The Extention Basin Greatly Reduces Stormwater Storage in the Florida D.O.T. Drainage Handbook Sample Problem

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Abstract:

The State of Florida Department of Transportation, in their 2004 Drainage Handbook, outlines a procedure to design a stormwater detention basin. The procedure requires the accounting for 50 unique storms, with durations from 1 hour to 10 days and recurrence frequencies of 2 through 100 years. The computations in the FDOT Sample Problem lead to the sizing of a conventional detention basin of about **1.89** acre-feet storage. To illustrate the benefits of the Extention Basin, we run an Extention Basin in the same Sample Problem. The end result is the Extention Basin requires only half the storage volume or about **0.94** acre-feet – a reduction of **50** per cent.

Methodology:

All the hydrologic inputs of the FDOT Sample Problem were used in HydroCad version 10, a popular stormwater modeling software, as follows:

Pre-Development:	CN=85.9	Tc=29 minutes	Area=11.9 acres
Post-Development	CN=89.9	Tc=21 minutes	Area=11.9 acres

The following storms were modeled.

1. FDOT 1 Hour Duration, 2 through 100 year Storm
2. FDOT 2 Hour Duration, 2 through 100 year Storm
3. FDOT 4 Hour Duration, 2 through 100 year Storm
4. FDOT 8 Hour Duration, 2 through 100 year Storm
5. FDOT 24 Hour Duration, 2 through 100 year Storm

6. FDOT 3- Day Duration, 2 through 100 year Storm
7. FDOT 7- Day Duration, 2 through 100 year Storm
8. FDOT 10 Day Duration, 2 through 100 year Storm

9. SCS Modified Florida Type 2, 2 through 100 year Storm
10. SFWMD 72 Hour, 25 Year Storm

The Detention Basin size used in the Sample Problem (FDOT page 61) is re-used in our analysis, having the following Stage-Storage relationship:

Stage (ft.)	Storage (ac.-ft.)
56.1	0
56.4	0.27
56.5	0.36
56.9	0.73
57.30	1.11
57.7	1.52
58.1	1.94

Weir Length: 4.5 feet Weir Elevation: 56.4 feet

Extention Basin:

In its simplest form the Extention Basin System operates by limiting flows into the storage basin. The system is patented and is in use in select areas of the northeast U.S. Full descriptions may be found at www.extentionbasin.com

Rainfall Volumes:

The FDOT Drainage Handbook (page 58) provides a Table of Rainfall Volumes for Narcoossee, Florida from 1 to 10 day durations and 2 through 100 year frequencies. In general, these rainfall values were used, except that we made minor adjustments to some rainfall values to let the peak flow precisely match the peak flows shown in the FDOT Sample Problem. These minor adjustments are necessary to equalize this analysis, since stormwater software programs rarely produce the same peak flow, even with the same input data. Regardless, these routines were also run using the exact rainfall data as the Sample Problem and the results (not included herein) were nearly identical; a reduction in storage of 50 per cent.

Storage:

Case 1: The maximum storage, computed by routing, in the FDOT Sample Problem is 1.887 acre-feet. This storage also satisfies the requirement that peak flows not increase for all storms studied. In fact, as computed by us, some FDOT storms do show increases but these are minor increases that probably could be eliminated using a slightly shorter weir.

Case 2: The same storage basin as Case 1 is used for the Extention Basin analysis.

Description of Case 1: Re-Create the FDOT Sample Problem "As-Is"

The FDOT sample problem was run using HydroCad 10, for all 50 storms to verify the software and use of selected input data. In general, the results from our "As-Is" analysis closely followed the FDOT sample problem. The results compare favorably with the values published in the FDOT Manual.

See Table 1 for the results of the Case 1 analysis.

Description of Case 2: Use the Extention Basin given the exact same input data.

The exact same 50 storms were run using HydroCad 10; however, this time the detention basin was equipped with the extention basin control structure.

The Extention Basin, in this case, includes a specialized control structure, a storage basin equal in size to the Case 1 basin, and another control structure to meter flows from the storage basin.

See Table 2 for the results of the Case 2 analysis.

Table 1: Storms and Routings for the FDOT Sample Problem -- Case 1 (“As-Is”)

STORM	PRE-DEV (CFS)	OUTFLOW (CFS)	STORAGE (AC. FT.)
FDOT 1HR-100 YR PK 256 RAINFALL=4.49"	35.16	25.47	1.74
FDOT 1HR-50 YR PK 256 RAINFALL=4.10"	31.04	22.29	1.6
FDOT 1HR-25 YR PK 256 RAINFALL=3.75"	27.39	19.5	1.472
FDOT 1HR-10 YR PK 256 RAINFALL=3.25"	22.25	15.61	1.289
FDOT 1HR-5 YR PK 256 RAINFALL=3.12"	20.94	14.63	1.241
FDOT 1HR-2 YR PK 256 RAINFALL=2.40"	13.89	9.39	0.975
FDOT 2HR-100 YR PK 256 RAINFALL=5.41"	31.9	26.52	1.786
FDOT 2HR-50 YR PK 256 RAINFALL=4.91"	28	23.22	1.641
FDOT 2HR-25 YR PK 256 RAINFALL=4.42"	24.22	20.05	1.498
FDOT 2HR-10 YR PK 256 RAINFALL=3.84"	19.81	16.37	1.326
FDOT 2HR-5 YR PK 256 RAINFALL=3.45"	16.91	13.98	1.208
FDOT 2HR-2 YR PK 256 RAINFALL=2.76"	11.93	9.88	1.001
FDOT 4HR-100 YR PK 256 RAINFALL=6.53"	27.01	26.92	1.803
FDOT 4HR-50 YR PK 256 RAINFALL=5.93"	23.99	23.92	1.672
FDOT 4HR-25 YR PK 256 RAINFALL=5.35"	21.09	21.05	1.543
FDOT 4HR-10 YR PK 256 RAINFALL=4.55"	17.12	17.1	1.36
FDOT 4HR-5 YR PK 256 RAINFALL=3.95"	14.17	14.18	1.218
FDOT 4HR-2 YR PK 256 RAINFALL=3.25"	10.79	10.83	1.049
FDOT 8HR-100 YR PK 256 RAINFALL=8.26"	29.52	28.88	1.887
FDOT 8HR-50 YR PK 256 RAINFALL=7.55"	26.52	25.94	1.761
FDOT 8HR-25 YR PK 256 RAINFALL=6.72"	23	22.53	1.61
FDOT 8HR-10 YR PK 256 RAINFALL=5.77"	18.99	18.63	1.432
FDOT 8HR-5 YR PK 256 RAINFALL=5.06"	16.01	15.73	1.295
FDOT 8HR-2 YR PK 256 RAINFALL=3.92"	11.3	11.17	1.066
FDOT 24HR 100 YR RAINFALL=10.90"	11.17	11.14	1.065
FDOT 24HR 50 YR RAINFALL=9.90"	10.03	10.03	1.008
FDOT 24HR 25 YR RAINFALL=8.90"	8.89	8.91	0.95
FDOT 24HR 10 YR RAINFALL=7.87"	7.7	7.76	0.887
FDOT 24HR 5 YR RAINFALL=6.40"	6.01	6.11	0.793
FDOT 24-HRFDOT 24HR 2 YR RAINFALL=4.92"	4.3	4.44	0.69
FDOT 3DAY 100 YR RAINFALL=14.90"	8.21	8.07	0.905
FDOT 3DAY 50 YR RAINFALL=12.95"	7.1	6.98	0.843
FDOT 3DAY 25 YR RAINFALL=11.40"	6.21	6.11	0.793
FDOT 3DAY 10 YR RAINFALL=9.63"	5.2	5.12	0.732
FDOT 3DAY 5 YR RAINFALL=8.41"	4.5	4.43	0.689
FDOT 3DAY 2 YR RAINFALL=6.52"	3.4	3.36	0.617
FDOT 7-DAY 100 YEAR RAINFALL=16.00"	5.87	5.76	0.771
FDOT 7-DAY 50 YEAR RAINFALL=14.20"	5.19	5.1	0.731
FDOT 7-DAY 25 YEAR RAINFALL=12.37"	4.5	4.42	0.688
FDOT 7-DAY 10 YEAR RAINFALL=11.00"	3.99	3.91	0.655
FDOT 7-DAY 5 YEAR RAINFALL=9.00"	3.23	3.17	0.604
FDOT 7-DAY 2 YEAR RAINFALL=7.00"	2.47	2.43	0.548
FDOT 10DAY 100 YR RAINFALL=20.00"	7.77	7.69	0.884
FDOT 10DAY 50 YR RAINFALL=17.80"	6.9	6.82	0.835
FDOT 10DAY 25 YR RAINFALL=15.80"	6.1	6.03	0.788
FDOT 10DAY 10 YR RAINFALL=13.80"	5.3	5.25	0.74
FDOT 10DAY 5 YR RAINFALL=11.55"	4.4	4.36	0.684
FDOT 10DAY 2 YR RAINFALL=9.08"	3.4	3.38	0.619
SFWMD 72-HR SF 3D-25 YR RAINFALL=11.06"	36.31	27.62	1.833
TYPE II FL 24-HR SCS-T2FLM-25 YEAR RAINFALL=9.04"	32.12	28.28	1.861
MAXIMUM STORAGE (AC. FT.)			**1.887**

Table 2: Storms and Routings using an **Extention Basin** for the FDOT Sample Problem – Case 2

STORM	PRE-DEV (CFS)	OUTFLOW (CFS)	STORAGE (AC. FT.)
FDOT 1HR-100 YR PK 256 RAINFALL=4.49"	35.16	34.4	0.748
FDOT 1HR-50 YR PK 256 RAINFALL=4.10"	31.04	29.64	0.704
FDOT 1HR-25 YR PK 256 RAINFALL=3.75"	27.39	26.92	0.651
FDOT 1HR-10 YR PK 256 RAINFALL=3.25"	22.25	21.97	0.578
FDOT 1HR-5 YR PK 256 RAINFALL=3.12"	20.94	20.62	0.559
FDOT 1HR-2 YR PK 256 RAINFALL=2.40"	13.89	13.64	0.439
FDOT 2HR-100 YR PK 256 RAINFALL=5.41"	31.9	29.51	0.844
FDOT 2HR-50 YR PK 256 RAINFALL=4.91"	28	26.6	0.795
FDOT 2HR-25 YR PK 256 RAINFALL=4.42"	24.22	22.91	0.748
FDOT 2HR-10 YR PK 256 RAINFALL=3.84"	19.81	18.51	0.681
FDOT 2HR-5 YR PK 256 RAINFALL=3.45"	16.91	15.78	0.624
FDOT 2HR-2 YR PK 256 RAINFALL=2.76"	11.93	11.31	0.506
FDOT 4HR-100 YR PK 256 RAINFALL=6.53"	27.01	26.25	0.91
FDOT 4HR-50 YR PK 256 RAINFALL=5.93"	23.99	22.85	0.871
FDOT 4HR-25 YR PK 256 RAINFALL=5.35"	21.09	19.67	0.826
FDOT 4HR-10 YR PK 256 RAINFALL=4.55"	17.12	15.29	0.753
FDOT 4HR-5 YR PK 256 RAINFALL=3.95"	14.17	12.45	0.683
FDOT 4HR-2 YR PK 256 RAINFALL=3.25"	10.79	8.97	0.584
FDOT 8HR-100 YR PK 256 RAINFALL=8.26"	29.52	29.15	0.941
FDOT 8HR-50 YR PK 256 RAINFALL=7.55"	26.52	25.74	0.905
FDOT 8HR-25 YR PK 256 RAINFALL=6.72"	23	21.74	0.858
FDOT 8HR-10 YR PK 256 RAINFALL=5.77"	18.99	17.26	0.79
FDOT 8HR-5 YR PK 256 RAINFALL=5.06"	16.01	14.11	0.735
FDOT 8HR-2 YR PK 256 RAINFALL=3.92"	11.3	9.44	0.61
FDOT 24HR 100 YR RAINFALL=10.90"	11.17	11.17	0.731
FDOT 24HR 50 YR RAINFALL=9.90"	10.03	9.96	0.698
FDOT 24HR 25 YR RAINFALL=8.90"	8.89	8.86	0.656
FDOT 24HR 10 YR RAINFALL=7.87"	7.7	7.7	0.619
FDOT 24HR 5 YR RAINFALL=6.40"	6.01	5.95	0.562
FDOT 24-HRFDOT 24HR 2 YR RAINFALL=4.92"	4.3	4.06	0.496
FDOT 3DAY 100 YR RAINFALL=14.90"	8.21	7.99	0.637
FDOT 3DAY 50 YR RAINFALL=12.95"	7.1	6.91	0.604
FDOT 3DAY 25 YR RAINFALL=11.40"	6.21	6.04	0.576
FDOT 3DAY 10 YR RAINFALL=9.63"	5.2	5.04	0.544
FDOT 3DAY 5 YR RAINFALL=8.41"	4.5	4.34	0.519
FDOT 3DAY 2 YR RAINFALL=6.52"	3.4	3.23	0.476
FDOT 7-DAY 100 YEAR RAINFALL=16.00"	5.87	5.76	0.569
FDOT 7-DAY 50 YEAR RAINFALL=14.20"	5.19	5.09	0.548
FDOT 7-DAY 25 YEAR RAINFALL=12.37"	4.5	4.41	0.524
FDOT 7-DAY 10 YEAR RAINFALL=11.00"	3.99	3.91	0.505
FDOT 7-DAY 5 YEAR RAINFALL=9.00"	3.23	3.17	0.477
FDOT 7-DAY 2 YEAR RAINFALL=7.00"	2.47	2.39	0.446
FDOT 10DAY 100 YR RAINFALL=20.00"	7.77	7.67	0.631
FDOT 10DAY 50 YR RAINFALL=17.80"	6.9	6.81	0.604
FDOT 10DAY 25 YR RAINFALL=15.80"	6.1	6.02	0.579
FDOT 10DAY 10 YR RAINFALL=13.80"	5.3	5.23	0.553
FDOT 10DAY 5 YR RAINFALL=11.55"	4.4	4.34	0.522
FDOT 10DAY 2 YR RAINFALL=9.08"	3.4	3.35	0.484
SFWMD 72-HR SF 3D-25 YR RAINFALL=11.06"	36.31	35.67	0.941
TYPE II FL 24-HR SCS-T2FLM-25 YEAR RAINFALL=9.04"	32.12	32.12	0.939
MAXIMUM STORAGE (AC. FT.)			**0.941**

Critical Storm Duration:

Table 3, below, shows that the Extention Basin re-orders the storm of critical duration slightly by placing the FDOT 8-hr, 100 year storm as most critical. Note that the 2nd and 3rd storms exchange their rankings using the Extention Basin.

The FDOT Sample Problem lists the 4 hour, 100 year storm as a critical duration as well as the SFWMD, 72 hour, 25 year storm, which are both represented in the top 4 storms here.

TABLE 3: Comparison of the top 4 storms for Critical Duration

EBS	PRE-DEV	OUTFLOW	STORAGE	**NO EBS**	PRE-DEV	OUTFLOW	STORAGE
Ranking	(CFS)	(CFS)	(AC. FT.)	**Ranking**	(CFS)	(CFS)	(AC. FT.)
1. FDOT 8hr - 100YR PK 256 Rainfall=8.26"	29.52	29.15	**0.941**	1. FDOT 8-hr 100YR PK 256 Rainfall=8.26"	29.52	28.88	**1.887**
2. SFWMD 72-hr SF3d-25yr Rainfall=11.06"	**36.31**	**35.67**	**0.941**	3. Type II FL 24-hr SCS-T2FLM-25 YEAR Rainfall=9.04"	32.12	28.28	1.861
3. Type II FL 24-hr SCS-T2FLM-25 YEAR Rainfall=9.04"	32.12	32.12	0.939	**2. SFWMD 72-hr SF 3d-25yr Rainfall=11.06"**	**36.31**	**27.62**	**1.833**
4. FDOT 4hr - 100YR PK 256 Rainfall=6.53"	**27.01**	**26.25**	**0.91**	**4. FDOT 4HR-100YR PK 256 Rainfall=6.53"**	**27.01**	**26.92**	**1.803**

Review:

The computations in this paper may be independently audited using the HydroCad Sampler, available free from the developer on their website.

The Hydrocad files that make up each run area available by emailing this author at hardycross@aol.com.

Figure 1: Simple Flow Schematic of the FDOT Sample Problem

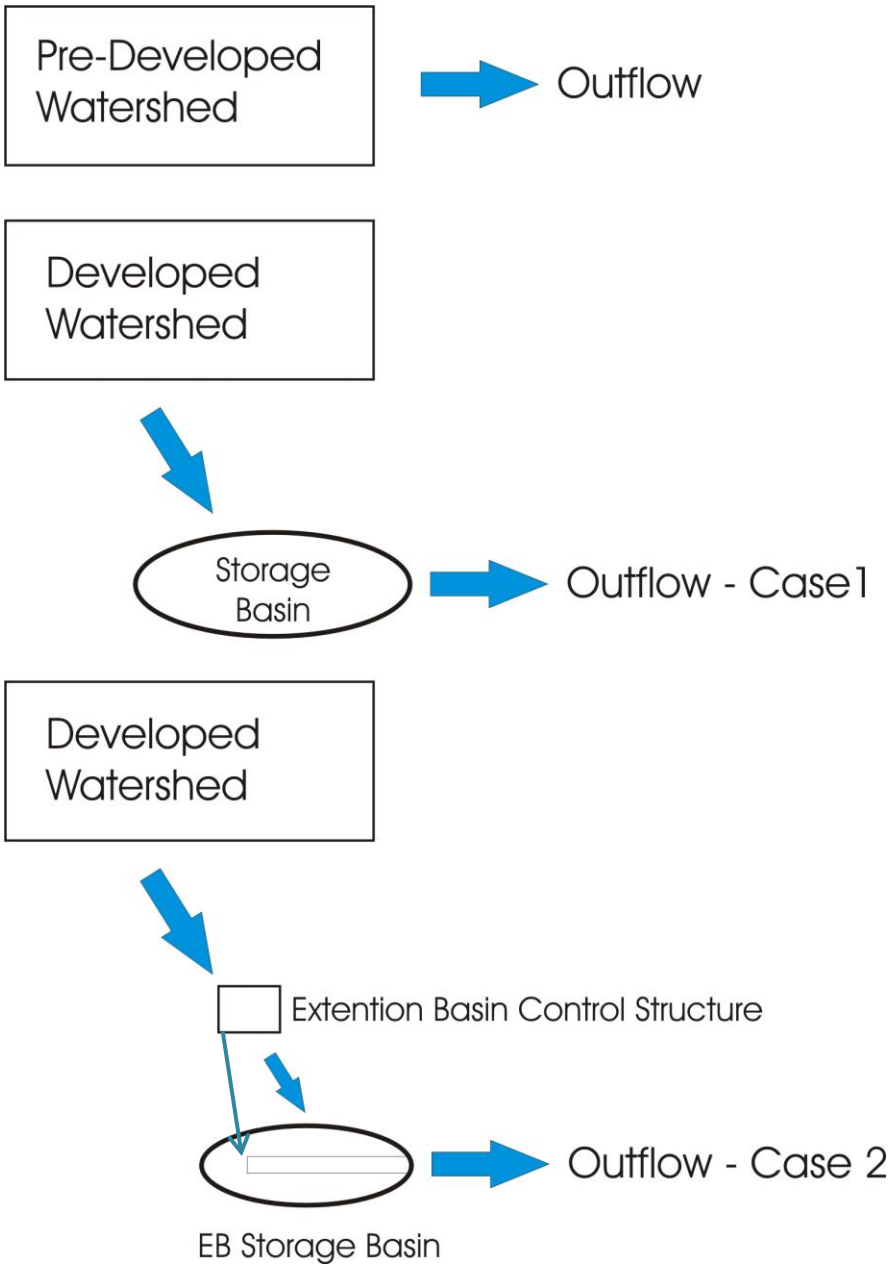

Figure 3: FDOT Manual Results

The following Tables are contained in the FDOT manual and are re-printed here for completeness and reference.

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Table 5.3-4 Pond Configuration: Pond Dimensions at SHWT = 88.0 m (288.7 ft) x 40.0 m (131.2 ft) SHWT El. = 17.71m (56.1ft) Avg Side Slope = 1 : 5 Weir Crest El. = 17.19 m (56.40 ft) Weir Width = 1.37 m (4.5 ft) Starting WS = 17.19 m (56.4 ft) Allowable Stage 17.71 (58.1)	Design Storm		Discharge m^3/s (cfs)	Peak Pond Stage m (ft)
	FDOT1hr - 100 year	Pre	1.00 (35.2)	17.65 (57.9)
		Post	0.73 (25.8)	
	FDOT2hr - 100 year	Pre	0.90 (31.9)	17.65 (57.9)
		Post	0.76 (26.7)	
	FDOT4hr - 100 year	Pre	0.76 (27.0)	17.65 (57.9)
		Post	0.76 (26.8)	
	FDOT8hr - 100 year	Pre	0.84 (29.5)	17.68 (58.0)
		Post	0.78 (27.6)	
	FDOT24hr - 100 year	Pre	0.32 (11.2)	17.46 (57.3)
		Post	0.31 (10.9)	
	SCS-T2FLM - 25 year	Pre	0.91 (32.1)	17.68 (58.0)
		Post	0.78 (27.5)	
	SFWMD-72hr - 25 year	Pre	1.08 (38.1)	17.68 (58.0)
		Post	0.86 (30.3)	

Note: The elevation 58.1 is equivalent to 1.94 acre-feet of storage.

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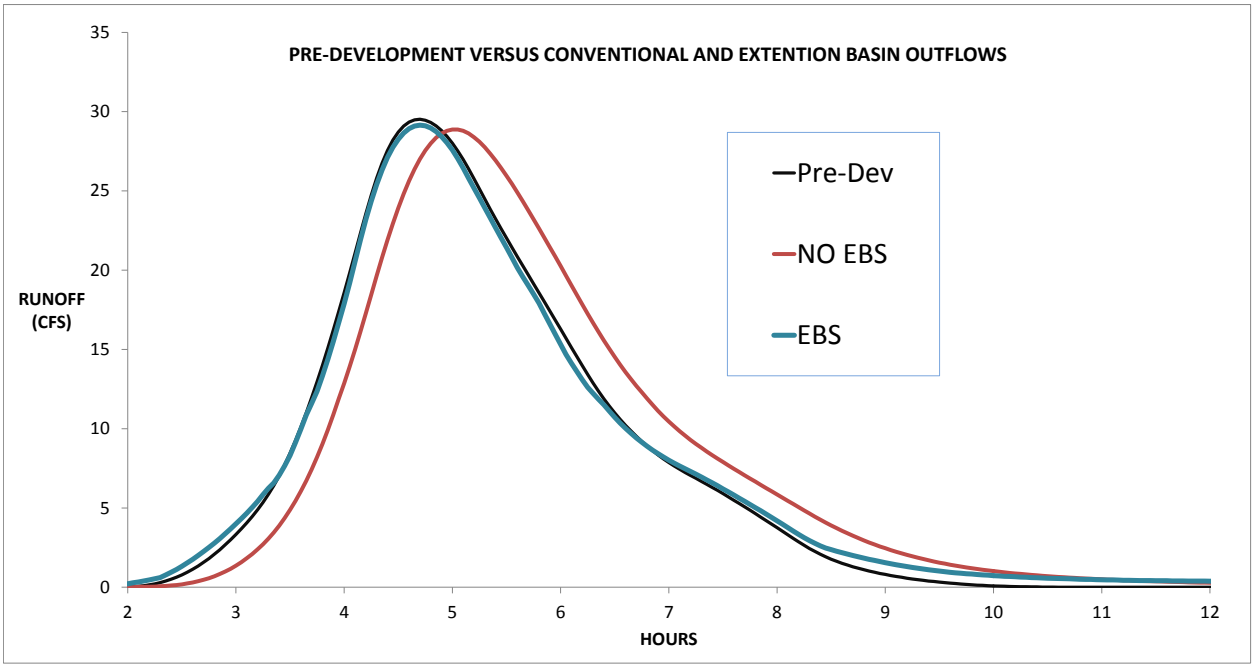
TABLE 5.3-5 (Example 5.3)

Pond Config. as in Table 5.3-4		100 - year Discharge m^3/s (cfs)	50 - year Discharge m^3/s (cfs)	25 - year Discharge m^3/s (cfs)	10 - year Discharge m^3/s (cfs)	5 - year Discharge m^3/s (cfs)	2 - year Discharge m^3/s (cfs)
1-hour	Pre	1.00 (35.2)	0.88 (31.0)	0.78 (27.4)	0.63 (22.3)	0.55 (19.3)	0.40 (14.0)
	Post	0.73 (25.8)	0.63 (22.3)	0.55 (19.4)	0.43 (15.3)	0.37 (13.0)	0.26 (9.1)
2-hour	Pre	0.90 (31.9)	0.79 (28.0)	0.69 (24.2)	0.56 (19.8)	0.48 (16.9)	0.34 (11.9)
	Post	0.76 (26.7)	0.66 (23.3)	0.57 (20.0)	0.46 (16.1)	0.39 (13.7)	0.27 (9.6)
4-hour	Pre	0.76 (27.0)	0.68 (24.0)	0.60 (21.1)	0.48 (17.1)	0.40 (14.2)	0.31 (10.8)
	Post	0.76 (26.8)	0.67 (23.7)	0.59 (20.7)	0.47 (16.8)	0.39 (13.8)	0.30 (10.5)
8 -hour	Pre	0.84 (29.5)	0.74 (26.5)	0.65 (23.0)	0.54 (19.0)	0.45 (16.0)	0.32 (11.3)
	Post	0.78 (27.6)	0.70 (24.5)	0.60 (21.1)	0.49 (17.3)	0.41 (14.3)	0.28 (9.9)
24 –hour	Pre	0.32 (11.2)	0.28 (10.0)	0.25 (8.9)	0.22 (7.7)	0.17 (6.0)	0.12 (4.3)
	Post	0.31 (10.9)	0.28 (9.7)	0.24 (8.6)	0.21 (7.4)	0.17 (5.8)	0.12 (4.1)
3-day	Pre	0.23 (8.2)	0.20 (7.1)	0.18 (6.2)	0.15 (5.2)	0.13 (4.5)	0.10 (3.4)
	Post	0.23 (8.2)	0.20 (7.1)	0.18 (6.2)	0.15 (5.2)	0.13 (4.4)	0.09 (3.3)
7 day	Pre	0.17 (5.9)	0.15 (5.2)	0.13 (4.5)	0.11 (4.0)	0.09 (3.2)	0.07 (2.5)
	Post	0.17 (5.9)	0.15 (5.2)	0.13 (4.5)	0.11 (4.0)	0.09 (3.2)	0.07 (2.6)
10 day	Pre	0.22 (7.8)	0.20 (6.9)	0.17 (6.1)	0.15 (5.3)	0.12 (4.4)	0.09 (3.4)
	Post	0.22 (7.8)	0.20 (6.9)	0.17 (6.1)	0.15 (5.3)	0.13 (4.4)	0.10 (3.4)

Figure 2: Outflow Comparison Timing of EBS with the FDOT Sample (NO EBS) for the Critical Storm (FDOT 8hr -100YR PK 256 Rainfall=8.26")



The Figure above shows the Extention Basin's ability to more closely match the timing of the original, pre-development watershed hydrograph. Conversely, the outflow of the conventional detention basin creates a wholly new hydrograph for the watershed.

Conclusion:

It is clear from the computations that the Extention Basin requires only half (50%) of the detention storage of the conventional detention basin, while maintaining peak flows at or below the pre-development levels, for all 50 storms studied.

In addition, the hydrograph timing of the Extention Basin follows, remarkably well, the pre-development hydrograph. This feature of the Extention Basin is helpful since it implies that developments can be made hydrologically transparent in the environment.

Submitted by:

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Extention Basin Systems, Inc.

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Ref: www.hydrocad.net
www.dot.state.fl.us/rddesign/dr/files/StrmWtrMgmtFacHB.pdf