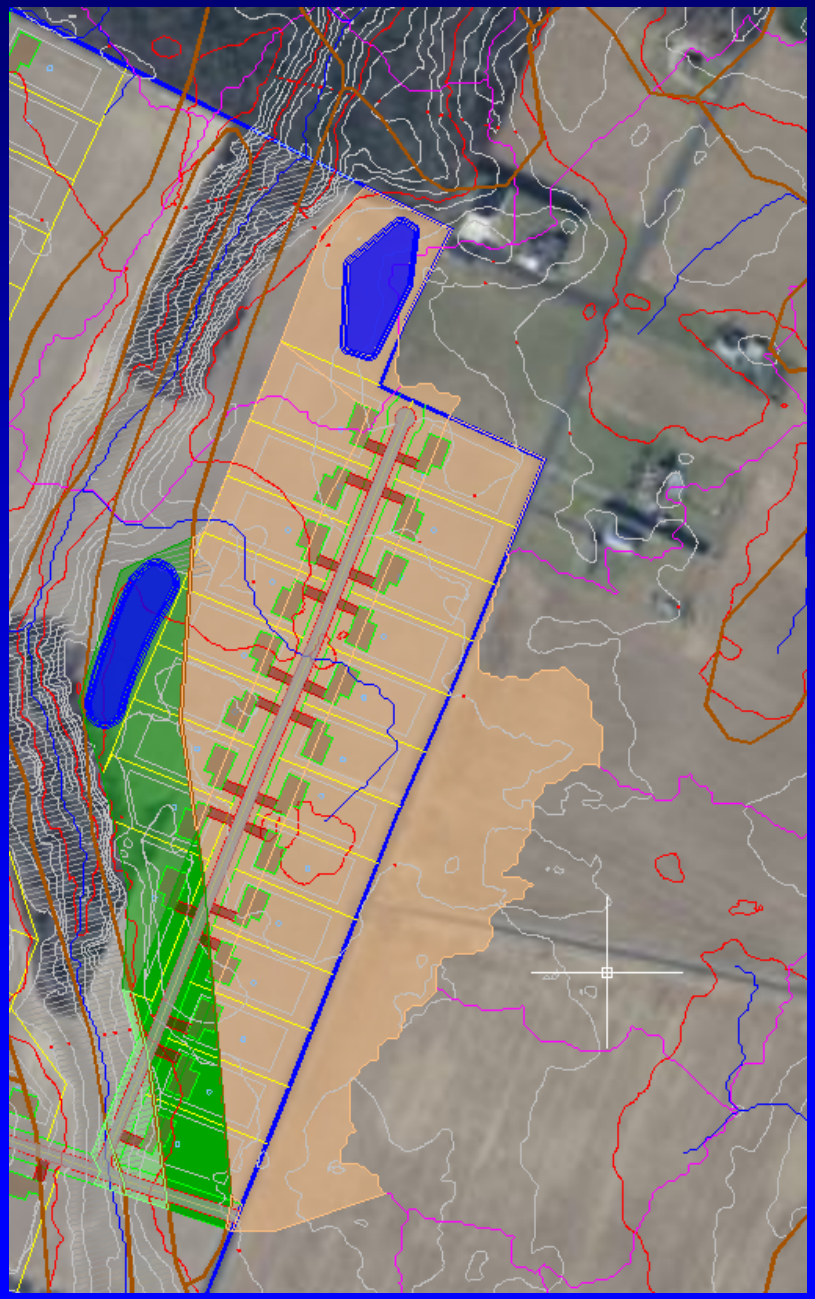
In the Beginning…



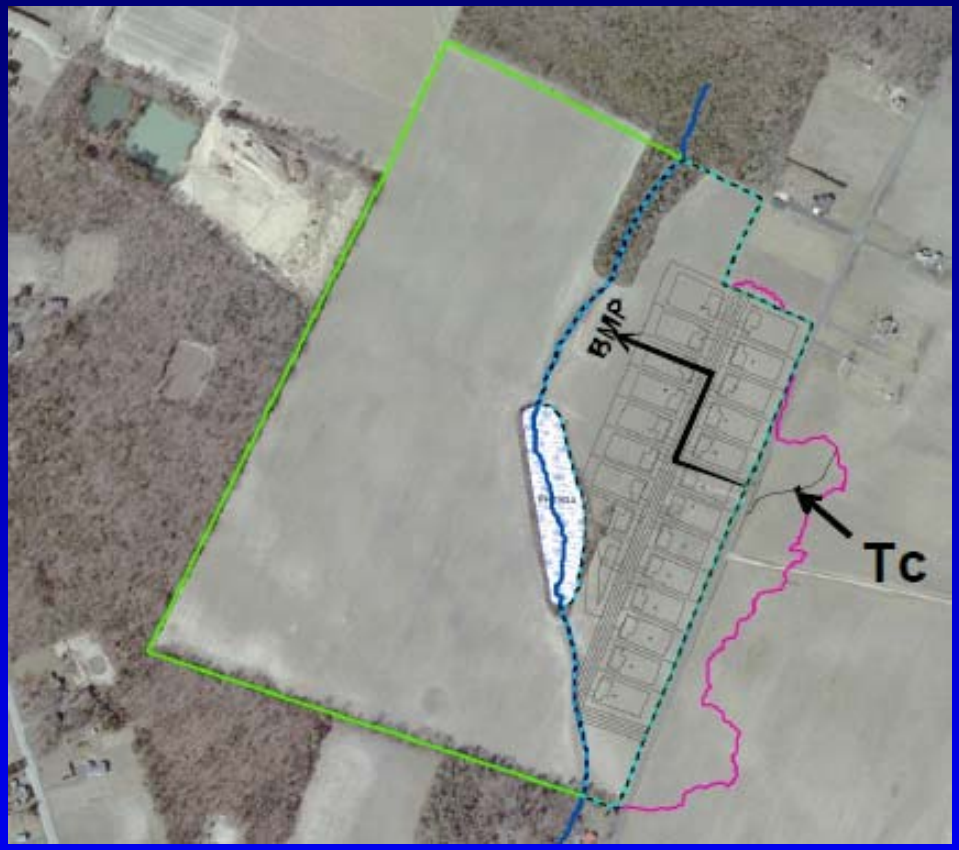
Site Design



Site Design w/ Soils

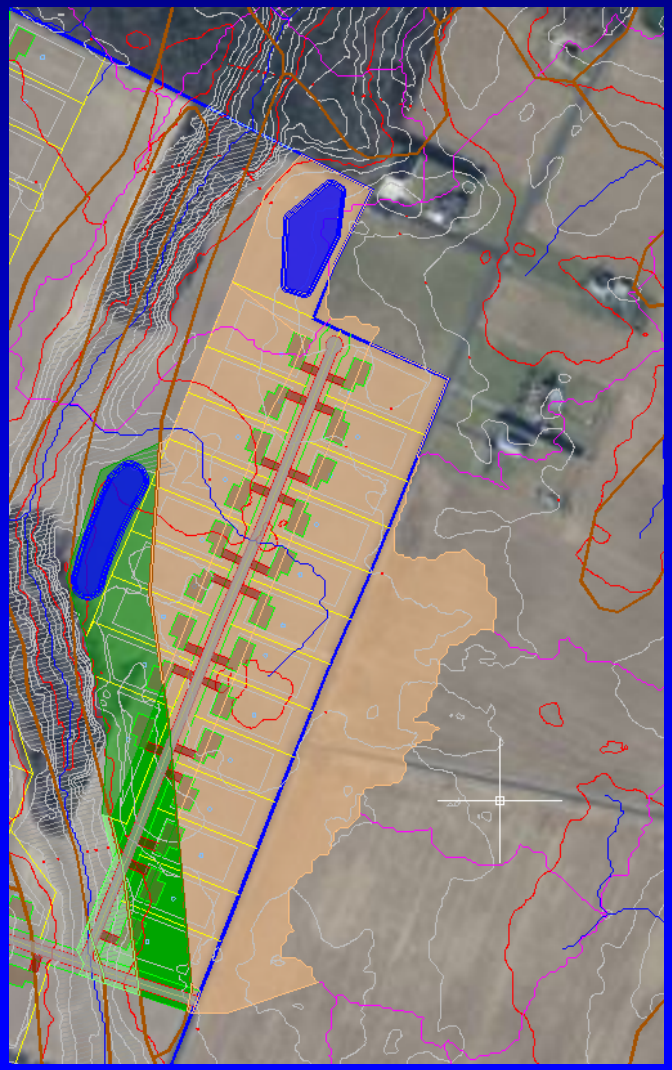


OLOD – Time of Concentration



For areas within the LOD, the allowable discharges for the Cv and Fv under the standards based approach are prescribed in the DSSR. However, these allowable discharges do not apply to areas outside the LOD. DURMM v.2 is capable of determining a weighted allowable discharge for the entire contributing area. This requires the user to enter an estimate of the time of concentration (Tc) for the area outside the LOD. Since the OLOD areas are often irregular in shape, it is adequate for the user to designate a single representative Tc path for the entire OLOD area for any particular subarea under analysis. The Tc path should be carried through to the final onsite stormwater management BMP in the flowpath.

Design Level Analysis
C.A. RCN Worksheet



- C.A. RCN Tab
  - Row Crops, SR + Crop Residue
    - HSG C: 7.08 ac.
  - Open Green Space
    - HSG A: 5.72 ac.
    - HSG B: 0.85 ac.
    - HSG C: 16.39 ac.
  - Impervious Area
    - HSG A: 0.95 ac.
    - HSG B: 0.22 ac.
    - HSG C: 3.11 ac.

Broadkill Estates – C.A. RCN

PROJECT:	Broadkill Estates
DRAINAGE SUBAREA ID:	Eastern Drainage Area
LOCATION (County):	Sussex
UNIT HYDROGRAPH:	DMV

CONTRIBUTING AREA RUNOFF CURVE NUMBER (C.A. RCN) WORKSHEET

Cover Type	Treatment	Hydrologic Condition	A Acres	A RCN	B Acres	B RCN	C Acres	C RCN	D Acres	D RCN
CULTIVATED AGRICULTURAL LANDS										
Fallow	Bare soil	----		77		86		91		94
	Crop residue (CR)	poor		76		85		90		93
	Crop residue (CR)	good		74		83		88		90
Row Crops	Straight row (SR)	poor		72		81		88		91
	Straight row (SR)	good		67		78		85		89
	SR + Crop residue	poor		71		80		87		90
	SR + Crop residue	good		64		75	7.08	82		85
	Contoured (C)	poor		70		79		84		88
	Contoured (C)	good		65		75		82		86
	C + Crop residue	poor		69		78		83		87
	C + Crop residue	good		64		74		81		85
	Cont & terraced(C&T)	poor		66		74		80		82
	Cont & terraced(C&T)	good		62		71		78		81
	C&T + Crop residue	poor		65		73		79		81
	C&T + Crop residue	good		61		70		77		80
Small Grain	Straight row (SR)	poor		65		76		84		88
	Straight row (SR)	good		63		75		83		87
	SR + Crop residue	poor		64		75		83		86
	SR + Crop residue	good		60		72		80		84
	Contoured (C)	poor		63		74		82		85
	Contoured (C)	good		61		73		81		84
	C + Crop residue	poor		62		73		81		84
	C + Crop residue	good		60		72		80		83
	Cont & terraced(C&T)	poor		61		72		79		82
	Cont & terraces(C&T)	good		59		70		78		81
	C&T + Crop residue	poor		60		71		78		81
	C&T + Crop residue	good		58		69		77		80
Close-seeded	Straight row	poor		66		77		85		89
or broadcast	Straight row	good		58		72		81		85
legumes or	Contoured	poor		64		75		83		85
rotation	Contoured	good		55		69		78		83
meadow	Cont & terraced	poor		63		73		80		83
	Cont & terraced	good		51		67		76		80

Offsite Crop – 7.08 Acres

ING AREA RUNOFF CURVE NUMBER (C.A. RCN) WORKSHEET

Treatment	Hydrologic Condition	A Acres	A RCN	B Acres	B RCN	C Acres	C RCN	D Acres	D RCN
OPED URBAN AREAS (Veg Established)									
ns,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%		4.77	39	0.63	61	16.39	74		80
Paved parking lots, roofs, driveways		0.95	98	0.22	98	3.11	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
	Avg % impervious								
Commercial & business	85		89		92		94		95
Industrial	72		81		88		91		93
s by average lot size	Avg % impervious								
/8 acre (town houses)	65		77		85		90		92
/4 acre	38		61		75		83		87
/3 acre	30		57		72		81		86
/2 acre	25		54		70		80		85
1 acre	20		51		68		79		84
2 acre	12		46		65		77		82
URBAN AREA (No Vegetation)									
Newly graded area (pervious only)			77		86		91		94

Subarea Contributing Area per Soil Type (ac)		5.72		0.85		26.58		0	
Subarea Contributing Area (ac)	33.15								

DITRIBUTING 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) 33.2

Weighted Runoff Curve Number (RCN) 74

Proposed On-Site Drainage

Design Level Analysis
LOD & OLOD Worksheets

- LOD Tab
  - HSG A
    - LOD Area: 5.72 ac.
    - Post-Dev. Impervious: 0.95 ac.
  - HSB B
    - LOD Area: 0.85 sc.
    - Post-Dev. Impervious: 0.22 ac.
  - HSB C
    - LOD Area: 19.50 ac.
    - Post-Dev. Impervious: 3.11 ac.
- OLOD Tab
  - Sheet Flow, 100 ft, 0.001 ft/ft. “d”
  - Shallow Conc., 300 ft, 0.002 ft/ft, “u”
  - Channel Flow, 1000 ft, 0.01 ft/ft. 1 fps

Broadkill Estates – LOD

1	PROJECT:	Broadkill Estates			
2	DRAINAGE SUBAREA ID:	Eastern Drainage Area			
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)	5.72	0.85	19.5	
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*	0.95	0.22	3.11	
11	1.4.b Post-Developed Imperviousness Within LOD, Option #2 (%)	17%	26%	16%	0%
12					
13	**Step 2 - Subarea LOD Runoff Calculations**				
14	2.1 RCN per HSG	48.80	70.58	77.83	0.00
15	2.2 RPv per HSG (in.)	0.24	0.95	1.28	0.00
16	2.3 Target Runoff per HSG (in.)	0.01	0.58	1.10	0.00
17	2.4 Cv Weighted Unit Discharge per HSG (cfs/ac)	0.75	0.75	0.75	0.00
18	2.5 Fv Weighted Unit Discharge per HSG (cfs/ac)	2.25	2.25	2.25	0.00
19					
20	2.6 Subarea LOD (ac)	26.07			
21	2.7 Subarea Weighted RCN	71.22			
22	2.8 Subarea Weighted RPv (in.)	1.04			
23	2.9 Subarea Weighted Target Runoff (in.)	0.85			
24					
25	**Step 3 - Upstream LOD Areas** *(from previous DURMM Report as a*	Area 1	Area 2	Area 3	Area 4
26	3.1 Upstream Sub-Area ID				
27	3.2 Upstream LOD Area (ac)				
28	3.3 Target Runoff for Upstream Area (in.)				
29	3.4 Adjusted CN after all reductions				
30	3.5 Adjusted RPv (in.)				
31	3.6 Adjusted Cv (in.)				
32	3.7 Adjusted Fv (in.)				
33					
34	**Step 4 - RPv Calculations for Combined LOD**				
35	4.1 Combined LOD (ac)	26.07			
36	4.2 Weighted RCN	71.22			
37	4.3 Weighted RPv (in.)	1.04			
38	4.4 Weighted Target Runoff (in.)	0.85			
39	4.5 Estimated Annual Runoff (in.)	12.20			
40	4.6 Req'd Runoff Reduction within LOD (in.)	0.19			
41	4.7 Req'd Runoff Reduction within LOD (%)	19%			
42					
43	**Step 5 - Cv Unit Discharge**				
44	5. LOD Allowable Unit Discharge (cfs/ac)	0.75			
45					
46	**Step 6 - Fv Unit Discharge**				
47	6. LOD Allowable Unit Discharge (cfs/ac)	2.25			

RESET

Broadkill Estates – OLOD

1	PROJECT:	Broadkill Estates
2	DRAINAGE SUBAREA ID:	Eastern Drainage Area
3	LOCATION (County):	Sussex
4	UNIT HYDROGRAPH:	DMV
5	OUTSIDE LIMIT OF DISTURBANCE	
6	(OLOD) WORKSHEET	
7	**Step 1 - Site Data**	
8	1.1 Total Contributing Area (ac)	33.15
9	1.2 C.A. RCN	74
10	1.3 LOD Area (ac)	26.07
11	1.4 LOD RCN	71
12	1.5 Outside LOD Area (ac)	7.08
13	1.6 Outside LOD RCN	82
14		

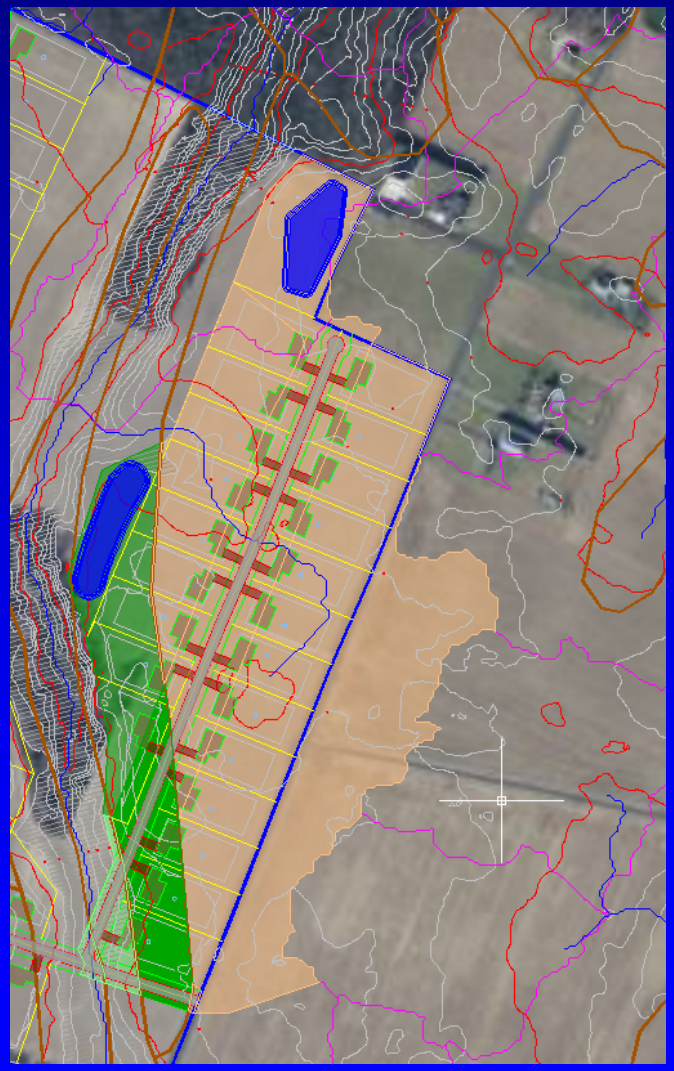
16	**Step 2 - Time of Concentration**	2.1	2.2	2.3	2.4	2.5	2.6
17		LENGTH	SLOPE	SURFACE	MANNINGS	VELOCITY	TRAVEL
18	FLOW TYPE	(feet)	(ft./ft.)	CODE	"n"	(ft./sec.)	TIME (hrs)
19	*Sheet*	100	0.001	d	0.17	N/A	0.59
20					----------	N/A	0.00
21					----------	N/A	0.00
22	*Shallow Concentrated*	300	0.002	u	N/A	0.7	0.12
23					N/A	----------	0.00
24					N/A	----------	0.00
25	*Open Channel*	1000		N/A	0.01	1.0	0.28
26				N/A			0.00
27				N/A			0.00
28				N/A			0.00
29				N/A			0.00
30							
31						2.7 Time of Concentration (Tc)	0.98
32							

CLEAR Tc

33				
34		***Sheet Flow Surface Codes***		***Shallow Concentrated Surface Codes***
35		a smooth surface	f grass, dense	u unpaved surface
36		b fallow (no residue)	g grass, bermuda	p paved surface
37		c cultivated < 20% Res.	h woods, light	
38		d cultivated > 20% Res.	i woods, dense	
39		e grass - range, short	j range, natural	
40				
41				

42	**Step 3 - Peak Discharge**		
43			
44	3.1 Unit Hydrograph Type	DMV	
45	3.2 Frequency (yr)	10	100
46	3.3 24-HR Rainfall, P (in.)	5.3	9.2
47	3.4 Initial Abstraction, Ia (in.)	0.439	0.439
48	3.5 Ia/P ratio	0.08	0.05
49	3.6 Unit Peak Discharge, qu (csm/in)	222	226
50	3.7 Runoff (in.)	3.35	7.01
51	3.8 Peak Discharge, qp (cfs)	8.24	17.49
52	3.9 Equiv. unit peak discharge (cfs/ac)	1.16	2.47
53			

Design Level Analysis
BMP Choices



- 8-B Grassed Channel
- 2-A Bioretention w/ Underdrain
  - 13,550 Cu. Ft.

Broadkill Estates – RPv

PROJECT:	Broadkill Estates
DRAINAGE SUBAREA ID:	Eastern Drainage Area
LOCATION (County):	Sussex

RESOURCE PROTECTION EVENT (RPv) WORKSHEET

RESET

	BMP 1		BMP 2		BMP 3		BMP 4		BMP 5	
	Type	8-B Grassed Channel	Type	2-A Traditional Bioretention - Underdrain	Type	--	Type	--	Type	--
Step 1 - Calculate Initial RPv	Data		Data		Data		Data		Data	
1.1 Total contributing area to BMP (ac)	33.15		33.15		33.15		33.15		33.15	
1.2 *Reserved*										
1.3 Initial RCN	73.52									
1.4 RPv for Contributing Area (in.)	1.07									
1.5 Req'd RPv Reduction for Contributing Area (in.)	0.15									
1.6 Req'd RPv Reduction for Contributing Area (%)	14%									
1.7 RPv allowable discharge rate (cfs)	1.14									
Step 2 - Adjust for Retention Reduction										
2.1 Storage volume (cu. ft.)			13550							
2.2 Retention reduction allowance (%)	0%		50%		N/A		N/A		N/A	
2.3 Retention reduction volume (ac-ft)	0.00		0.16		N/A		N/A		N/A	
2.4 Retention reduction volume (in.)	0.00		0.06		N/A		N/A		N/A	
2.5 Runoff volume after retention reduction (in.)	1.07		0.92		N/A		N/A		N/A	
2.6 Adjusted CN*	73.52		70.02		N/A		N/A		N/A	
Step 3 - Adjust for Annual Runoff Reduction										
3.1 Annual CN (ACN)	73.52		71.34		N/A		N/A		N/A	
3.2 Annual runoff (in.)	13.63		12.27		N/A		N/A		N/A	
3.3 Proportion A/B soils in BMP footprint (%)	0%		0%		0%		0%		0%	
3.4 Annual runoff reduction allowance (%)	10%		0%		N/A		N/A		N/A	
3.5 Annual runoff after reduction (in.)	12.27		12.27		N/A		N/A		N/A	
3.6 Adjusted ACN	71.34		71.34		N/A		N/A		N/A	
3.7 Annual Runoff Reduction Allowance for RPv (in.)	0.10		0.10		N/A		N/A		N/A	
Step 4 - Calculate RPv with BMP Reductions										
4.1 RPv runoff volume after all reductions (in.)	0.98		0.92		N/A		N/A		N/A	
4.2 Total RPv runoff reduction (in.)	0.10		0.15		N/A		N/A		N/A	
4.3 Total RPv runoff reduction (%)	9%		14%		N/A		N/A		N/A	
4.4 Adjusted CN after all reductions	71.34		70.02		N/A		N/A		N/A	
4.5 Adjusted equivalent annual runoff (in.)	12.27		11.49		N/A		N/A		N/A	
4.6 Equivalent TR-55 RCN for H&H modeling	79.08		78.03		N/A		N/A		N/A	
4.7 Required reduction met?	NO		YES		N/A		N/A		N/A	
4.8 If required reduction met, reduction credit (cu.ft)	N/A		-5.64		N/A		N/A		N/A	
Step 5 - Determine Runoff Reduction Shortfall										
5.1 Runoff Reduction Shortfall (in.)	0.06		N/A		N/A		N/A		N/A	
5.2 Runoff Reduction Shortfall (cu.ft./ac)	204		N/A		N/A		N/A		N/A	
5.3 Total Shortfall Volume (cu.ft.)	6,770		N/A		N/A		N/A		N/A	

Broadkill Estates – TMDL

1	PROJECT:	Broadkill Estates																		
2	DRAINAGE SUBAREA ID:	Eastern Drainage Area																		
3	LANDUSE TYPE:	Residential																		
4	TMDL WATERSHED:	Broadkill River																		
5	TOTAL MAXIMUM DAILY LOAD (TMDL) WORKSHEET																			
6		BMP 1				BMP 2				BMP 3				BMP 4				BMP 5			
7		Type:	8-B Grassed Channel			Type:	2-A Traditional Bioretention - Underdrain			Type:	--			Type:	--			Type:	--		
8	*Step 1 - Calculate Annual Runoff Volume*	Data	TN	TP	TSS	Data	TN	TP	TSS	Data	TN	TP	TSS	Data	TN	TP	TSS	Data	TN	TP	TSS
9	1.1 Total contributing area to BMP (ac)	33.15																			
10	1.2 Initial RCN	74																			
11	1.3 Annual runoff volume (in.)	13.63																			
12	1.4 Annual runoff volume (liters)	4.65E+07																			
13																					
14	*Step 2 - Calculate Annual Pollutant Load*																				
15	2.1 EMC (mg/L)		2.00	0.27	60.00		2.00	0.27	60.00		N/A	N/A	N/A		N/A	N/A	N/A		N/A	N/A	N/A
16	2.2 Load (mg/yr)		9.29E+07	1.25E+07	2.79E+09		8.36E+07	1.13E+07	2.51E+09		N/A	N/A	N/A		N/A	N/A	N/A		N/A	N/A	N/A
17	2.3 Stormwater Load (lb/ac/yr)		6.18	0.83	185.38		5.56	0.75	166.85		N/A	N/A	N/A		N/A	N/A	N/A		N/A	N/A	N/A
18																					
19	*Step 3 - Adjust for Pollutant Reduction*																				
20	3.1 BMP annual runoff reduction (%)	10%				6%				N/A				N/A				N/A			
21	3.2 Adjusted annual runoff volume (in)	12.27				11.49				N/A				N/A				N/A			
22	3.3 Adjusted annual runoff volume (liters)	4.18E+07				3.92E+07				N/A				N/A				N/A			
23	3.4 Adjusted load from annual reductions (lb/ac/yr)		5.56	0.75	166.85		5.21	0.70	156.29		N/A	N/A	N/A		N/A	N/A	N/A		N/A	N/A	N/A
24	3.5 BMP removal efficiency (%)		N/A	N/A	N/A		30%	40%	80%		N/A	N/A	N/A		N/A	N/A	N/A		N/A	N/A	N/A
25	3.6 Treatment train removal efficiency (%)		N/A	N/A	N/A		23%	30%	60%		N/A	N/A	N/A		N/A	N/A	N/A		N/A	N/A	N/A
26	3.7 BMP effluent concentration (mg/L)		2.00	0.27	60.00		1.55	0.19	24.00		N/A	N/A	N/A		N/A	N/A	N/A		N/A	N/A	N/A
27	3.8 Final Adjusted load (lb/ac/yr)		5.56	0.75	166.85		4.04	0.49	62.51		N/A	N/A	N/A		N/A	N/A	N/A		N/A	N/A	N/A
28	3.9 Final Adjusted load (lb/yr)		184.36	24.89	5530.93		133.84	16.32	2072.37		N/A	N/A	N/A		N/A	N/A	N/A		N/A	N/A	N/A
29																					
30	*Step 4 - Pollutant Reduction Met? (For Informational Purposes)*																				
31	4.1 TMDL (lb/ac/yr)		11.90	0.50	N/A																
32	4.2 Reduction met?		YES	NO	N/A		YES	YES	N/A		N/A	N/A	N/A		N/A	N/A	N/A		N/A	N/A	N/A
33	4.3 Removed Load (lb/yr)		20.49	2.77	614.55		50.52	8.57	3458.56		N/A	N/A	N/A		N/A	N/A	N/A		N/A	N/A	N/A
34																					

Broadkill Estates – Cv

1	**PROJECT:**	Broadkill Estates									
2	**DRAINAGE SUBAREA ID:**	Eastern Drainage Area									
3	**LOCATION (County):**	Sussex									
4	**CONVEYANCE EVENT (Cv) WORKSHEET**										
5		**BMP 1**		**BMP 2**		**BMP 3**		**BMP 4**		**BMP 5**	
6		**Type:**	**8-B Grassed Channel**	**Type:**	**2-A Traditional Bioretention -**	**Type:**	--	**Type:**	--	**Type:**	--
7	***Step 1 - Calculate Initial Cv***	**Data**		**Data**		**Data**		**Data**		**Data**	
8	1.1 Total contributing area to BMP (ac)	33.15		33.15		33.15		33.15		33.15	
9	1.2 Initial RCN	73.52									
10	1.3 10-Year Rainfall (in.)	5.3									
11	1.4 Cv runoff volume (in.)	2.56									
12	1.5 LOD allowable unit discharge (cfs/ac)	0.75									
13	1.6 Equiv. unit discharge outside LOD (cfs/ac)	1.16									
14	1.7 Cv allowable discharge rate (cfs)	27.79									
15											
16	***Step 2 - Adjust for Retention Reduction***										
17	2.1 Storage volume (cu. ft.)	0.00		13550.00		N/A		N/A		N/A	
18	2.2 Storage volume (ac-ft)	0.00		0.31		N/A		N/A		N/A	
19	2.3 Storage volume (in.)	0.00		0.11		N/A		N/A		N/A	
20	2.4 Runoff volume after reduction (in.)	2.56		2.43		N/A		N/A		N/A	
21	2.5 CN*	73.52		71.93		N/A		N/A		N/A	
22											
23	***Step 3 - Adjust for Annual Runoff Reduction***										
24	3.1 Runoff reduction allowance (%)	1%		0%		N/A		N/A		N/A	
25	3.2 Annual runoff after reduction (in.)	2.54		2.54		N/A		N/A		N/A	
26	3.3 Adjusted ACN	73.23		73.23		N/A		N/A		N/A	
27	3.4 Event-based runoff reduction (in.)	0.03		0.03		N/A		N/A		N/A	
28											
29	***Step 4 - Calculate Cv with BMP Reductions***										
30	4.1 Cv runoff volume after all reductions (in.)	2.54		2.43		N/A		N/A		N/A	
31	4.2 Total Cv runoff reduction (%)	1%		5%		N/A		N/A		N/A	
32	4.3 Adjusted RCN for H&H modeling	73.23		71.93		N/A		N/A		N/A	

Broadkill Estates – Fv

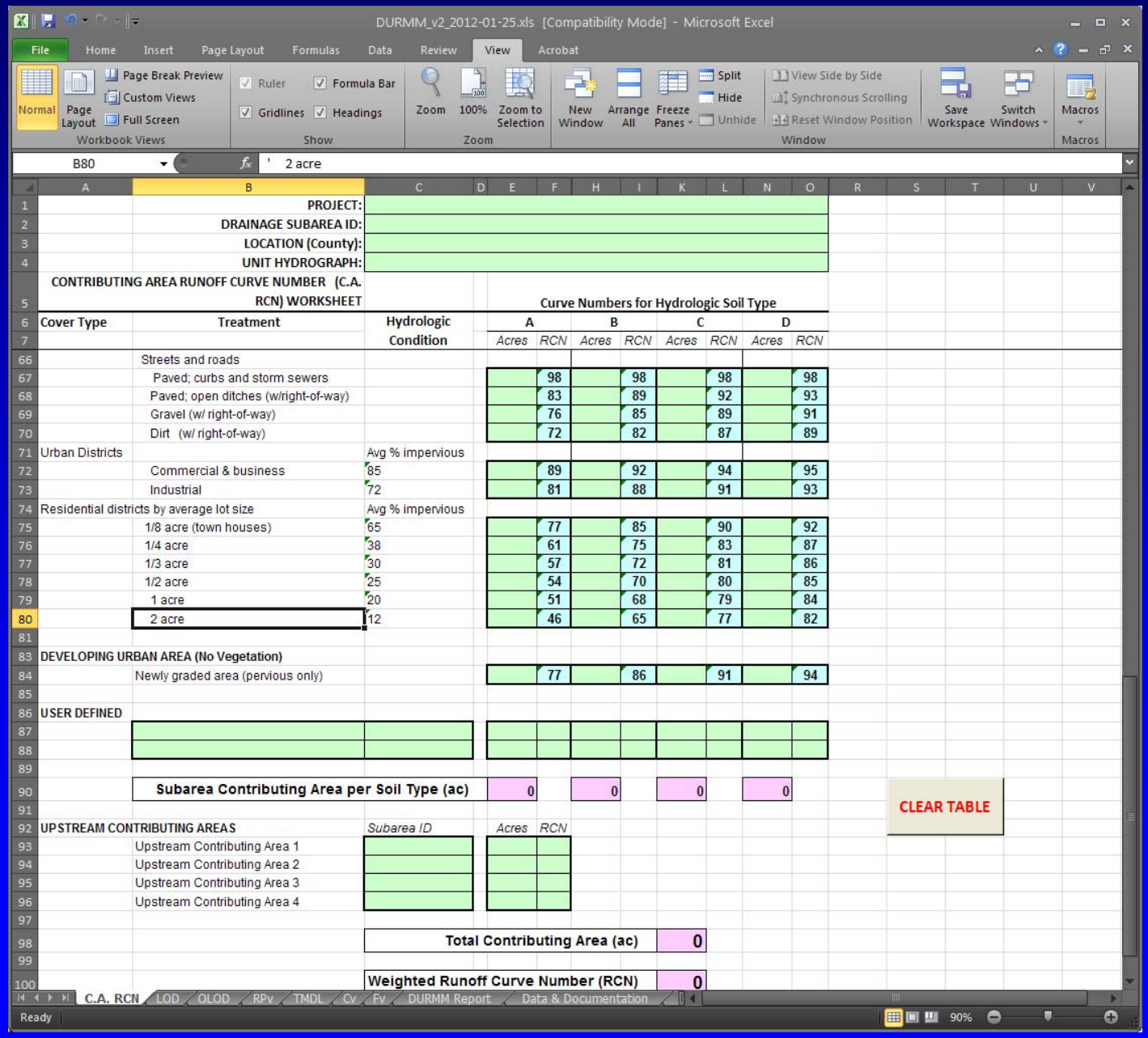
1	**PROJECT:**	Broadkill Estates									
2	**DRAINAGE SUBAREA ID:**	Eastern Drainage Area									
3	**LOCATION (County):**	Sussex									
4	**FLOODING EVENT (Fv) WORKSHEET**										
5		**BMP 1**		**BMP 2**		**BMP 3**		**BMP 4**		**BMP 5**	
6		**Type:**	**8-B Grassed Channel**	**Type:**	**2-A Traditional Bioretention -**	**Type:**	--	**Type:**	--	**Type:**	--
7	***Step 1 - Calculate Initial Fv***	**Data**		**Data**		**Data**		**Data**		**Data**	
8	1.1 Total contributing area to BMP (ac)	33.15		33.15		33.15		33.15		33.15	
9	1.2 Initial RCN	73.52									
10	1.3 100-Year Rainfall (in.)	9.2									
11	1.4 Fv runoff volume (in.)	5.95									
12	1.5 LOD allowable unit discharge (cfs/ac)	2.25									
13	1.6 Equiv. unit discharge outside LOD (cfs/ac)	2.47									
14	1.7 Fv allowable discharge rate (cfs)	76.15									
15											
16	***Step 2 - Adjust for Retention Reduction***										
17	2.1 Storage volume (cu. ft.)	0.00		13550.00		N/A		N/A		N/A	
18	2.2 Storage volume (ac-ft)	0.00		0.31		N/A		N/A		N/A	
19	2.3 Storage volume (in.)	0.00		0.11		N/A		N/A		N/A	
20	2.4 Runoff volume after reduction (in.)	5.95		5.84		N/A		N/A		N/A	
21	2.5 CN*	73.52		72.62		N/A		N/A		N/A	
22											
23	***Step 3 - Adjust for Annual Runoff Reduction***										
24	3.1 Runoff reduction allowance (%)	0%		0%		N/A		N/A		N/A	
25	3.2 Annual runoff after reduction (in.)	5.95		5.95		N/A		N/A		N/A	
26	3.3 Adjusted ACN	73.52		73.52		N/A		N/A		N/A	
27	3.4 Event-based runoff reduction (in.)	0.00		0.00		N/A		N/A		N/A	
28											
29	***Step 4 - Calculate Fv with BMP Reductions***										
30	4.1 Fv runoff volume after all reductions (in.)	5.95		5.84		N/A		N/A		N/A	
31	4.2 Total Fv runoff reduction (%)	0%		2%		N/A		N/A		N/A	
32	4.3 Adjusted RCN for H&H modeling	73.52		72.62		N/A		N/A		N/A	

Broadkill Estates – Report

1	PROJECT:	Broadkill Estates			
2	DRAINAGE SUBAREA ID:	Eastern Drainage Area			
3	COUNTY:	Sussex	UNIT HYDROGRAPH:	DMV	
4	TMDL Watershed:	Broadkill River	LANDUSE:	Residential	
5	DURMM OUTPUT WORKSHEET				DURMM v2.00.130226
6	***Site Data***				
7	Contributing Area to BMPs (ac.)	33.15			
8	C.A. RCN	73.52			
9	Subarea LOD (ac.)	26.07			
10	Subarea RCN	71.22			
11	Upstream Subarea ID				
12	Upstream Subarea LOD (ac.)	0.00	0.00	0.00	0.00
13	Combined LOD with Upstream Areas (ac.)	26.07			
14	Combined RCN with Upstream Areas (ac.)	71.22			
15	Watershed TMDL-TN (lb/ac/yr)	11.90			
16	Watershed TMDL-TP (lb/ac/yr)	0.50			
17	Watershed TMDL-TSS (lb/ac/yr)	N/A			
18					
19	***BMP Data***	**BMP 1**	**BMP 2**	**BMP 3**	**BMP 4**	**BMP 5**
20						
21		8-B Grassed Channel	2-A Traditional Bioretention - Underdrain	--	--	--
22						
23	RPv runoff volume after all reductions (in.)	0.98	0.92	N/A	N/A	N/A
24	Total RPv runoff reduction (in.)	0.10	0.15	N/A	N/A	N/A
25	Total RPv runoff reduction (%)	9%	14%	N/A	N/A	N/A
26	Req'd runoff reduction met?	NO	YES	N/A	N/A	N/A
27	RPv Offset Volume (cu. ft.)	6,770	N/A	N/A	N/A	N/A
28	Adjusted pollutant load, TN (lb/ac/yr)	5.56	4.04	N/A	N/A	N/A
29	Adjusted pollutant load, TP (lb/ac/yr)	0.75	0.49	N/A	N/A	N/A
30	Adjusted pollutant load, TSS (lb/ac/yr)	166.85	62.51	N/A	N/A	N/A
31	Cv runoff volume after all reductions (in.)	2.54	2.43	N/A	N/A	N/A
32	Fv runoff volume after all reductions (in.)	5.95	5.84	N/A	N/A	N/A
33						
34	***Resource Protection Event (RPV)***				
35	RPv for Contributing Area (in.)	1.07			
36	Annual Runoff for Contributing Area (in.)	13.63			
37	Req'd RPv Reduction for Contributing Area (in.)	0.15			
38	Req'd RPv Reduction for Contributing Area (%)	14%			
39	RPv Runoff Reduction Shortfall or Credit (cu.ft.)	-5.64	CREDIT		
40	C.A. allowable discharge rate (cfs)	1.14			
41	Adjusted CN after all reductions	70.02			
42	Equivalent RCN for H&H Modeling	78.03			

1	PROJECT:	Broadkill Estates			
2	DRAINAGE SUBAREA ID:	Eastern Drainage Area			
3	COUNTY:	Sussex	UNIT HYDROGRAPH:	DMV	
4	TMDL Watershed:	Broadkill River	LANDUSE:	Residential	
5	DURMM OUTPUT WORKSHEET				DURMM v2.00.130226
43					
44	***Conveyance Event (Cv)***				
45	Cv runoff volume (in.)	2.56			
46	Stds-based allowable discharge (cfs)	27.79			
47	Equivalent RCN for H&H Modeling	71.93			
48					
49	***Flooding Event (Fv)***				
50	Fv runoff volume (in.)	5.95			
51	Stds-based allowable discharge (cfs)	76.15			
52	Equivalent RCN for H&H Modeling	72.62			
53					
54	***Adjusted Subarea Data for Downstream DURMM Modeling***				
55	Subarea ID	ern Drainage Area			
56	Contributing Area (ac.)	33.15			
57	C.A. RCN	73.52			
58	LOD Area (ac.)	26.07			
59	Weighted Target Runoff (in.)	0.85			
60	Adjusted CN after all reductions	70.02			
61	Adjusted RPv (in.)	0.92			
62	Adjusted Cv (in.)	2.43			
63	Adjusted Fv (in.)	5.84			
64					
65	***Adjusted Subarea Data for Nutrient Protocol Modeling***				
66	Contributing Area (ac.)	33.15			
67	LOD Area (ac.)	26.07			
68	TN Pollutant Load (lb/yr)	133.84			
69	TP Pollutant Load (lb/yr)	16.32			
70	TSS Pollutant Load (lb/yr)	2072.37			
71	Percent Impervious Cover	16%			
72					
73	***Adjusted Subarea Data for the Summary Table for Sub-Areas Draining to a Common Point of Interest***				
74	Subarea ID	ern Drainage Area			
75	Contributing Area (ac.)	33.15			
76	Runoff Reduction Shortfall or Credit (cu.ft.)	-5.64	CREDIT		
77	Adjusted CN after all reductions	70.02			
78	Cv RCN for H&H Modeling	71.93			
79	Fv RCN for H&H Modeling	72.62			
80	TN Pollutant Load (lb/yr)	133.84			
81	TP Pollutant Load (lb/yr)	16.32			
82	TSS Pollutant Load (lb/yr)	2072.37			

Questions?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Custom Views
Full Screen
Workbook Views
Ruler
Formula Bar
Gridlines
Headings
Show
Zoom
100%
Zoom to Selection
Zoom
New Window
Arrange All
Freeze Panes
Split
Hide
Unhide
View Side by Side
Synchronous Scrolling
Reset Window Position
Window
Save Workspace
Switch Windows
Macros
B80
2 acre
PROJECT:
DRAINAGE SUBAREA ID:
LOCATION (County):
UNIT HYDROGRAPH:
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
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 0 0
CLEAR TABLE
UPSTREAM CONTRIBUTING AREAS
Subarea ID
Upstream Contributing Area 1
Upstream Contributing Area 2
Upstream Contributing Area 3
Upstream Contributing Area 4
Total Contributing Area (ac) 0
Weighted Runoff Curve Number (RCN) 0
C.A. RCN
LOD
OLOD
RPv
TMDL
Cv
Fv
DURMM Report
Data & Documentation
Ready
90%

Revisions to the Delaware Sediment & Stormwater Regulations

Broadkill Estates

Cv & Fv Compliance

Options for Cv & Fv Compliance

- Option 1, Standards-Based Unit Discharge
- Option 2, Performance Based H&H Analysis
  - Level 1 – Peak Comparison
  - Level 2a – Pre vs Post Comparison
  - Level 2b – Steady Flow Water Surface Model
  - Level 3 – Unsteady Flow Water Surface Model

Compliance does not have to be shown in chronological order; but will be discussed in order

STATE OF DELAWARE
DEPARTMENT OF NATURAL RESOURCES
AND ENVIRONMENTAL CONTROL
DIVISION OF WATERSHED STEWARDSHIP
89 Kings Highway
DOVER, DELAWARE 19901

PHONE: (302) 739-9921
FAX: (302) 739-6724

SEDIMENT AND STORMWATER PLAN APPROVAL

Tracking No.: 2013-028

Issued To: Michael R ... tions
Departm
1901 N
New C

September 20, 2013

Dear Mr. Bundek,

Your plans for th ... Parking Lot Rehabilita ... as submitted by your authorized age ... Bowen & Friede, Inc. have been reviewed and evaluated reg ... Management Requirements of this Division and are approved wit ...

Approval o ... does not grant or imply a right to discharge stormwater runoff. The ... acquiring any and all agreements, easements, etc., necessary to ... and other applicable laws. Effective July 1, 2004, all State and Federal projects will ... vices by an approved Certified Construction Reviewer.

This plan approval perta ... pliance with the *Delaware Sediment and Stormwater Regulations*, effective January 23, 1991, a ... current version of the Delaware Erosion and Sediment Control Handbook. Please understand that the approval of this plan does not relieve you from complying with any and all federal, state, county, or municipal laws and regulations.

We provide technical assistance, environmental education, and training to those we regulate. If we may be of any assistance to you, regarding the sediment and stormwater specifications of this project, please contact us at the address and number listed above.

Sincerely,

Elaine Z. Webb

Elaine Z. Webb, P.E.
Engineer IV

cc: Jamie Rutherford, Program Manager II
Ring Lardner, DBF

APPROVED

Delaware's good nature depends on you!

Options for Cv & Fv Compliance

Option 1, Standards-Based Unit Discharge

Option 1, Standards-based Unit Discharge (cfs/ac)

- Only projects that receive **All Minor** ratings on the SAR qualify for the Unit Discharge option
- Per the SAS study for the Broadkill Estates example, this project Does Not qualify for the Standards Based Approach → Calculations shown for informational purposes only!

Stormwater Assessment Report

Project: _____

Owner/Developer: _____

Consultant: _____

Assessment Item	*Anticipated Engineering Effort*		
	Minor	*Moderate*	*Significant*
1. Soils - On-site soils have low permeability, high water table, or other limitations that could adversely affect adequate stormwater management for the proposed project.	☑	☐	☐
2. Runoff Potential - Change in land cover due to removal of trees, increases in impervious cover, etc. could adversely affect adequate stormwater management for the proposed project.	☑	☐	☐
3. Water Resource Protection - Site conditions may adversely affect runoff reduction and/or pollutant loading reductions.	☑	☐	☐
4. Sump Conditions - Existing topography of site creates depressional areas (closed 2' contours) where runoff tends to collect without direct discharge.	☑	☐	☐
5. Discharge Points - Areas where stormwater runoff leaves the site have limitations due to low gradient, backwater effects, lack of a defined channel or other hydraulic limitations.	☑	☐	☐
6. Off-Site Drainage - Areas draining into the site could adversely affect adequate stormwater management for the proposed project.	☑	☐	☐
7. Conveyance - Downstream conditions such as inadequate pipe or channel capacity could limit adequate drainage from the site.	☑	☐	☐

Mitigation under consideration for "Significant" ratings:

- ☐ Over-management
- ☐ Off-site improvements
- ☐ Easement(s)
- ☐ Offset Option

Reporting Agency: _____

Contact Person: _____

Date of Project-Application Meeting: _____

03/2013 3.02.1.3-1

Options for Cv & Fv Compliance

Option 1, Standards-Based Unit Discharge

Unit Discharge

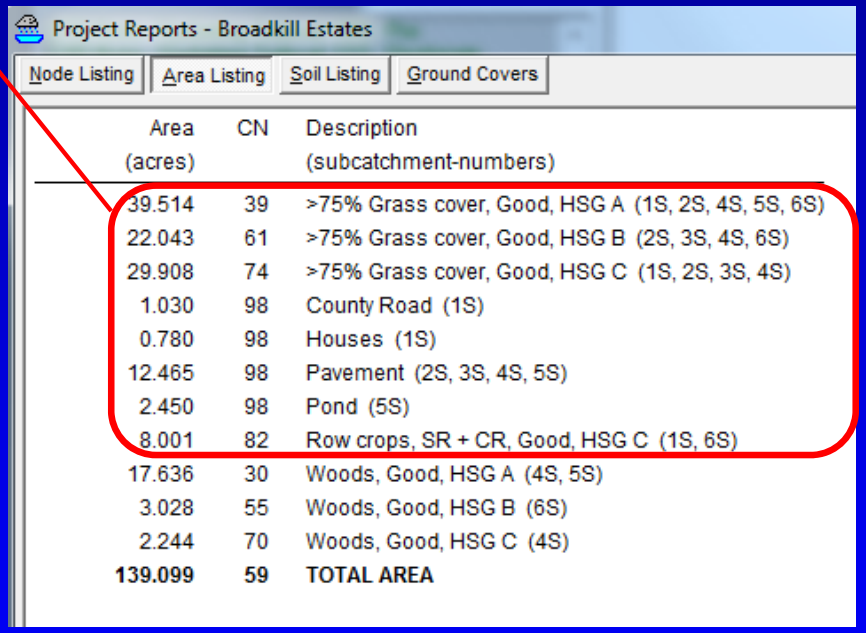
- Based on 2007 LULC
- Use Site Area, including any Off-Site Areas that are routed through a BMP
- Non-Woodland/Non-Meadow
  - » 10-YR: 0.75 cfs/ac
  - » 100-YR: 2.25 cfs/ac
- Woodland/Meadow
  - » 10-YR: 0.375 cfs/ac
  - » 100-YR: 1.25 cfs/ac
- HSG-A Woods
  - » 10-YR: 0 cfs/ac
  - » 100-YR: 0.25 cfs/ac

Options for Cv & Fv Compliance

Option 1, Standards-Based Unit Discharge

Allowable Site Unit Discharge

- Non-Woodland/Non-Meadow
  - » 10-YR: 0.75 cfs/ac * 116.19 ac = 87.14 cfs
  - » 100-YR: 2.25 cfs/ac * 116.19 ac = 261.43 cfs



Project Reports - Broadkill Estates

Node Listing | Area Listing | Soil Listing | Ground Covers

Area (acres)	CN	Description (subcatchment-numbers)
39.514	39	>75% Grass cover, Good, HSG A (1S, 2S, 4S, 5S, 6S)
22.043	61	>75% Grass cover, Good, HSG B (2S, 3S, 4S, 6S)
29.908	74	>75% Grass cover, Good, HSG C (1S, 2S, 3S, 4S)
1.030	98	County Road (1S)
0.780	98	Houses (1S)
12.465	98	Pavement (2S, 3S, 4S, 5S)
2.450	98	Pond (5S)
8.001	82	Row crops, SR + CR, Good, HSG C (1S, 6S)
17.636	30	Woods, Good, HSG A (4S, 5S)
3.028	55	Woods, Good, HSG B (6S)
2.244	70	Woods, Good, HSG C (4S)
139.099	**59**	**TOTAL AREA**

Options for Cv & Fv Compliance

Option 1, Standards-Based Unit Discharge

Allowable Site Unit Discharge

- Non-Woodland/Non-Meadow
  - » 10-YR: 0.75 cfs/ac * 116.19 ac = 87.14 cfs
  - » 100-YR: 2.25 cfs/ac * 116.19 ac = 261.43 cfs

- Woodland/Meadow
  - » 10-YR: 0.375 cfs/ac * 5.27 ac = 1.98 cfs
  - » 100-YR: 1.25 cfs/ac* 5.27 ac = 6.64 cfs

Project Reports - Broadkill Estates

Node Listing | Area Listing | Soil Listing | Ground Covers

Area (acres)	CN	Description (subcatchment-numbers)
39.514	39	>75% Grass cover, Good, HSG A (1S, 2S, 4S, 5S, 6S)
22.043	61	>75% Grass cover, Good, HSG B (2S, 3S, 4S, 6S)
29.908	74	>75% Grass cover, Good, HSG C (1S, 2S, 3S, 4S)
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139.099	**59**	**TOTAL AREA**

Options for Cv & Fv Compliance

Option 1, Standards-Based Unit Discharge

Allowable Site Unit Discharge

- Non-Woodland/Non-Meadow
  - » 10-YR: 0.75 cfs/ac * 116.19 ac = 87.14 cfs
  - » 100-YR: 2.25 cfs/ac * 116.19 ac = 261.43 cfs
- Woodland/Meadow
  - » 10-YR: 0.375 cfs/ac * 5.27 ac = 1.98 cfs
  - » 100-YR: 1.25 cfs/ac* 5.27 ac = 6.64 cfs
- HSG-A Woods
  - » 10-YR: 0 cfs/ac * 17.64 ac = 0 cfs
  - » 100-YR: 0.25 cfs/ac * 17.64 ac = 4.41 cfs

Project Reports - Broadkill Estates

Node Listing | Area Listing | Soil Listing | Ground Covers

Area (acres)	CN	Description (subcatchment-numbers)
39.514	39	>75% Grass cover, Good, HSG A (1S, 2S, 4S, 5S, 6S)
22.043	61	>75% Grass cover, Good, HSG B (2S, 3S, 4S, 6S)
29.908	74	>75% Grass cover, Good, HSG C (1S, 2S, 3S, 4S)
1.030	98	County Road (1S)
0.780	98	Houses (1S)
12.465	98	Pavement (2S, 3S, 4S, 5S)
2.450	98	Pond (5S)
8.001	82	Row crops, SR + CR, Good, HSG C (1S, 6S)
17.636	30	Woods, Good, HSG A (4S, 5S)
3.028	55	Woods, Good, HSG B (6S)
2.244	70	Woods, Good, HSG C (4S)
139.099	**59**	**TOTAL AREA**

Options for Cv & Fv Compliance

Option 1, Standards-Based Unit Discharge

Allowable Site Unit Discharge

- Non-Woodland/Non-Meadow
  - » 10-YR: 0.75 cfs/ac * 116.19 ac = 87.14 cfs
  - » 100-YR: 2.25 cfs/ac * 116.19 ac = 261.43 cfs
- Woodland/Meadow
  - » 10-YR: 0.375 cfs/ac * 5.27 ac = 1.98 cfs
  - » 100-YR: 1.25 cfs/ac* 5.27 ac = 6.64 cfs
- HSG-A Woods
  - » 10-YR: 0 cfs/ac * 17.64 ac = 0 cfs
  - » 100-YR: 0.25 cfs/ac * 17.64 ac = 4.41 cfs
- Total Allowable Unit Discharge
  - » 10-YR: 87.14 cfs + 1.98 cfs + 0 cfs = 89.12 cfs
  - » 100-YR: 261.43 cfs + 6.64 cfs + 4.41 cfs = 272.48 cfs
  - » (For a Total of 139.10 ac)

Project Reports - Broadkill Estates

Node Listing | Area Listing | Soil Listing | Ground Covers

Area (acres)	CN	Description (subcatchment-numbers)
39.514	39	>75% Grass cover, Good, HSG A (1S, 2S, 4S, 5S, 6S)
22.043	61	>75% Grass cover, Good, HSG B (2S, 3S, 4S, 6S)
29.908	74	>75% Grass cover, Good, HSG C (1S, 2S, 3S, 4S)
1.030	98	County Road (1S)
0.780	98	Houses (1S)
12.465	98	Pavement (2S, 3S, 4S, 5S)
2.450	98	Pond (5S)
8.001	82	Row crops, SR + CR, Good, HSG C (1S, 6S)
17.636	30	Woods, Good, HSG A (4S, 5S)
3.028	55	Woods, Good, HSG B (6S)
2.244	70	Woods, Good, HSG C (4S)
139.099	**59**	**TOTAL AREA**

Options for Cv & Fv Compliance

Option 1, Standards-Based Unit Discharge

Summary Results for Junction "Site - Combined"

Project: Broadkill Estates
Simulation Run: Sussex 10-YR Junction: Site - Combined

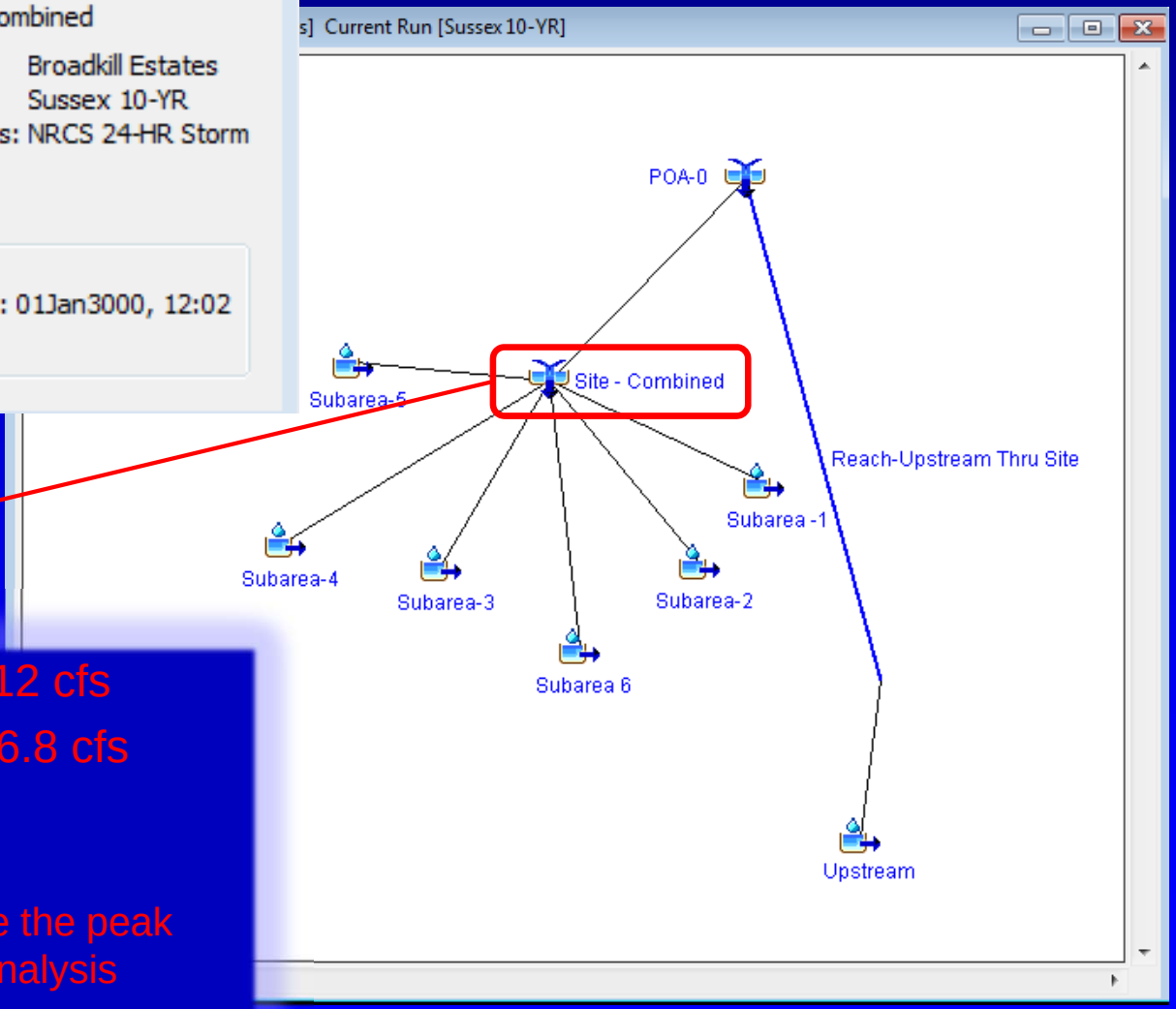
Start of Run:	01Jan3000, 00:00	Basin Model:	Broadkill Estates
End of Run:	03Jan3000, 00:00	Meteorologic Model:	Sussex 10-YR
Compute Time:	17Oct2013, 11:09:16	Control Specifications:	NRCS 24-HR Storm

Volume Units: IN AC-FT

Computed Results

Peak Outflow : 186.8 (CFS) Date/Time of Peak Outflow : 01Jan3000, 12:02
Total Outflow : 1.94 (IN)

Total Site Discharge
for the Combined Site



» 10-YR Allowable Discharge = 89.12 cfs

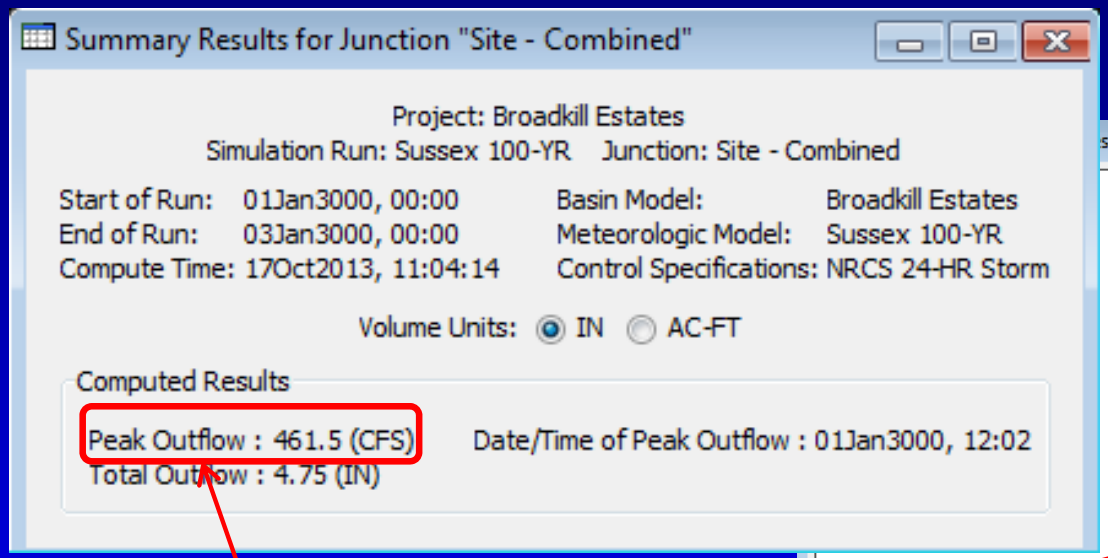
» 10-YR HEC-HMS Discharge = 186.8 cfs

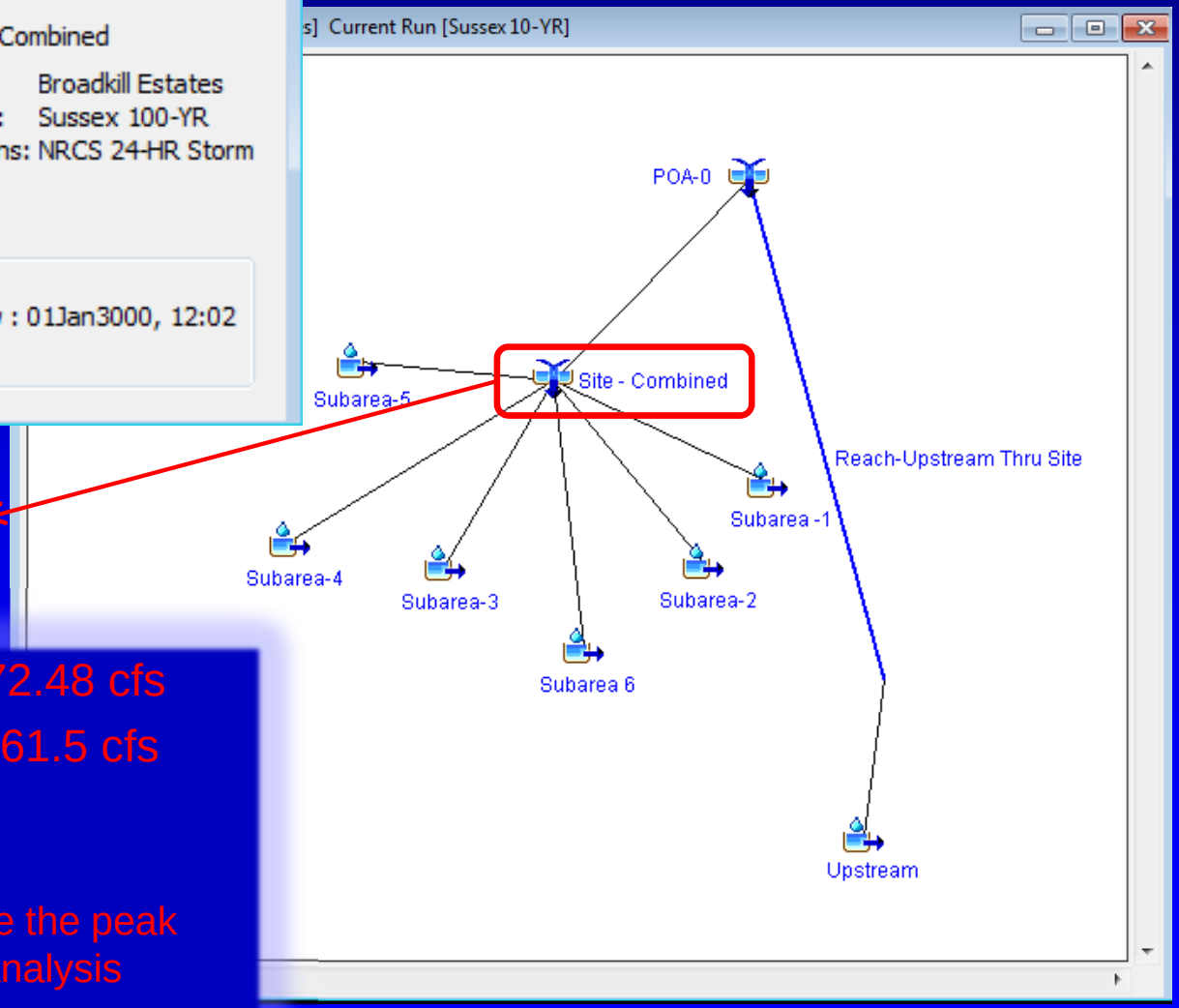
X No Compliance

Either provide detention storage to reduce the peak outflow, or proceed to Option 2, Level 1 analysis

Options for Cv & Fv Compliance

Option 1, Standards-Based Unit Discharge





Total Site Discharge for the Combined Site

- » 100-YR Allowable Discharge = 272.48 cfs
- » 100-YR HEC-HMS Discharge = 461.5 cfs

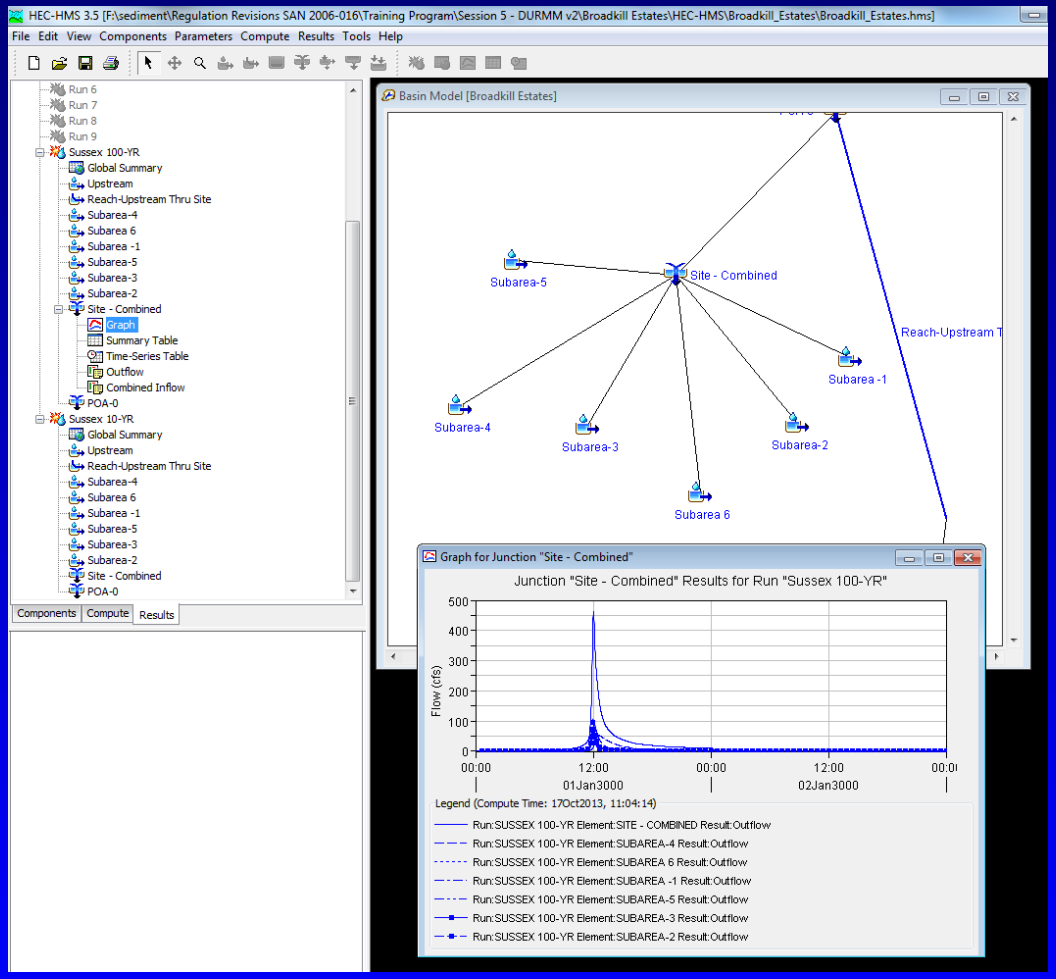
X No Compliance

Either provide detention storage to reduce the peak outflow, or proceed to Option 2, Level 1 analysis

Options for Cv & Fv Compliance

Option 2, Performance-Based H&H Analysis

- Option 2
  - Performance-based
  - Criteria based on:
    - hydrograph timing
    - channel stability
    - system capacity
  - H&H analysis required
  - 3 Levels of increasing detail
    - Level 1, Peak Comparison
    - Level 2
      - a. Site Pre & Post Comparison
      - b. Steady Flow Watershed Model
    - Level 3, Un-Steady Flow Watershed Model



Options for Cv & Fv Compliance

Option 2, Level 1 Peak Comparison

Procedure for Conducting Hydrologic & Hydraulic Analyses For Preliminary Sediment & Stormwater Plans

Background

The Hydrologic & Hydraulic (H&H) Analysis couples field collected data with desktop watershed modeling methodology to provide a tool for stormwater management agencies to help determine the most appropriate method to manage stormwater runoff from developing sites based on "No Adverse Impact" principles. The general approach is one of increasing level of detail and analysis depending on the complexity of the watershed. It is NOT intended to be a substitute for detailed Watershed Master Plans that have been endorsed by the Department. When such detailed plans are available, the peak discharge and/or volume management requirements from the Watershed Master Plan shall take precedence over the requirements of the Level 2 Analysis. Additionally, the methodologies used for this analysis are not considered to be precise enough to be applied at the site level.

Procedure

1. **Applicability**
   1.1. The H&H analysis will be required for all projects using the performance-based option and/or where a sump condition exists.
2. **Methodology**
   2.1. Level 1 Analysis
      2.1.1. The Level 1 Analysis combines field reconnaissance data with hydrologic modeling of the upstream watershed and site using latest soils, LULC, and terrain data. Hydrographs are then compared to check for coincidental peaking effects.
      2.1.2. Limit of study shall be the most-downstream junction of the site and the upstream contributing area.
      2.1.3. To comply at this level of analysis, hydrologic modeling must indicate no adverse impact due to coincidental peaking effects. For purposes of this policy, "no adverse impact" shall mean that the developed site hydrograph peak is less than, and the inflection point occurs before, the peak of the upstream hydrograph OR that it can be demonstrated that on-site detention would exacerbate downstream impacts. If compliance cannot be demonstrated, proceed to Level 2.
   2.2. Level 2 Analysis
      2.2.1. The Level 2 Analysis combines field measurement data with hydraulic modeling of structures, channels, etc. using an expanded hydrologic model.

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- Level 1: Peak comparison

Article 3.02.2.2, Technical Document

Options for Cv & Fv Compliance

Option 2, Level 1 Peak Comparison

Procedure for Conducting Hydrologic & Hydraulic Analyses for Preliminary Sediment & Stormwater Plans, Sect. 2.1.3:

To comply at this level of analysis, hydrologic modeling must indicate no adverse impact due to coincidental peaking effects. For purposes of this policy, "no adverse impact" shall mean that the developed site hydrograph peak is less than, and the inflection point occurs before, the peak of the upstream hydrograph OR that it can be demonstrated that on-site detention would exacerbate downstream impacts.

Options for Cv & Fv Compliance

Option 2, Level 1 Peak Comparison

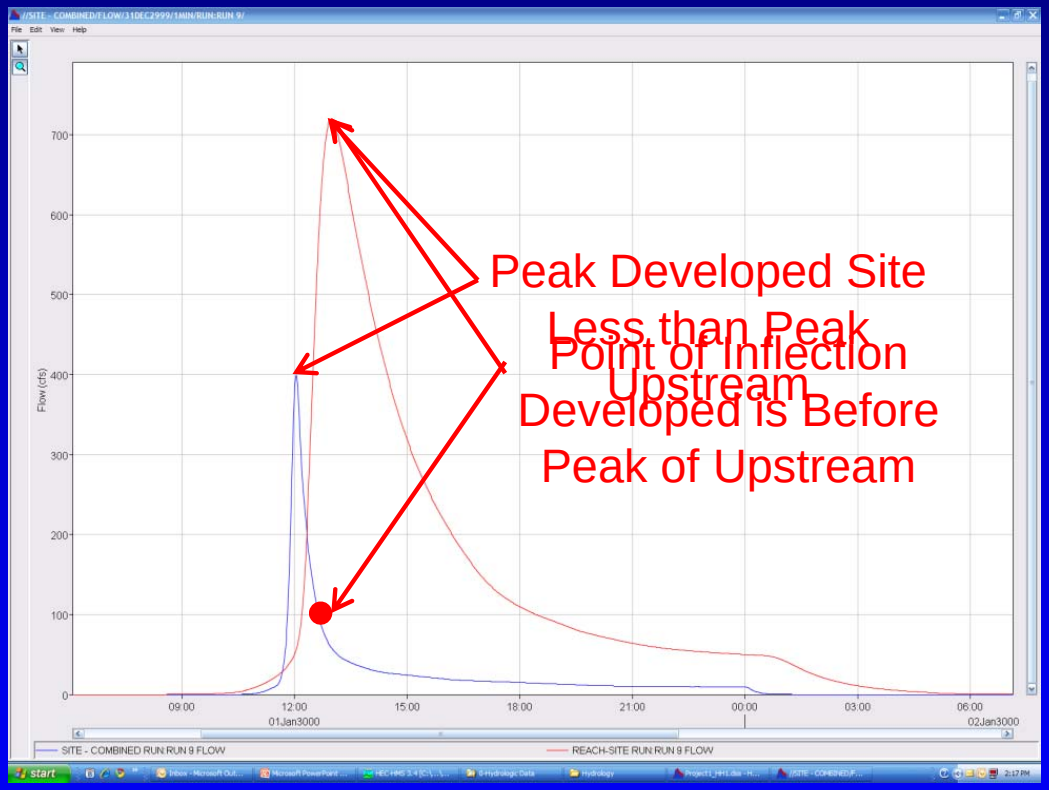
Procedure for Conducting Hydrologic & Hydraulic Analyses for Preliminary Sediment & Stormwater Plans, Sect. 2.1.3:

To comply at the level of analysis, hydrologic modeling must indicate no adverse impact due to coincidental peaking effects. For purposes of this policy, "no adverse impact" shall mean that the developed site hydrograph peak is less than and the inflection point occurs before, the peak of the upstream hydrograph OR that it can be demonstrated that on-site detention would exacerbate downstream impacts.

Compare the Combined Site Hydrograph to the Upstream Hydrograph for both Timing and Peak Discharge.

Options for Cv & Fv Compliance

Option 2, Level 1 Peak Comparison

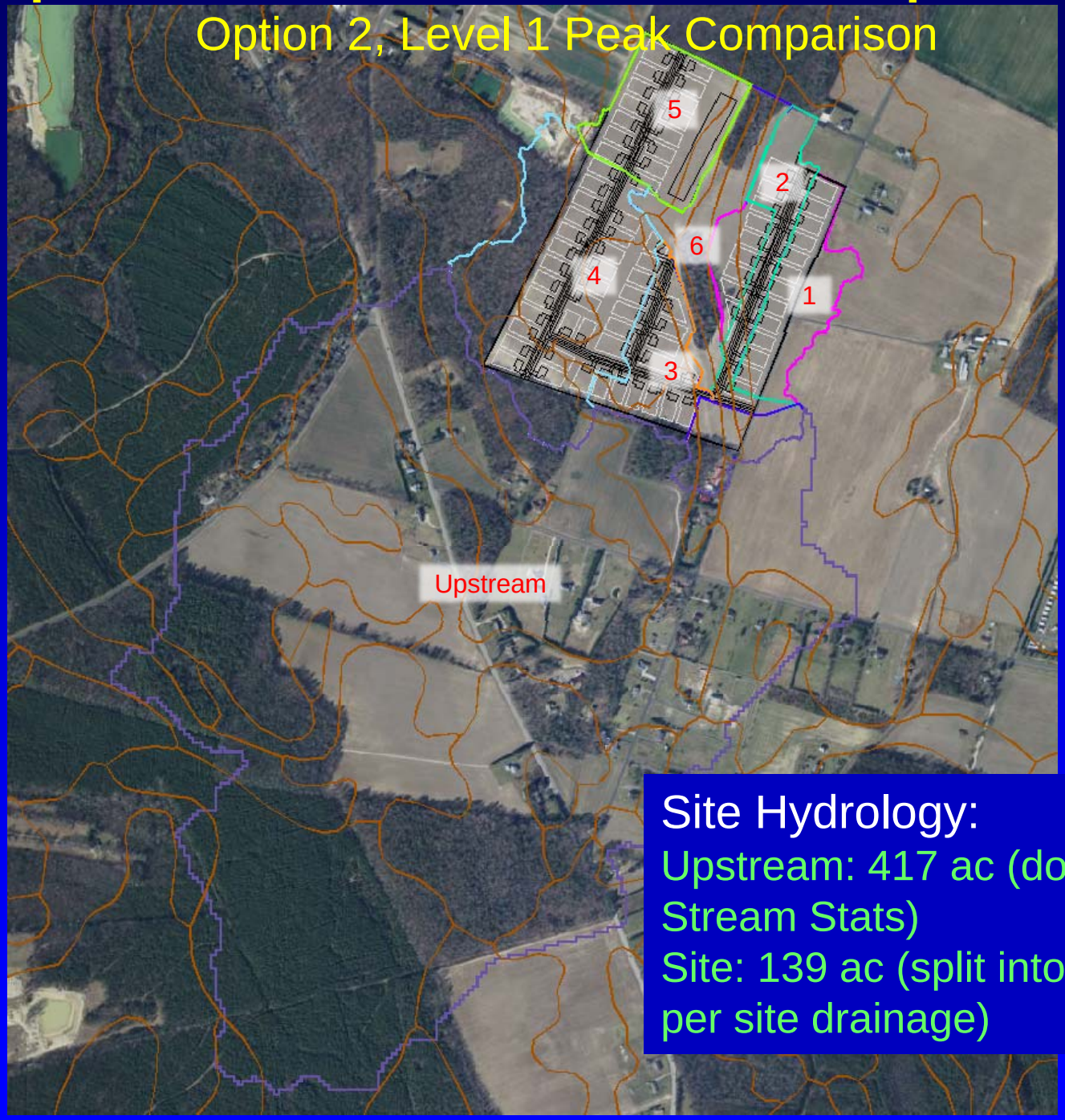


- ✓ Developed site hydrograph peak less than peak of upstream hydrograph

AND…

- ✓ Developed site hydrograph inflection point occurs before peak of the upstream hydrograph

Options for Cv & Fv Compliance



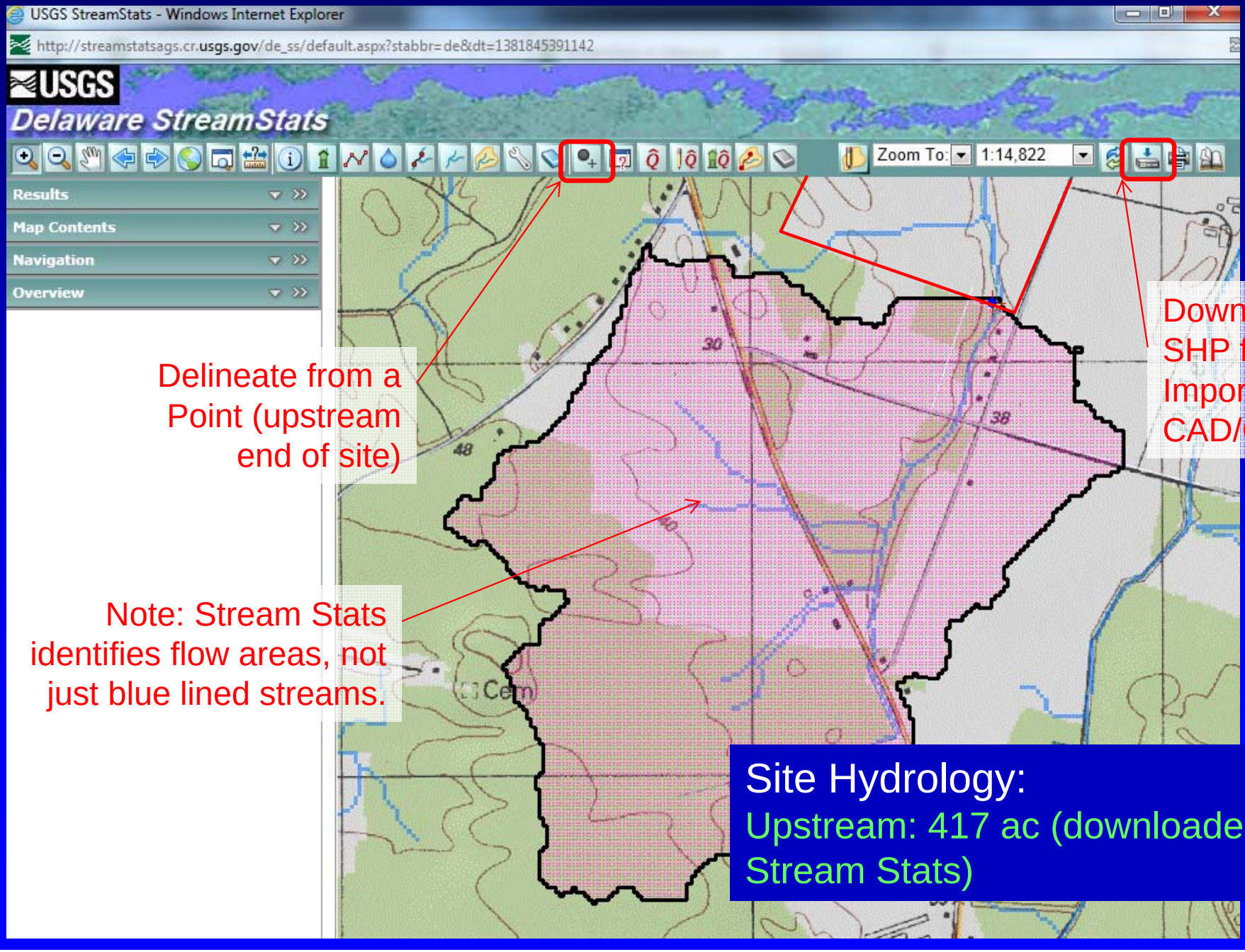
Site Hydrology:

Upstream: 417 ac (downloaded from Stream Stats)

Site: 139 ac (split into 6 subsheds per site drainage)

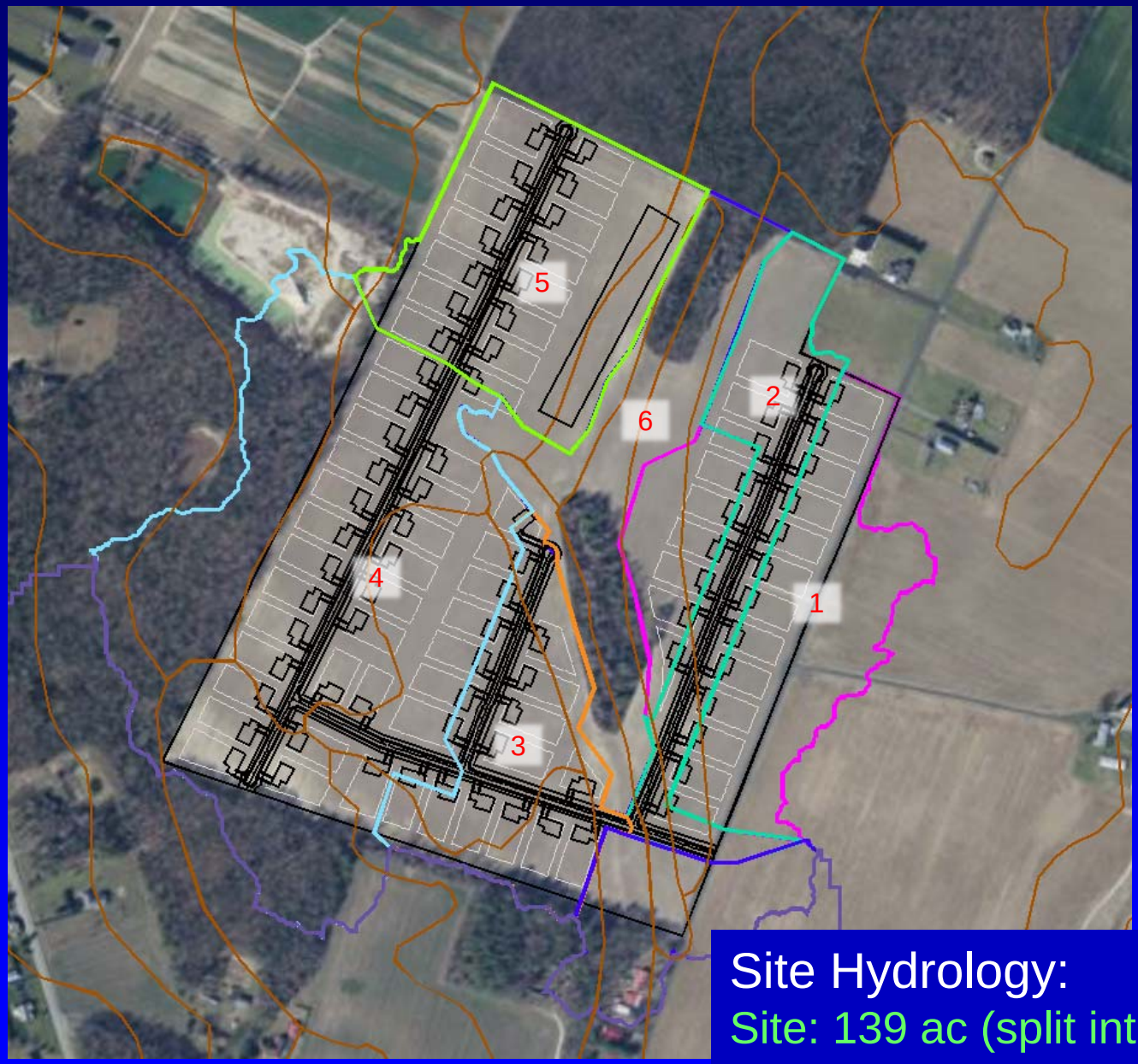
Options for Cv & Fv Compliance

Option 2, Level 1 Peak Comparison



Options for Cv & Fv Compliance

Option 2, Level 1 Peak Comparison



Site Hydrology:

Site: 139 ac (split into 6 subsheds per site drainage)

Options for Cv & Fv Compliance

Option 2, Level 1 Peak Comparison

Workflow for Performing Level 1 H&H Analysis

1. **Part 1 – Watershed Delineation**

   1.1. Use procedures from "Workflow Site Hydrology" document to delineate all watersheds draining to the site discharge Point of Analysis (POA)

2. **Part 2 –HEC-HMS Analysis**

   2.1. Open "HH1_Analysis.hms" template file

   2.2. Save As "Projectname.hms" (If an error occurs, close HEC-HMS and re-open "Projectname.hms" in the newly created "Project name" directory.)

   2.3. In Watershed Explorer window, expand "Basin Models" and click on "Project"; template basin model will open in the Desktop window

   2.4. Left-click "Upstream" subbasin icon; subbasin parameters will open in the Component Editor window

   2.4.1. Subbasin tab:

   2.4.1.1. Enter watershed area in sq. miles as determined in Part 1

   2.4.1.2. Loss Method: SCS Curve Number

   2.4.1.3. Transform Method: SCS Unit Hydrograph

   2.4.2. "Loss" tab:

   2.4.2.1. Enter Curve Number for upstream watershed

   2.4.2.2. Leave remaining fields set to their default values

   2.4.3. "Transform" tab:

   2.4.3.1. Select "Standard" or "Delmarva" from Graph Type dropdown list

   2.4.3.2. Enter Lag Time in minutes (Lag = 0.6Tc) as used in GISHydro TR-20 run

   2.5. Repeat Step 2.4 for "Site" subarea(s) using data for post-developed condition based on the DURMM v.2 analysis. (NOTE: If the site consists of multiple subareas, they should be combined at the site POA.)

   2.6. Click on the "Compute" tab at the bottom of the Watershed Explorer window; expand "Simulation Runs"

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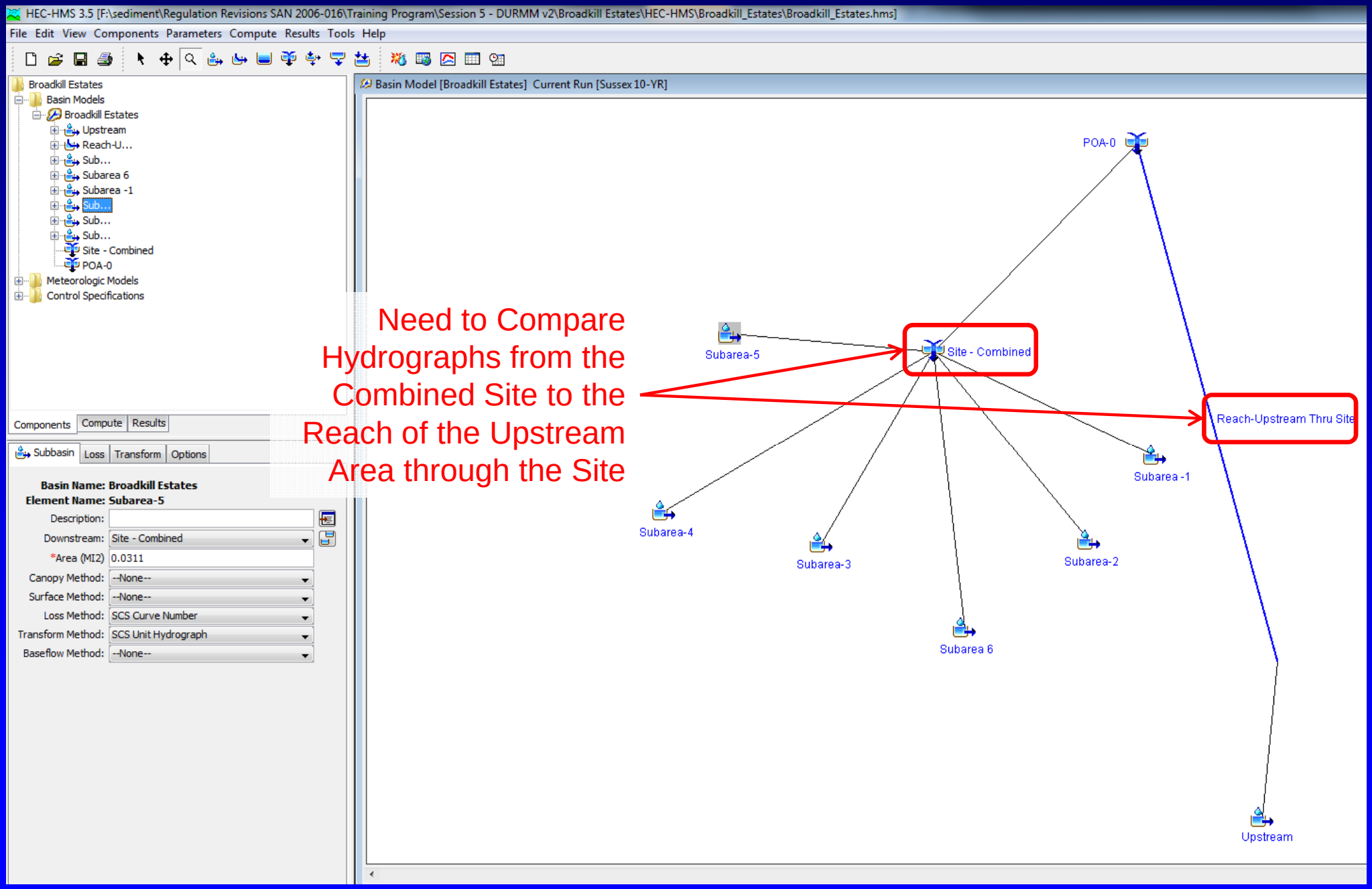
- Next Step is to Enter Site and Upstream Info into HEC-HMS
- HydroCAD or similar can be used, but HEC-HMS is the preferred platform, and will be used for any disputed analyses
- HEC-HMS Workflow is outlined in Tech Doc, "Workflow for Performing Level 1 H&H Analysis", Article 3.02.2.3

Options for Cv & Fv Compliance

Option 2, Level 1 Peak Comparison



Need to Compare Hydrographs from the Combined Site to the Reach of the Upstream Area through the Site

Options for Cv & Fv Compliance

Option 2, Level 1 Peak Comparison

Summary Results for Junction "Site - Combined"

Project: Broadkill Estates

Simulation Run: Sussex 10-YR Junction: Site - Combined

Start of Run:	01Jan3000, 00:00	Basin Model:	Broadkill Estates
End of Run:	03Jan3000, 00:00	Meteorologic Model:	Sussex 10-YR
Compute Time:	15Oct2013, 14:23:09	Control Specifications:	NRCS 24-HR Storm

Volume Units: IN AC-FT

Computed Results

Peak Outflow : 186.8 (CFS) Date/Time of Peak Outflow : 01Jan3000, 12:02

Total Outflow : 1.94 (IN)

Summary Results for Reach "Reach-Upstream Thru Site"

Project: Broadkill Estates

Simulation Run: Sussex 10-YR Reach: Reach-Upstream Thru Site

Start of Run:	01Jan3000, 00:00	Basin Model:	Broadkill Estates
End of Run:	03Jan3000, 00:00	Meteorologic Model:	Sussex 10-YR
Compute Time:	15Oct2013, 14:23:09	Control Specifications:	NRCS 24-HR Storm

Volume Units: IN AC-FT

Computed Results

Peak Inflow :	168.9 (CFS)	Date/Time of Peak Inflow :	01Jan3000, 13:03
Peak Outflow :	164.8 (CFS)	Date/Time of Peak Outflow :	01Jan3000, 13:31
Total Inflow :	2.00 (IN)	Total Outflow :	2.00 (IN)

X

Combined Site Peak is Not Less Than the Upstream Peak for the Cv (10-Year)

Options for Cv & Fv Compliance

Option 2, Level 1 Peak Comparison

Summary Results for Junction "Site - Combined"

Project: Broadkill Estates

Simulation Run: Sussex 100-YR Junction: Site - Combined

Start of Run:	01Jan3000, 00:00	Basin Model:	Broadkill Estates
End of Run:	03Jan3000, 00:00	Meteorologic Model:	Sussex 100-YR
Compute Time:	15Oct2013, 14:23:01	Control Specifications:	NRCS 24-HR Storm

Volume Units: IN AC-FT

Computed Results

Peak Outflow : 461.5 (CFS) Date/Time of Peak Outflow : 01Jan3000, 12:02

Total Outflow : 4.75 (IN)

Summary Results for Reach "Reach-Upstream Thru Site"

Project: Broadkill Estates

Simulation Run: Sussex 100-YR Reach: Reach-Upstream Thru Site

Start of Run:	01Jan3000, 00:00	Basin Model:	Broadkill Estates
End of Run:	03Jan3000, 00:00	Meteorologic Model:	Sussex 100-YR
Compute Time:	15Oct2013, 14:23:01	Control Specifications:	NRCS 24-HR Storm

Volume Units: IN AC-FT

Computed Results

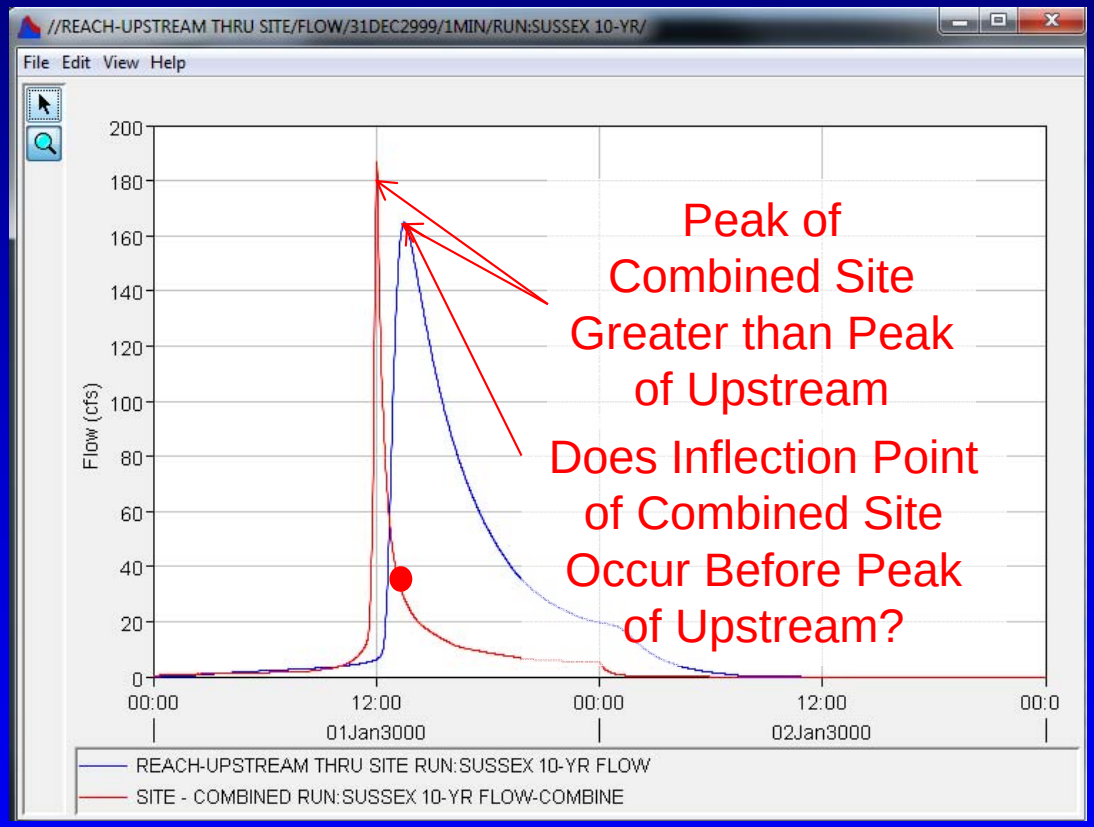
Peak Inflow :	461.9 (CFS)	Date/Time of Peak Inflow :	01Jan3000, 13:01
Peak Outflow :	450.3 (CFS)	Date/Time of Peak Outflow :	01Jan3000, 13:22
Total Inflow :	5.01 (IN)	Total Outflow :	5.01 (IN)

X

Combined Site Peak is Not Less Than the Upstream Peak for the Fv (100-Year)

Options for Cv & Fv Compliance

Option 2, Level 1 Peak Comparison



X Developed site hydrograph peak less than peak of upstream hydrograph

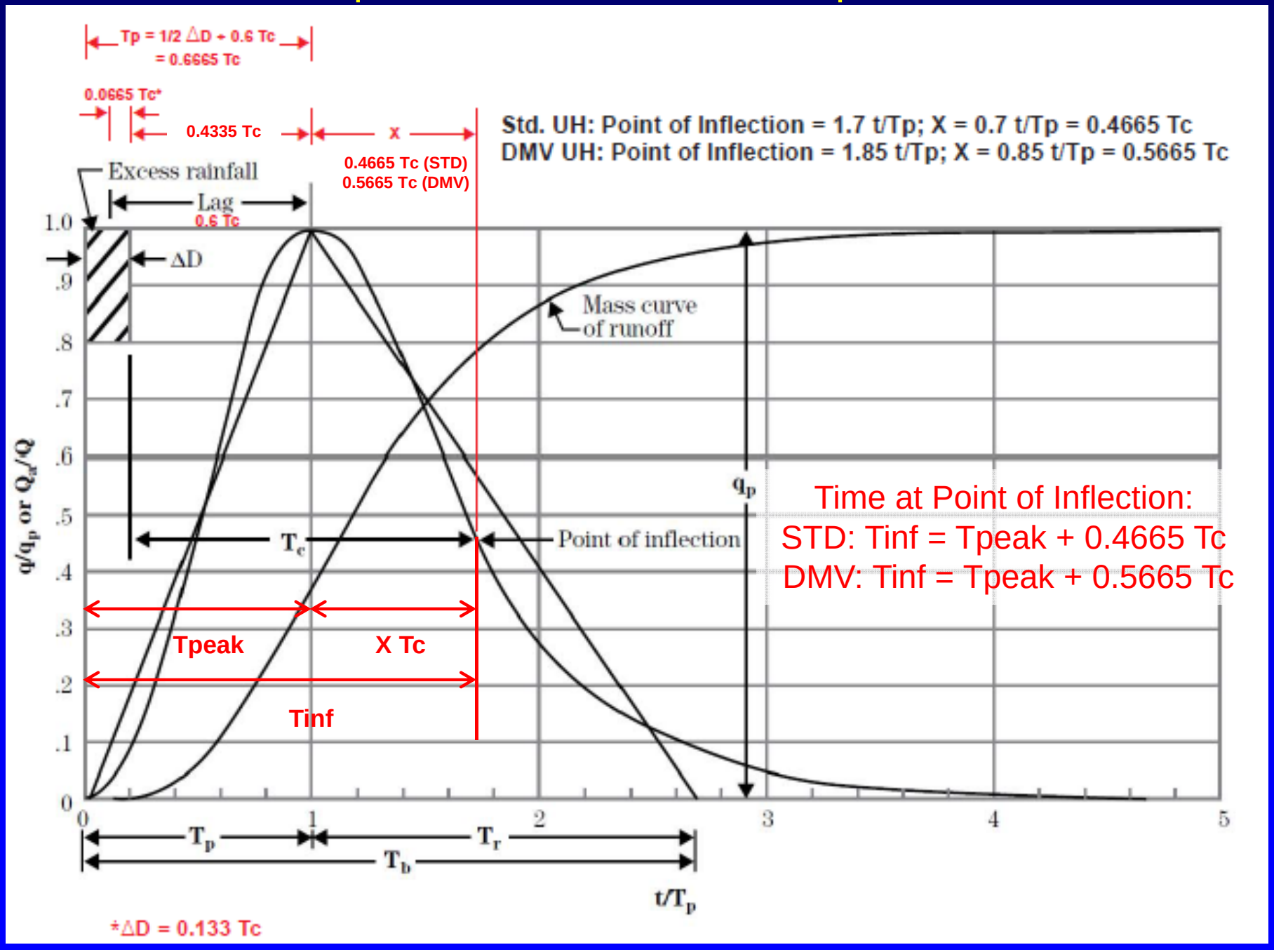
AND…

? Developed site hydrograph inflection point occurs before peak of the upstream hydrograph

(no point in continuing other than demonstration purposes)

Options for Cv & Fv Compliance

Option 2, Level 1 Peak Comparison



Options for Cv & Fv Compliance

Option 2, Level 1 Peak Comparison

Summary Results for Junction "Site - Combined"

Project: Broadkill Estates

Simulation Run: Sussex 10-YR Junction: Site - Combined

Start of Run:	01Jan3000, 00:00	Basin Model:	Broadkill Estates
End of Run:	03Jan3000, 00:00	Meteorologic Model:	Sussex 10-YR
Compute Time:	15Oct2013, 14:23:09	Control Specifications:	NRCS 24-HR Storm

Volume Units: IN AC-FT

Computed Results

Peak Outflow : 186.8 (CFS)
Total Outflow : 1.94 (IN)
Date/Time of Peak Outflow : 01Jan3000, 12:02

Time at Point of Inflection
Tinf = Tpeak + 0.5665 Tc
= 12:02 + 0.5665*60min
= 12:02 + 33 min
= 12:35

Summary Results for Reach "Reach-Upstream Thru Site"

Project: Broadkill Estates

Simulation Run: Sussex 10-YR Reach: Reach-Upstream Thru Site

Start of Run:	01Jan3000, 00:00	Basin Model:	Broadkill Estates
End of Run:	03Jan3000, 00:00	Meteorologic Model:	Sussex 10-YR
Compute Time:	15Oct2013, 14:23:09	Control Specifications:	NRCS 24-HR Storm

Volume Units: IN AC-FT

Computed Results

Peak Inflow : 168.9 (CFS)
Peak Outflow : 164.8 (CFS)
Total Inflow : 2.00 (IN)
Date/Time of Peak Inflow : 01Jan3000, 13:03
Date/Time of Peak Outflow : 01Jan3000, 13:31
Total Outflow : 2.00 (IN)

Combined Site Time of Inflection Point is Less Than the Time of Upstream Peak for the Cv (10-Year)

12:35 < 13:31

Options for Cv & Fv Compliance

Option 2, Level 1 Peak Comparison

Summary Results for Junction "Site - Combined"

Project: Broadkill Estates

Simulation Run: Sussex 100-YR Junction: Site - Combined

Start of Run:	01Jan3000, 00:00	Basin Model:	Broadkill Estates
End of Run:	03Jan3000, 00:00	Meteorologic Model:	Sussex 100-YR
Compute Time:	15Oct2013, 14:23:01	Control Specifications:	NRCS 24-HR Storm

Volume Units: IN AC-FT

Computed Results

Peak Outflow : 461.5 (CFS)
Total Outflow : 4.75 (IN)
Date/Time of Peak Outflow : 01Jan3000, 12:02

Time at Point of Inflection
Tinf = Tpeak + 0.5665 Tc
= 12:02 + 0.5665*60min
= 12:02 + 33 min
= 12:35

Summary Results for Reach "Reach-Upstream Thru Site"

Project: Broadkill Estates

Simulation Run: Sussex 100-YR Reach: Reach-Upstream Thru Site

Start of Run:	01Jan3000, 00:00	Basin Model:	Broadkill Estates
End of Run:	03Jan3000, 00:00	Meteorologic Model:	Sussex 100-YR
Compute Time:	15Oct2013, 14:23:01	Control Specifications:	NRCS 24-HR Storm

Volume Units: IN AC-FT

Computed Results

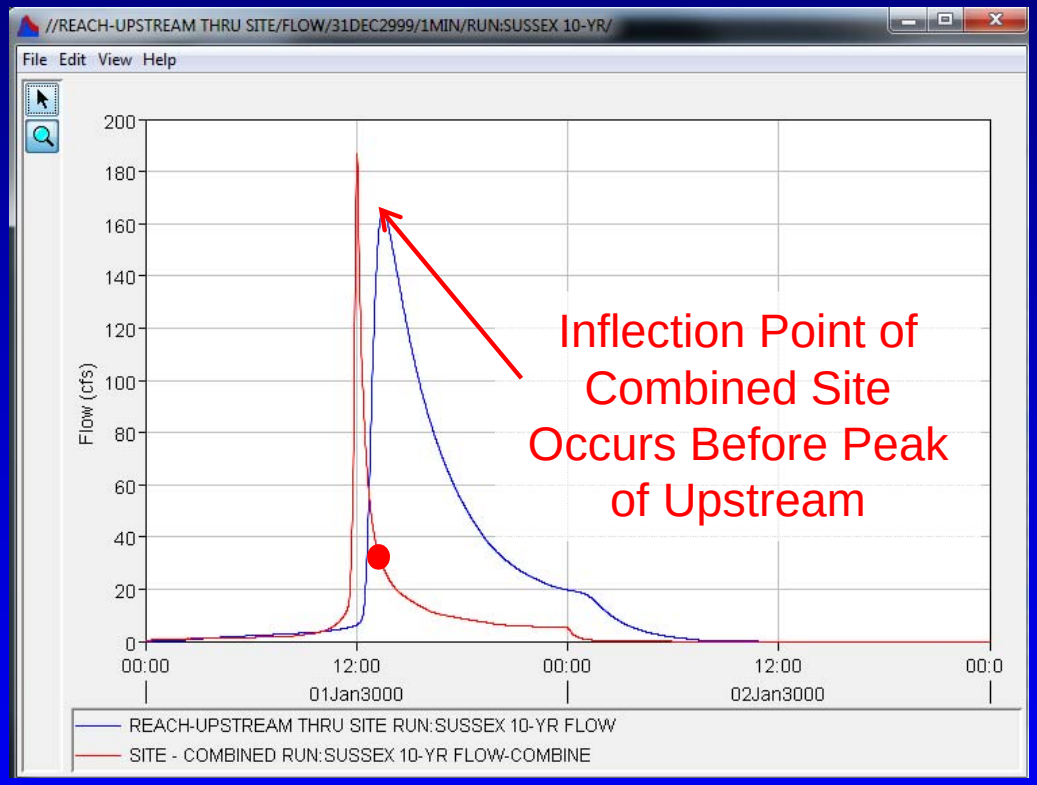
Peak Inflow : 461.9 (CFS)
Peak Outflow : 450.3 (CFS)
Total Inflow : 5.01 (IN)
~~Date/Time of Peak Inflow : 01Jan3000, 13:01~~
Date/Time of Peak Outflow : 01Jan3000, 13:22
~~Total Outflow : 5.01 (IN)~~

✓ Combined Site Time of Inflection Point is Less Than the Time of Upstream Peak for the Fv (100-Year)

12:35 < 13:22

Options for Cv & Fv Compliance

Option 2, Level 1 Peak Comparison



At this point, detention storage could be added until compliance is met, or Proceed to Level 2 analysis

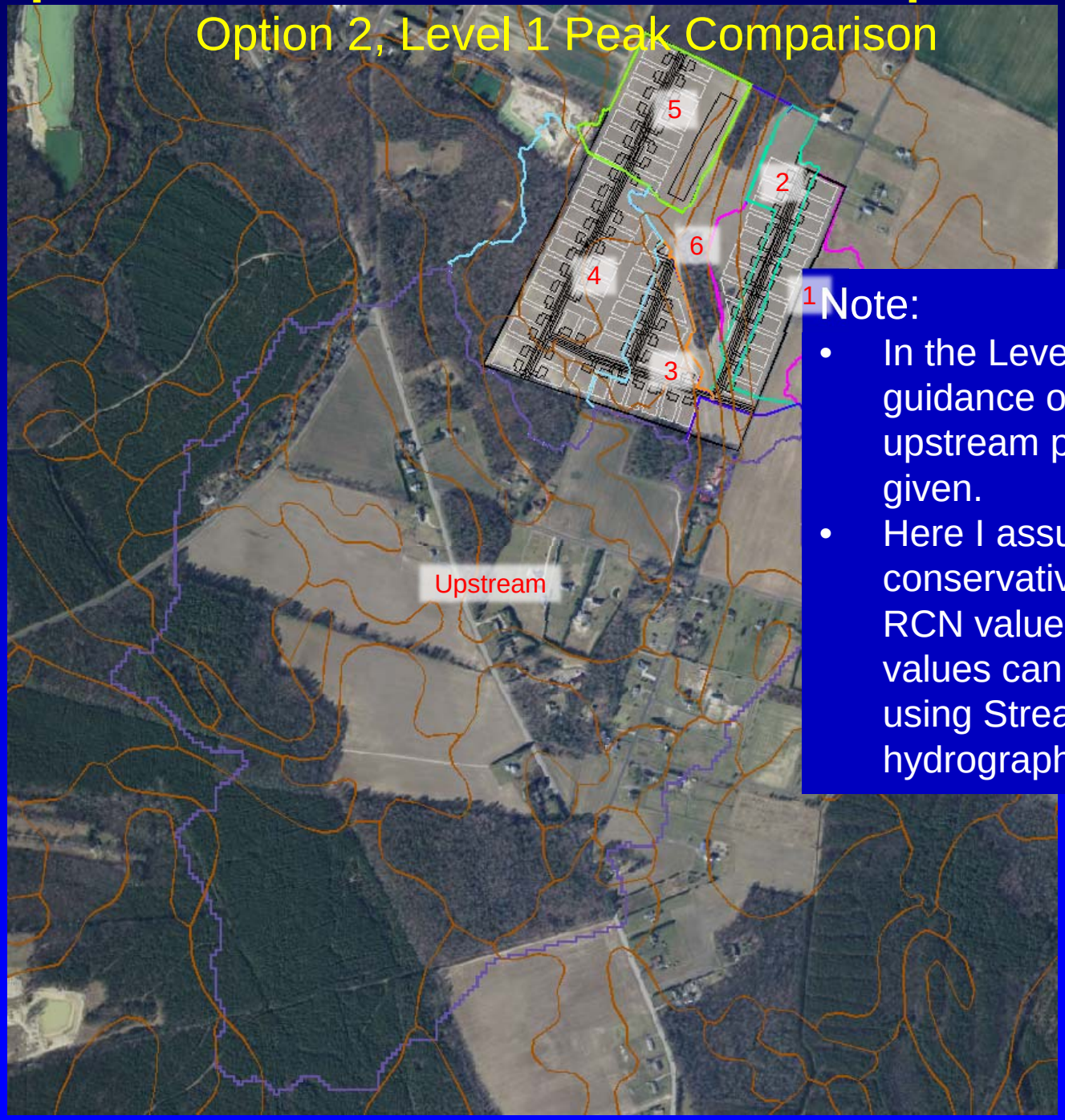
X Developed site hydrograph peak less than peak of upstream hydrograph

AND…

✓ Developed site hydrograph inflection point occurs before peak of the upstream hydrograph

= X

Options for Cv & Fv Compliance



Note:

- In the Level II training, more guidance on determining the upstream parameters will be given.
- Here I assumed a conservative Tc path and RCN values, but these values can be determined using StreamStats and hydrograph calibration.

Options for Cv & Fv Compliance

Option 2, Level 2 Analysis

Procedure for Conducting Hydrologic & Hydraulic Analyses For Preliminary Sediment & Stormwater Plans

Background

The Hydrologic & Hydraulic (H&H) Analysis couples field collected data with desktop watershed modeling methodology to provide a tool for stormwater management agencies to help determine the most appropriate method to manage stormwater runoff from developing sites based on "No Adverse Impact" principles. The general approach is one of increasing level of detail and analysis depending on the complexity of the watershed. It is NOT intended to be a substitute for detailed Watershed Master Plans that have been endorsed by the Department. When such detailed plans are available, the peak discharge and/or volume management requirements from the Watershed Master Plan shall take precedence over the requirements of the Level 2 Analysis. Additionally, the methodologies used for this analysis are not considered to be precise enough to be applied at the site level.

Procedure

1. **Applicability**
   1.1. The H&H analysis will be required for all projects using the performance-based option and/or where a sump condition exists.
2. **Methodology**
   2.1. Level 1 Analysis
      2.1.1. The Level 1 Analysis combines field reconnaissance data with hydrologic modeling of the upstream watershed and site using latest soils, LULC, and terrain data. Hydrographs are then compared to check for coincidental peaking effects.
      2.1.2. Limit of study shall be the most-downstream junction of the site and the upstream contributing area.
      2.1.3. To comply at this level of analysis, hydrologic modeling must indicate no adverse impact due to coincidental peaking effects. For purposes of this policy, "no adverse impact" shall mean that the developed site hydrograph peak is less than, and the inflection point occurs before, the peak of the upstream hydrograph OR that it can be demonstrated that on-site detention would exacerbate downstream impacts. If compliance cannot be demonstrated, proceed to Level 2.
   2.2. Level 2 Analysis
      2.2.1. The Level 2 Analysis combines field measurement data with hydraulic modeling of structures, channels, etc. using an expanded hydrologic model.

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Article 3.02.2.2, Technical Document

- 3 Increasing Levels of Detail
  - Level 1: Peak comparison
  - Level 2:
    a. Pre vs. Post comparison (peak rate and volume); or
    b. Steady flow water surface analysis

Options for Cv & Fv Compliance

Option 2, Level 2-a Pre vs Post Comparison

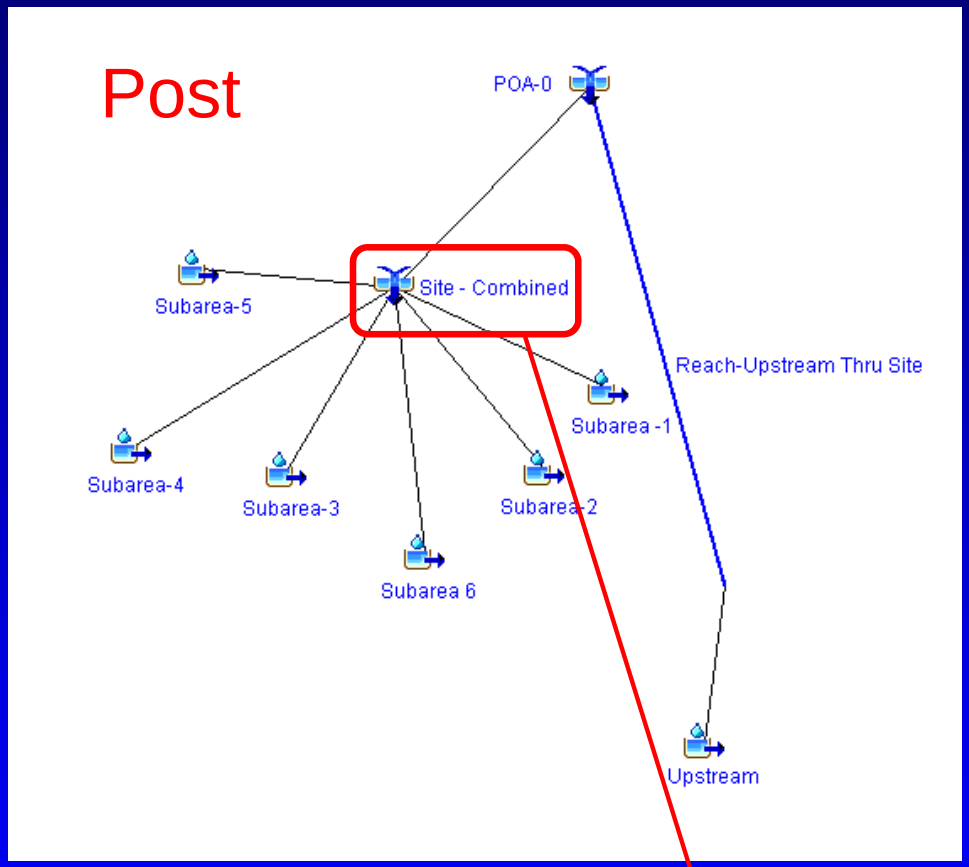
Procedure for Conducting Hydrologic & Hydraulic Analyses for Preliminary Sediment & Stormwater Plans, Sect. 2.2.3.1:

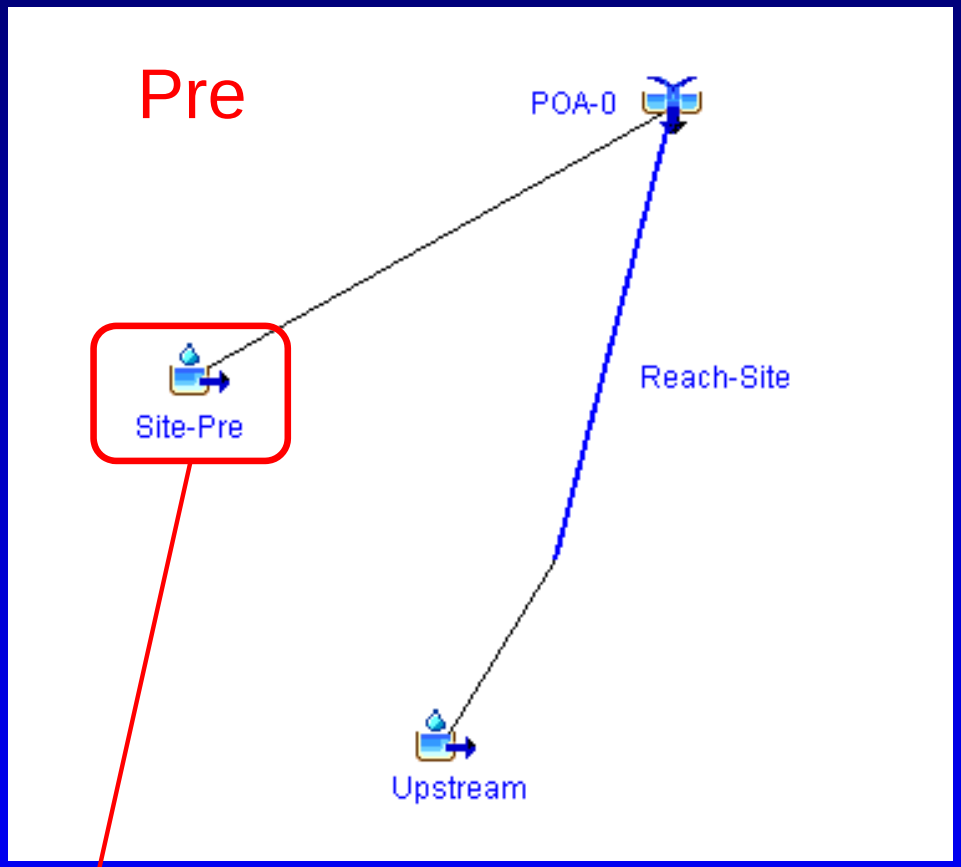
The runoff volume based on the NRCS Runoff Curve Number (RCN) and the rate of runoff based on the calculated peak discharge for the post-developed condition does not exceed that of the pre-developed condition;

At the Site Level, but including any offsite areas that contribute to a BMP

Options for Cv & Fv Compliance

Option 2, Level 2-a Pre vs Post Comparison





Comparing the Site in Pre-Condition (with any adjacent offsite areas) to the Combined Site in Post Developed Condition (also including adjacent offsite areas that get routed through the BMP)

Options for Cv & Fv Compliance

Option 2, Level 2-a Pre vs Post Comparison

Summary Results for Junction "Site - Combined"

Post

Project: Broadkill Estates
Simulation Run: Sussex 10-YR Junction: Site - Combined

Start of Run:	01Jan3000, 00:00	Basin Model:	Broadkill Estates
End of Run:	03Jan3000, 00:00	Meteorologic Model:	Sussex 10-YR
Compute Time:	17Oct2013, 11:09:16	Control Specifications:	NRCS 24-HR Storm

Volume Units: IN AC-FT

Computed Results

Peak Outflow : 186.8 (CFS)
Total Outflow : 1.94 (IN)
Date/Time of Peak Outflow : 01Jan3000, 12:02

At this point, detention storage could be added until compliance is met, or Proceed to Level 2-b analysis

Summary Results for Subbasin "Site-Pre"

Pre

Project: Broadkill_Pre
Simulation Run: Sussex 10-YR Subbasin: Site-Pre

Start of Run:	01Jan3000, 00:00	Basin Model:	Broadkill Estates
End of Run:	03Jan3000, 00:00	Meteorologic Model:	Sussex 10-YR
Compute Time:	17Oct2013, 12:49:17	Control Specifications:	NRCS 24-HR Storm

Volume Units: IN AC-FT

Computed Results

Peak Discharge :	49.2 (CFS)	Date/Time of Peak Discharge :	01Jan3000, 13:17
Total Precipitation :	5.30 (IN)	Total Direct Runoff :	1.94 (IN)
Total Loss :	3.36 (IN)	Total Baseflow :	0.00 (IN)
Total Excess :	1.94 (IN)	Discharge :	1.94 (IN)

X

Post Runoff Volume Does Not exceed Pre for the Cv (10-yr), but the Post Peak Discharge Does

Options for Cv & Fv Compliance

Option 2, Level 2-a Pre vs Post Comparison

Summary Results for Junction "Site - Combined"

Post

Project: Broadkill Estates
Simulation Run: Sussex 100-YR Junction: Site - Combined

Start of Run:	01Jan3000, 00:00	Basin Model:	Broadkill Estates
End of Run:	03Jan3000, 00:00	Meteorologic Model:	Sussex 100-YR
Compute Time:	17Oct2013, 11:04:14	Control Specifications:	NRCS 24-HR Storm

Volume Units: IN AC-FT

Computed Results

Peak Outflow : 461.5 (CFS)
Total Outflow : 4.75 (IN)
Date/Time of Peak Outflow : 01Jan3000, 12:02

At this point, detention storage could be added until compliance is met, or Proceed to Level 2-b analysis

Summary Results for Subbasin "Site-Pre"

Pre

Project: Broadkill_Pre
Simulation Run: Sussex 100-YR Subbasin: Site-Pre

Start of Run:	01Jan3000, 00:00	Basin Model:	Broadkill Estates
End of Run:	03Jan3000, 00:00	Meteorologic Model:	Sussex 100-YR
Compute Time:	17Oct2013, 12:49:09	Control Specifications:	NRCS 24-HR Storm

Volume Units: IN AC-FT

Computed Results

Peak Discharge :	138.1 (CFS)	Date/Time of Peak Discharge :	01Jan3000, 13:13
Total Precipitation :	9.20 (IN)	Total Direct Runoff :	5.01 (IN)
Total Loss :	4.19 (IN)	Total Baseflow :	0.00 (IN)
Total Excess :	5.01 (IN)	Discharge :	5.01 (IN)

X

Post Runoff Volume Does Not exceed Pre for the Fv (100-yr), but the Post Peak Discharge Does

Options for Cv & Fv Compliance

Option 2, Level 2-b Steady Flow Water Surface Model

Procedure for Conducting Hydrologic & Hydraulic Analyses for Preliminary Sediment & Stormwater Plans, Sect. 2.2.3.2:

Steady flow hydraulic modeling must indicate no adverse impacts to headwater, water surface elevations and/or areas of inundation at designated POAs. For purposes of this policy, "no adverse impact" shall mean less than 0.05' increase in water surface elevations in channels and/or in headwater at hydraulic structures for all points of analysis. In addition, the area of inundation shall not encroach upon buildings or similar structures previously not impacted.

Options for Cv & Fv Compliance

Option 2, Level 2-b Steady Flow Water Surface Model

Procedure for Conducting Hydrologic & Hydraulic Analyses for Preliminary Sediment & Stormwater Plans, Sect. 2.2.2:

Limit of the study shall be the point downstream where the site is 10% of the total contributing drainage area. Points of Analysis (POAs) shall be established at the site boundary and all hydraulic structures within the study reach. In cases where there are no hydraulic structures within the study reach, representative section(s) based on LiDAR data shall be used; locations to be determined at the Project Application Meeting.

Options for Cv & Fv Compliance

Option 2, Level 2-b Steady Flow Water Surface Model

Workflow for Performing Level 2 H&H Analysis

The following procedure is based on what is considered the minimum requirements for the Level 2 H&H Analysis, which involves determining the water surface elevation for the pre-developed and post-developed conditions at the point of discharge from the site. The hydraulic model consists of three (3) cross sections. The middle cross section is established immediately downstream from the site discharge point. A minimum of one cross section upstream and one cross section downstream must be used to ensure the model will yield reasonable results. It may be necessary to analyze additional sections downstream to the "10% Rule" POA based on current Departmental guidance and/or policy.

1. **Part 1 – Watershed Delineation**

   1.1. Use procedures from "Workflow Site Hydrology" document to delineate all watersheds draining to the Point of Analysis (POA) based on the "10% Rule".

2. **Part 2 –HEC-HMS Analysis**

   2.1. Open "HH2_Analysis.hms" template file

   2.2. Save As "Projectname.hms" (If an error occurs, close HEC-HMS and re-open "Projectname.hms" in the newly created "Project name" directory.

   2.3. Use procedures from "Workflow H&H Level 1 Analysis" to develop a watershed model for both the "pre-developed" site condition and the "post-developed" site condition to the POA from Part 1.

3. **Part 3 – HEC-RAS Analysis**

   3.1. Create HEC-RAS Project: *File>New Project*

   3.2. Click "Edit/Enter geometry data" button or: *Edit>Geometric Data*

   3.2.1. Switch to Geometric Data workspace window

   3.2.2. Create new river segment

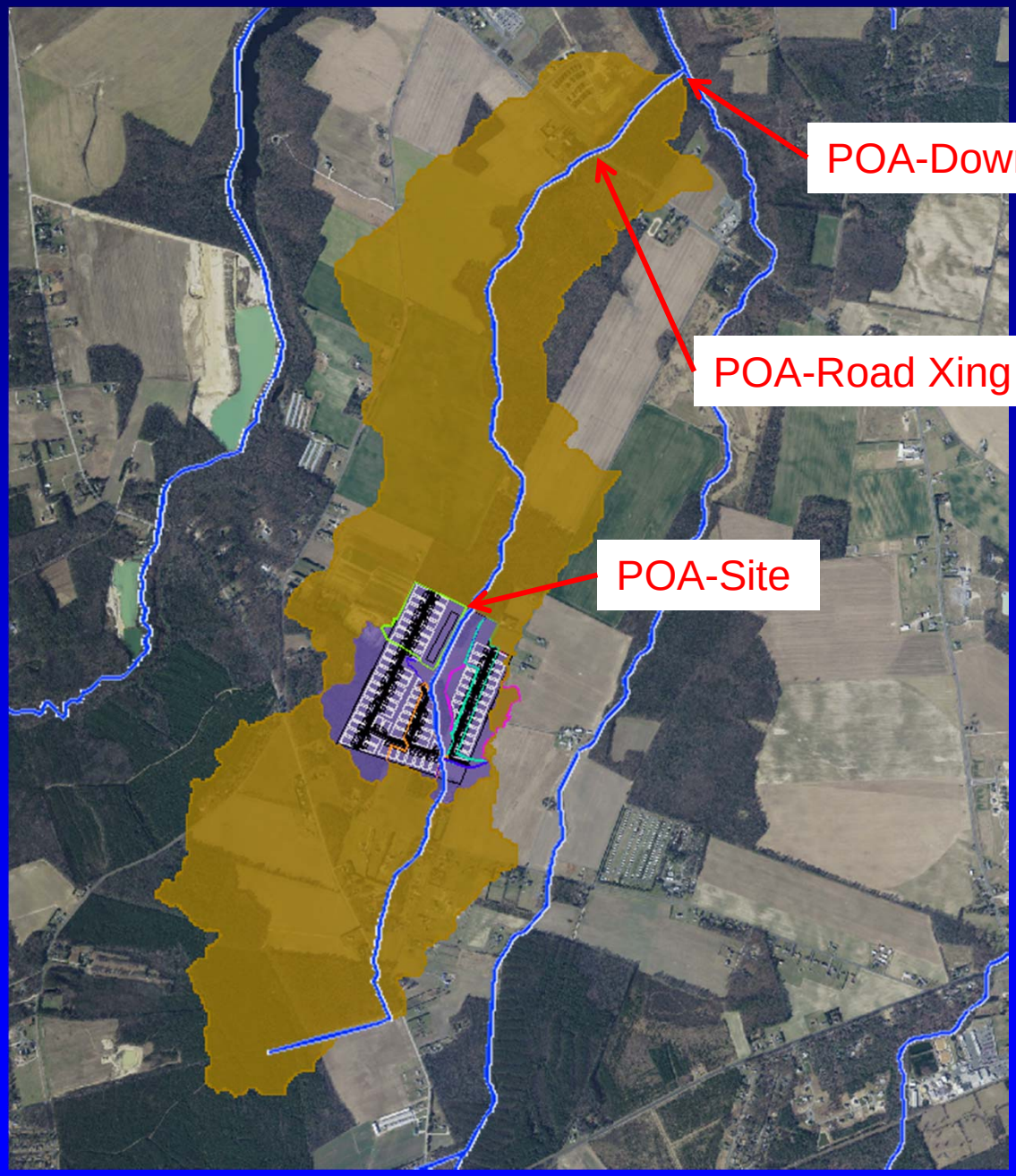
   3.2.2.1. Click on the "River Reach" button and sketch a river segment; double-click to complete sketch (NOTE: When sketching the river segment, the model assumes the initial starting point is the most upstream point for the analysis.)

   3.2.2.2. Enter "River" and "Reach" names in pop-up window

- Data from HEC-HMS (or similar program) is entered into HEC-RAS
- Workflow is outlined in Tech Doc, "Workflow for Performing Level 2 H&H Analysis", Article 3.02.2.4

Options for Cv & Fv Compliance

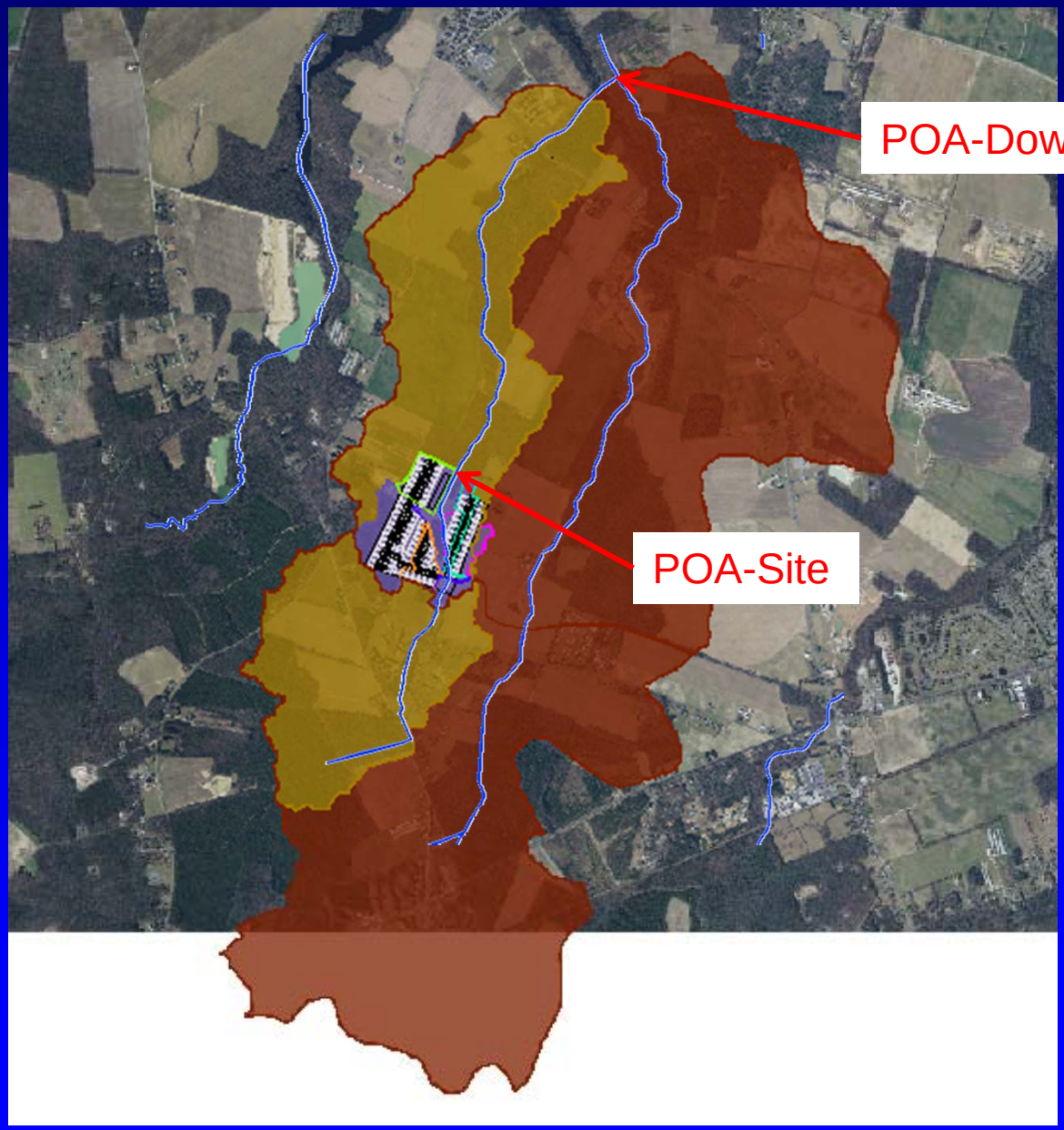
Option 2, Level 2-b Steady Flow Water Surface Model



StreamStats is used to determine when the site is 10% of the watershed Here the site is 139.1 ac (purple) and the rest is 1051.9 ac (orange) so the site is 11.7% of the total, not quite 10% but…

Options for Cv & Fv Compliance

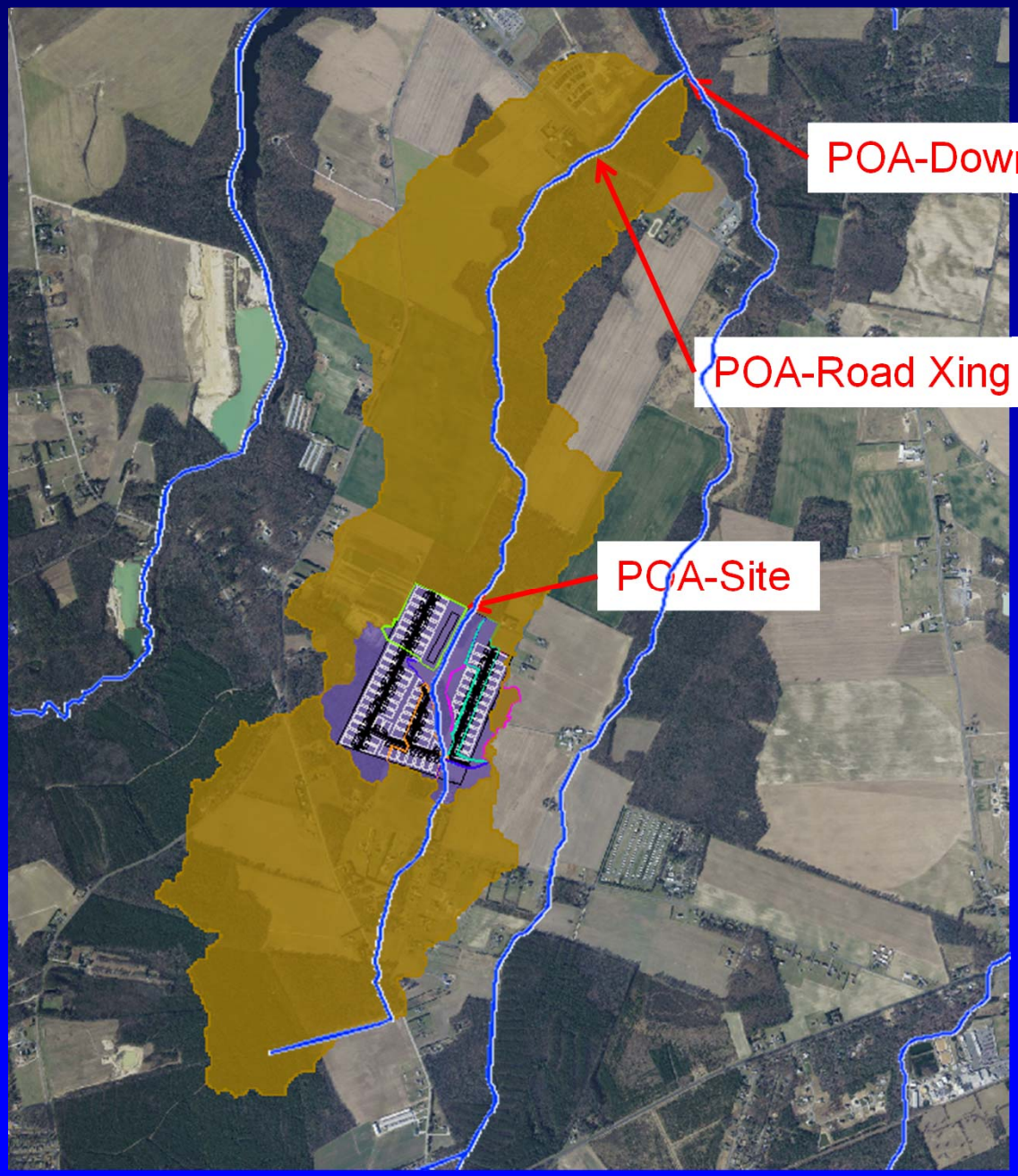
Option 2, Level 2-b Steady Flow Water Surface Model



… the local branch converges with a main tributary so the site would become 3.5% of the watershed and not reflect direct impacts on the main tributary, so the analysis point is left at the 11.7% mark.

Options for Cv & Fv Compliance

Option 2, Level 2-b Steady Flow Water Surface Model



… the local branch converges with a main tributary so the site would become 3.5% of the watershed and not reflect direct impacts on the main tributary, so the analysis point is left at the 11.7% mark.

This would have already been discussed at the Project's Pre-Application Meeting

Options for Cv & Fv Compliance

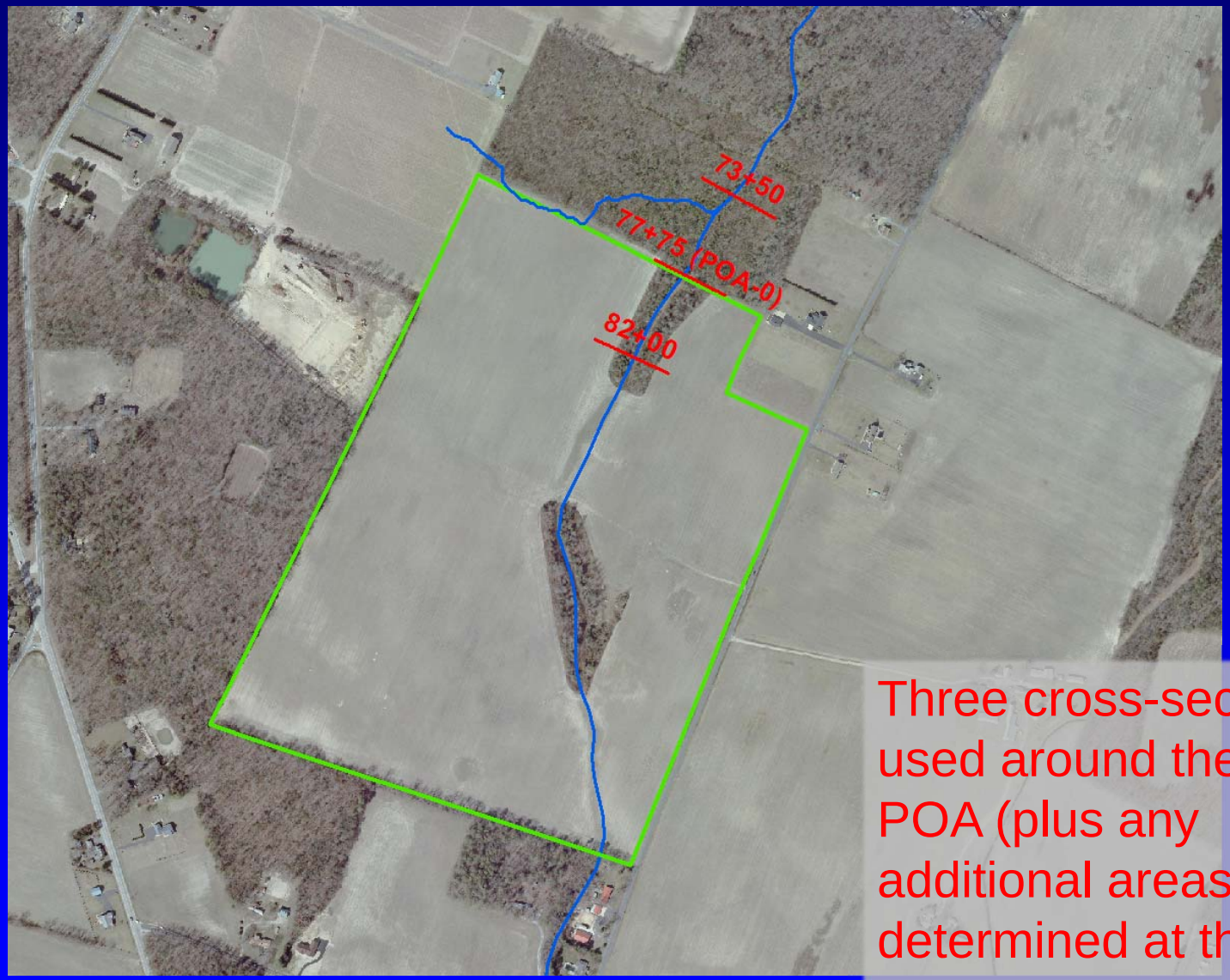
Option 2, Level 2-b Steady Flow Water Surface Model

"The following procedure is based on what is considered the minimum requirements for the Level 2 H&H Analysis, which involves determining the water surface elevation for the pre-developed and post-developed conditions at the point of discharge from the site. The hydraulic model consists of three (3) cross sections. The middle cross section is established immediately downstream from the site discharge point. A minimum of one cross section upstream and one cross section downstream must be used to ensure the model will yield reasonable results. It may be necessary to analyze additional sections downstream to the "10% Rule" POA based on current Departmental guidance and/or policy."

Ref: "Workflow for Performing Level 2 H&H Analysis", DNREC (draft)

Options for Cv & Fv Compliance

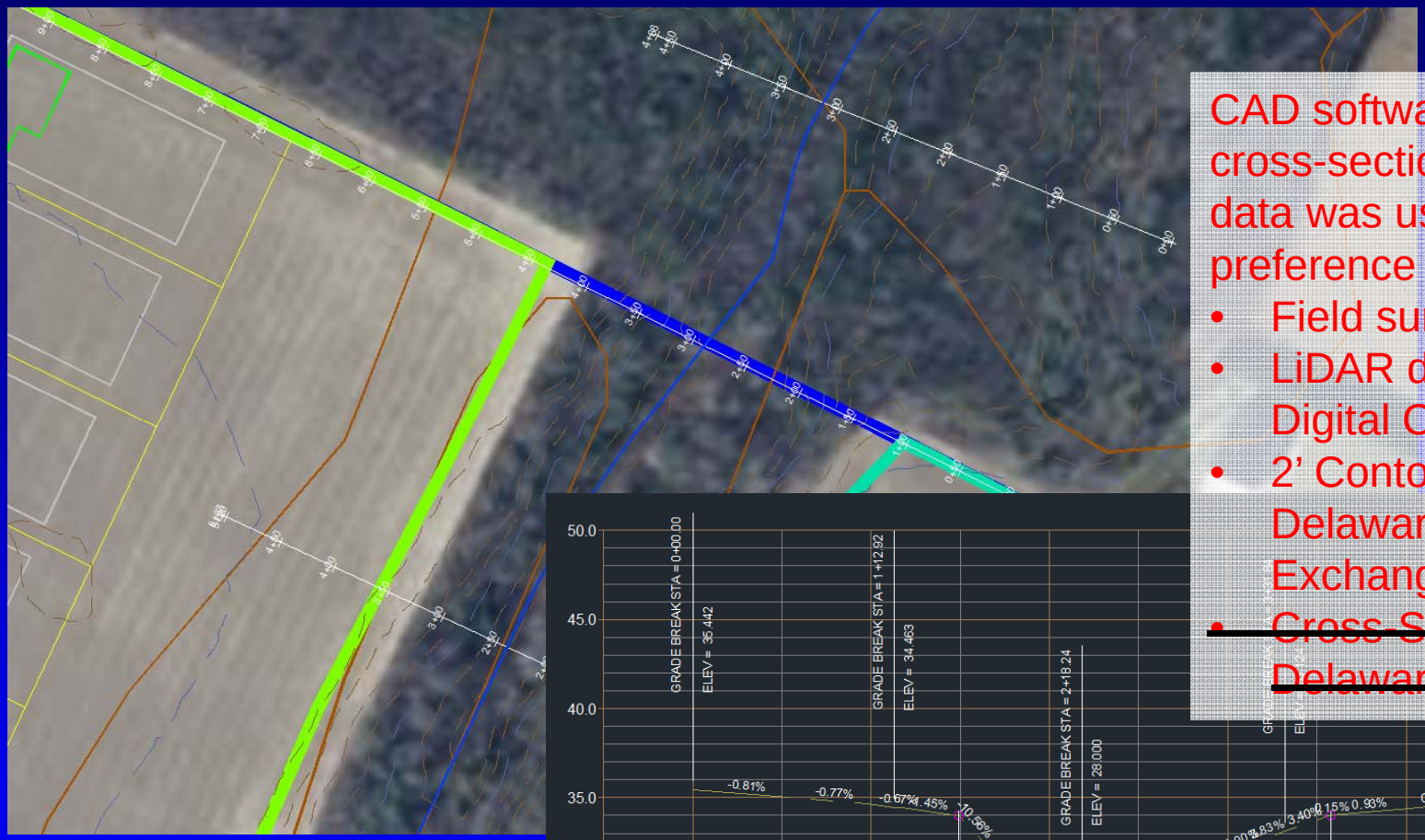
Option 2, Level 2-b Steady Flow Water Surface Model

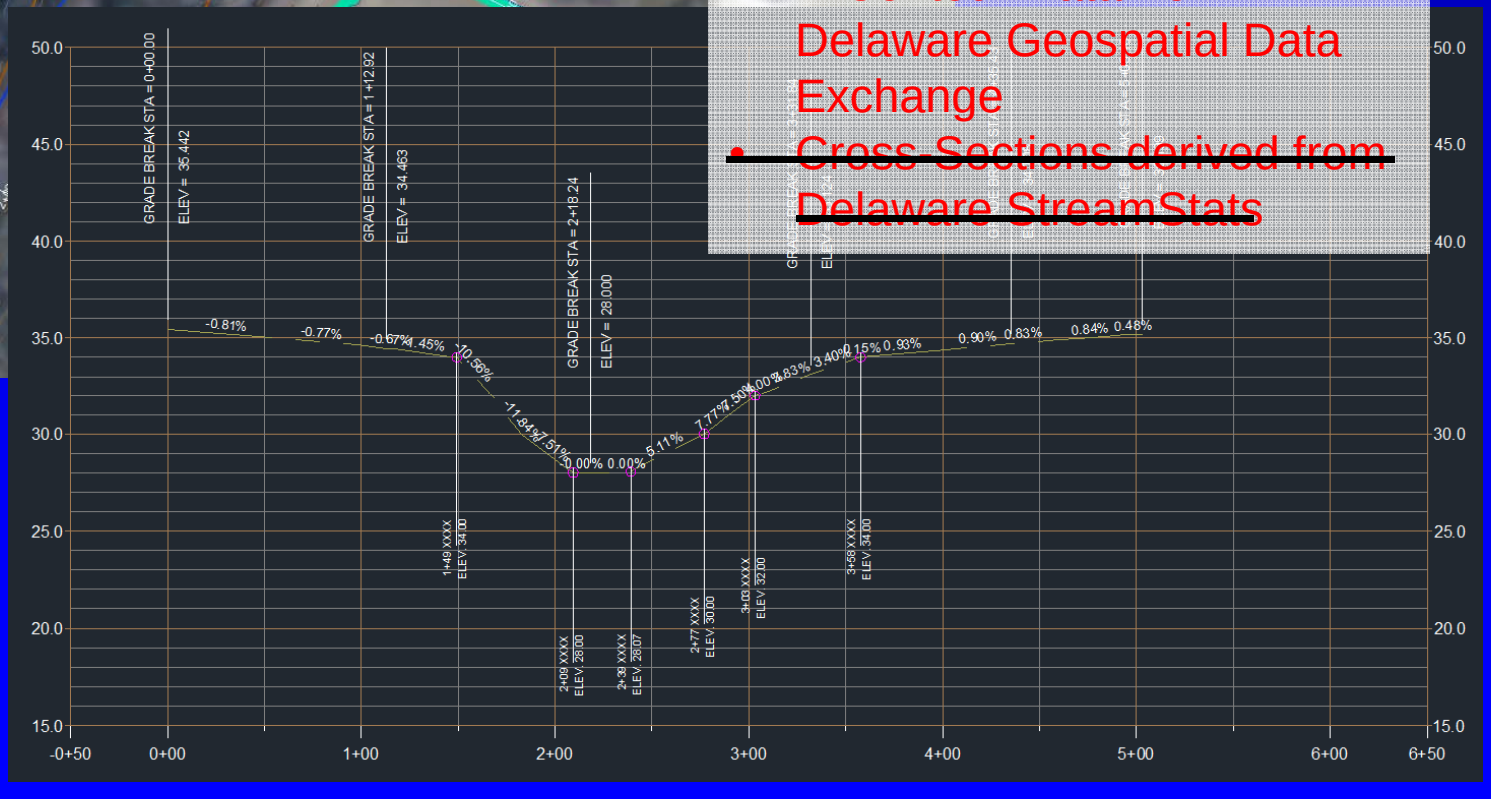


Three cross-sections used around the site's POA (plus any additional areas determined at the site's pre-application meeting)

Options for Cv & Fv Compliance

Option 2, Level 2-b Steady Flow Water Surface Model





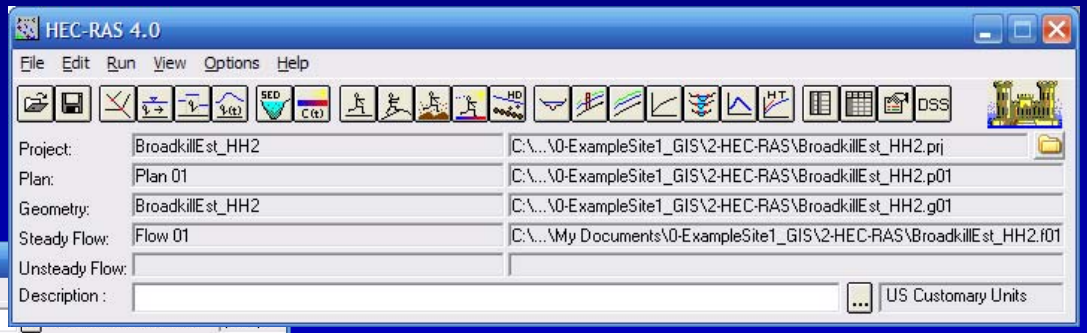
CAD software used to develop cross-sections. Here, 2' contour data was used. Order of preference is:

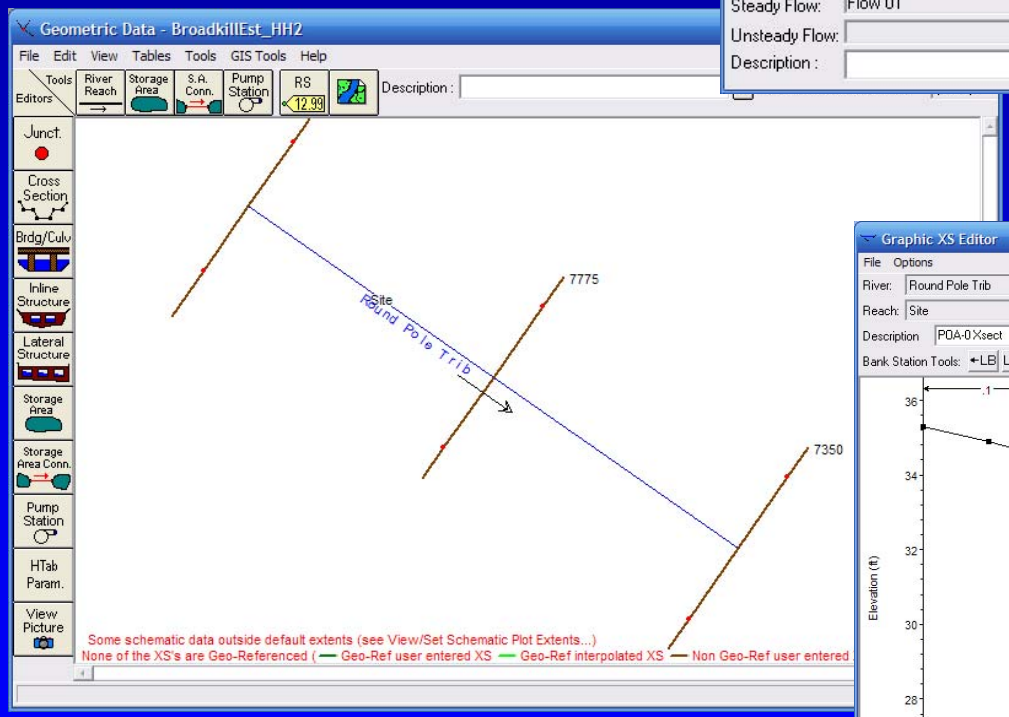
- Field survey data
- LiDAR data from NOAA Digital Coast
- 2' Contour Data from Delaware Geospatial Data Exchange
- ~~Cross-Sections derived from Delaware StreamStats~~

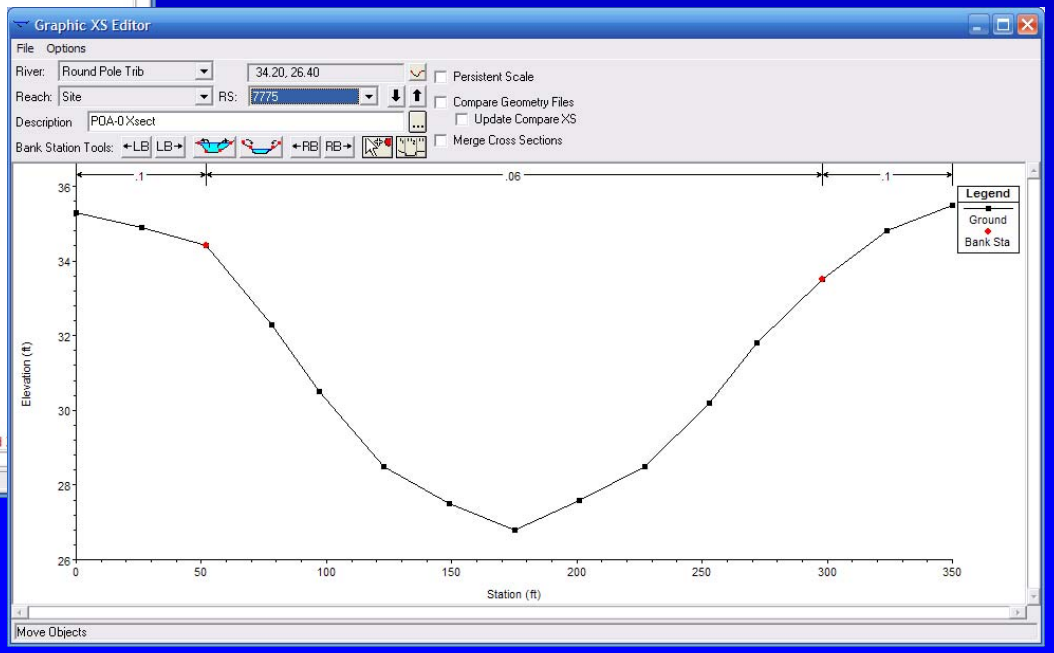
Options for Cv & Fv Compliance

Option 2, Level 2-b Steady Flow Water Surface Model

HEC-RAS model set up using the 3 site cross-sections, and the pre and post developed flows from HEC-HMS

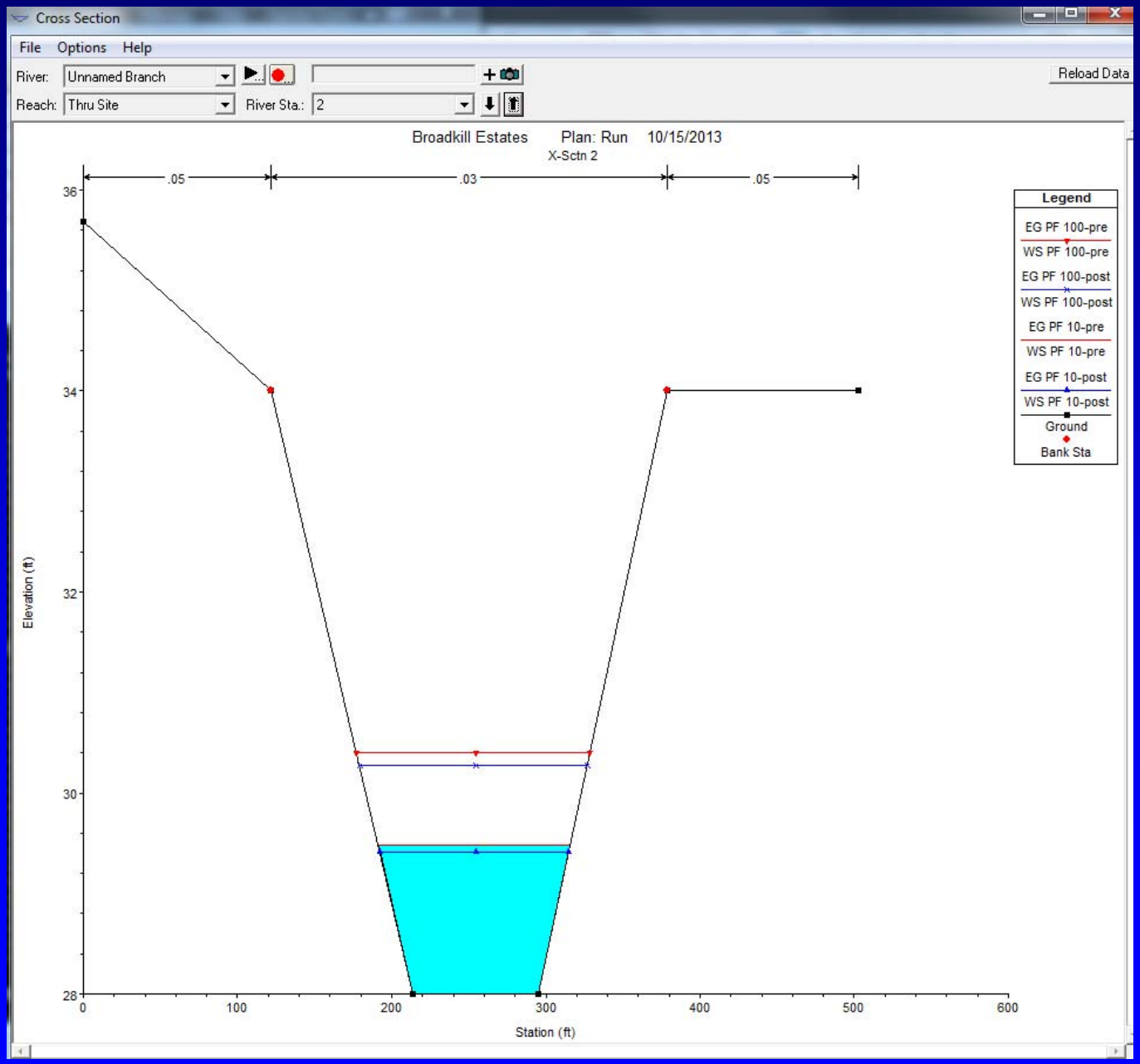






Options for Cv & Fv Compliance

Option 2, Level 2-b Steady Flow Water Surface Model



Pre-Developed water surface elevations (in red) for 10 and 100-yr are greater than the Post Developed (in blue)

✓ Post Runoff Water Surface Elevations Do Not Exceed the Pre Water Surface Elevations by More than 0.05'

Options for Cv & Fv Compliance

Option 2, Level 3 Un-Steady Flow Water Surface Model

2.2.2. Limit of the study shall be the point downstream where the site is 10% of the total contributing drainage area. Points of Analysis (POAs) shall be established at the site boundary and all hydraulic structures within the study reach. In cases where there are no hydraulic structures within the study reach, representative section(s) based on LiDAR data shall be used; locations to be determined at the Project Application Meeting.

2.2.3. To comply at this level of analysis, the applicant must show that:

2.2.3.1. The runoff volume based on the NRCS Runoff Curve Number (RCN) and the rate of runoff based on the calculated peak discharge for the post-developed condition does not exceed that for the pre-developed condition, or;

2.2.3.2. Steady flow hydraulic modeling must indicate no adverse impacts to headwater, water surface elevations and/or areas of inundation at designated POAs. For purposes of this policy, "no adverse impact" shall mean less than 0.05' increase in the calculated water surface elevations in channels and/or in headwater at hydraulic structures for all points of analysis. In addition, the area of inundation shall not encroach upon buildings or similar structures previously not impacted. If the "no adverse impact" condition can not be met, a remedy must be provided in accordance with Section 3 of this policy. If impacts are uncertain, proceed to Level 3.

2.3. Level 3 Analysis

2.3.1. The Level 3 Analysis shall be used in situations in which the watershed is so complex that a more rigorous analysis is needed to determine the appropriate stormwater management technique(s). It is expected that this would require survey-level field data to support development of an unsteady flow model. This may also require accounting for existing storage structures within the watershed study area.

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2.3.3. To comply at this level of analysis, unsteady flow hydraulic modeling must indicate no adverse impacts to headwater, water surface elevations and/or areas of inundation at designated POAs. For purposes of this policy, "no adverse impact" shall mean less than 0.05' increase in water surface elevations in channels and/or in headwater at hydraulic structures for all points of investigation. In

03/2013 3.02.2.2-2

Article 3.02.2.2, Technical Document

- Section 2.2.3.2

… If impacts are uncertain, proceed to Level 3 or provide more storage onsite.

Options for Cv & Fv Compliance

Option 2, Level 3 Un-Steady Flow Water Surface Model

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03/2013 3.02.2.2-2

Article 3.02.2.2, Technical Document

- Section 2.2.3.2

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Options for Cv & Fv Compliance

Questions??