December 9, 2010

Pond Design

American Development Inc.
Land Development - Commercial Mall

Project Manager: Daniel Sullivan
Project Engineers: Christopher Barden, Jonathan Hickey

Hydrologic Engineering - Prof. David Bedoya
Northeastern University – College of Engineering

Introduction:

The 50 acre lot of land purchased by American Development Inc. is planned to be constructed into a commercial shopping mall. Currently, the land is occupied by 95% woodlands; the development will modify 85% of the land surface, and will consist of commercial buildings, paved parking lots, and access roads. The State of Massachusetts storm water guidelines require that any developed plot of land cannot result in an increased peak flow from the 2 and 10-year storms. This constraint and other design requirements (as stated below) were followed in the design of the development's drainage system.

Pre-Design Conditions:

The 50 acre lot of land scheduled for commercialization is 95% woodlands (with 50/50 mixture of soil types A and B), and 5% paved access roads. The slope of the basin is 3% (3 ft vertical per 100 feet horizontal), with a greatest hydraulic length of 2,100 feet.

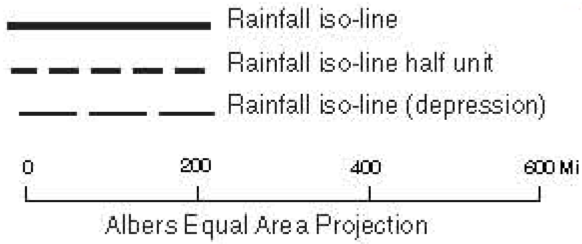
Assumptions:
- Square Area = 50 acres → Greatest Length to Divide = Hypotenuse = 2100'
- Drainage Basin will be constructed at the lowest elevation (near the natural outlet of the basin's)
- Type III Storms for Boston/Massachusetts

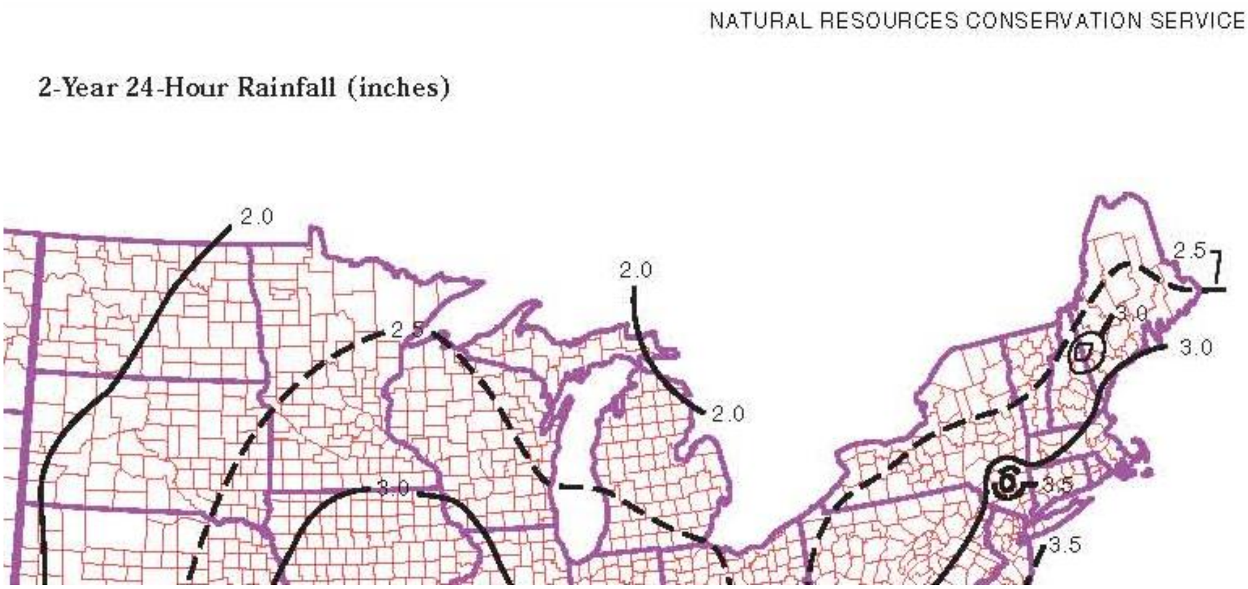
Summary of Final Design and Model Results:

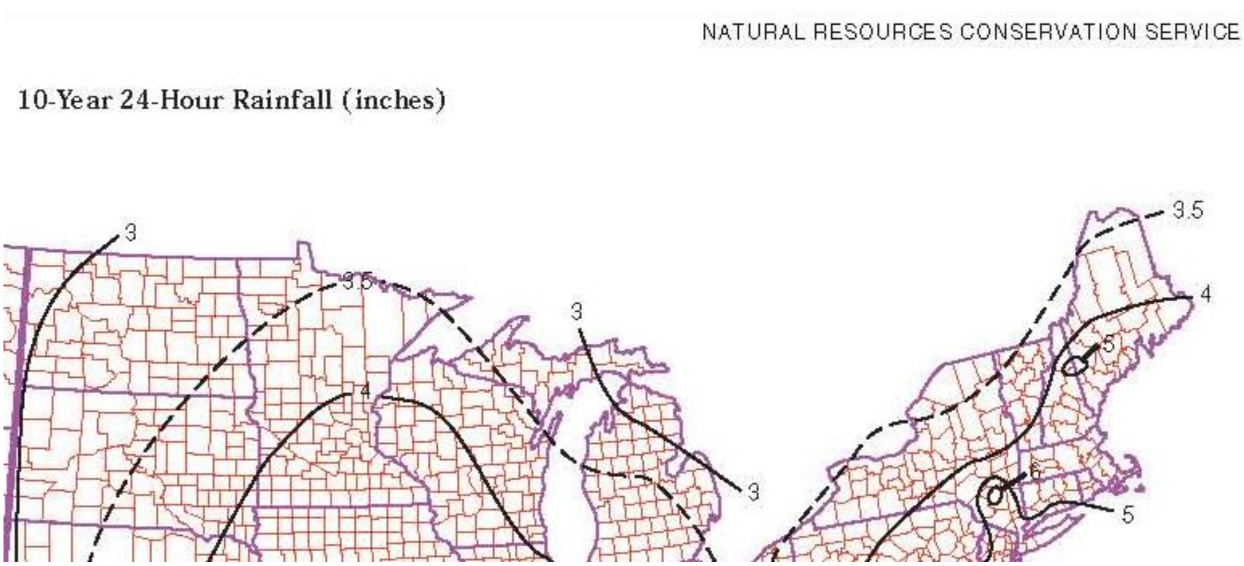
In the development of this plot of land, a detention basin must also be constructed in order to alleviate the additional flow resulting from the removed drainage capacity. The peak flow (discharge) from the plot were calculated for pre and post development conditions; the outlet of the new detention basin will have a maximum flow equal to or less than the discharge in the pre-development condition (for the 2 and 10 year storms). The inflow into the detention basin was given as the peak runoff flow for post-development conditions, and the pond was designed using these inflow and outflow conditions.

Several iterations were conducted in order to find the maximum runoff quantities, and the resulting size of the detention basin required. It was found that a basin with greater than 375,000 ft^3 of volume is required to hold the excess runoff generated by the development. This detention basin requires an outlet structure that limits the peak flow of the 10-year storm to the pre-development conditions of approximately 13 cfs. A 25% contingency gives a detention basin of approximately 480,000 cubic feet, which was the size chosen for the design. The square dry detention basin can hold a maximum head of water of 10', with outer dimensions of 250'x250' and a wall slope of 1:3. A circular detention basin with largest water height of 12’ is 260’ in diameter at the ground elevation, walls at a slope of 1:3, and an inner diameter of 188’. A 9”x9” box culvert will convey a maximum of 8 cfs under the 10’ of head in the detention basin (well below the peak value of 13 cfs for the 10 year storm), assuming an inlet-controlled concrete box culvert.

Rainfall Distribution – 2 and 10 Year Storms







Hydrologic Engineering 12/6/2010
Prof. David Bedoya
Pond Design - Project #3

Barden, Hickey, Sullivan

SCS UNIT HYDROGRAPHS:

EXISTING CONDITION Hydrograph:
Assuming 1 hour storm duration (D)
T(lag) = (L^.8 * [S+1]^.7) / (1900*sqrt(y))

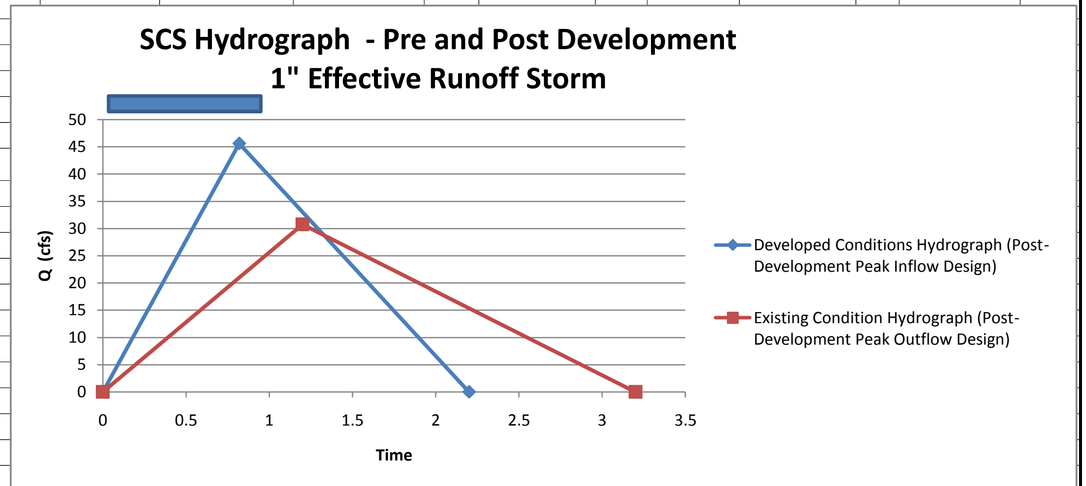
L = 2100'				
S = 9.8		--> T(lag) =	0.7308998	hours
y = 3%				

PEAK TIME = 1/2*Duration + T(lag) = **1.23 Hours = T(peak) = T(rise)**

Q(peak) = 484*A / T(rise) =	30.74186992	cfs
T(base) = 2.67*T(rise) =	3.2841	hrs
Vol Runoff =	181,727	ft^3

Existing Condition Hydrograph (Post-Development Peak Outflow Design)

Time [hrs]	Q [cfs]	
0	0	
1.2	30.75	Peak Flow Time
3.2	0	Base Time



10-year, 24-hour Storm - P=4.75" Ia= .5" Peffective = 4.25" D=24 hrs

	Peak Flow =				Peak Time =			
	Developed		**Undeveloped**		Developed		Undeveloped	
Qp*(Pe/D) =	**8.15**	**cfs**	**5.4453125**	**cfs**				
***Modified Peak Flow =**	**64.40**	**cfs**	**42**	**cfs**	**12.162**	**hrs**	**12.722**	**hrs**

*For Type III Storm - Peff = 65% * Ptot = 2.8 @ D = 2 hrs *See SCS Storm Distribution Curve Type III

POST-DEVELOPMENT HYDROGRAPH
Assuming 1 hour storm duration (D)

T(lag) = (L^.8 * [S+1]^.7) / (1900*sqrt(y))

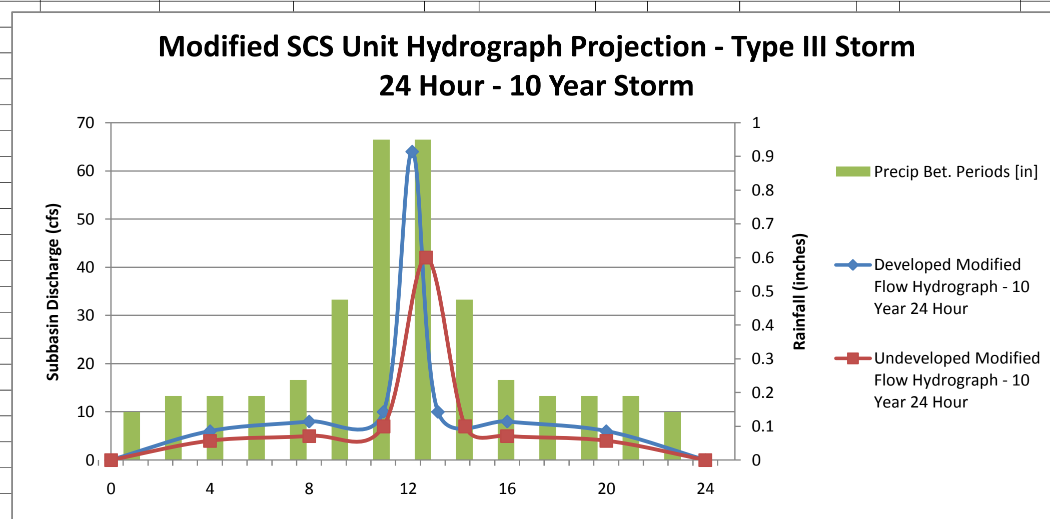
L = 2100'			
S = 2.5		--> T(lag) =	0.3321306
y = 3%			

Peak Time = 1/2*Duration + T(lag) = **.83 Hours = T(peak) = T(rise)**

Q(peak) = 484*A/T(rise) =	45.55722892	cfs
T(base) = 2.67*T(rise) =	2.2161	hours
Vol Runoff =	181,727	ft^3

Developed Conditions Hydrograph (Post-Development Peak Inflow Design)

Time [hrs]	Q [cfs]
0	0
0.82	45.6
2.2	0



Hydrologic Project #3

Barden, Hickey, Sullivan 10-Year, 24-Hour Storm Runoff Analysis

						Incremental Runoff Using SCS Equations					Incremental Runoff Using SCS Equations					Rational Method	
10 year - 24 Hour Storm			Area =	2178000	sq. ft	PRE Development					POST Development					Q(peak) = c i A A = 50 acres, i=precip [in]	
Time [hrs]	P(cum.) [%]	Precip Bet. Periods [in]	Cumulative P	Total Volume [ft^3]		Ia (Ia max =1.96")	F [in.]	Cumulative Pe [in.]	Pre-Development Excess Rainfall Hyetograph [in/hr]		Ia (Ia max =.5")	F [in.]	Cumulative Pe [in.]	Post-Development Excess Rainfall Hyetograph [in/hr]		Prior Qp (Runoff) (c=.11) [cfs]	Developed Qp (Runoff) (c=.8) [cfs]
0	0					0	0	0	0		0	0	0	0			
2	3	0.1425	0.1425	25863.75		0.1425	0	0	0		0.1425	0	0	0		0.391875	2.85
4	7	0.19	0.3325	34485		0.3325	0	0	0		0.3325	0	0	0		0.5225	3.8
6	11	0.19	0.5225	34485		0.5225	0	0	0		0.5	0	0.0225	0.0225		0.5225	3.8
8	15	0.19	0.7125	34485		0.7125	0	0	0		0.5	0.02927568	0.183224	0.160724316		0.5225	3.8
10	20	0.2375	0.95	43106.25		0.95	0.180220994	0	0		0.5	0.18022099	0.269779	0.109054689		0.653125	4.75
11	30	0.475	1.425	86212.5		1.425	0.42958486	0	0		0.5	0.42958486	0.495415	0.386360451		1.30625	9.5
12	50	0.95	2.375	172425		1.96	0.787443013	0	0		0.5	0.78744301	1.087557	0.701196536		2.6125	19
13	70	0.95	3.325	172425		1.96	1.474753962	0	0		0.5	1.0318849	1.793115	1.09191856		2.6125	19
14	80	0.475	3.8	86212.5		1.96	1.610958269	0.22904173	0.229041731		0.5	1.12718702	2.172813	1.080894423		1.30625	9.5
16	85	0.2375	4.0375	43106.25		1.96	1.671826314	0.40567369	0.176631955		0.5	1.16977637	2.367724	1.286829207		0.653125	4.75
18	89	0.19	4.2275	34485		1.96	1.717502718	0.54999728	0.373365327		0.5	1.20173614	2.525764	1.238934656		0.5225	3.8
20	93	0.19	4.4175	34485		1.96	1.760730159	0.69676984	0.323404515		0.5	1.23198236	2.685518	1.44658298		0.5225	3.8
22	97	0.19	4.6075	34485		1.96	1.801700447	0.84579955	0.522395039		0.5	1.26064926	2.846851	1.400267758		0.5225	3.8
24	100	0.1425	4.75	25863.75		1.96	1.831051213	0.95894879	0.436553748		0.5	1.28118598	2.968814	1.568546258		0.391875	2.85
			Sum Total Volume	862125	ft^3