Graphical Hydrograph Method for Stormwater Detention
Mansions Family - Rockwall, Texas
2 Year Detention Calculations

Purpose: Use the graphical hydrograph method to determine the volume of stormwater storage needed to compensate for increased runoff due to development.

Method: Use the Rational Method to determine maximum rate of runoff

Q = c*I*A Where: c = Runoff Coefficient; I = Rainfall Intensity (in/hr); A = Drainage Area (acres)

Assumptions: Rainfall Intensity determined from attached graph given Time of Concentration (Tc) or Duration and the Return Period of the storm.

For Existing Conditions: Allowable release rate is based upon 20 minute, 2 year storm event for undeveloped flows where c = 0.35, I = 3.90 in./hr.

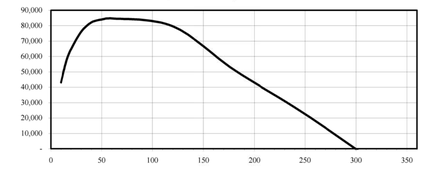
For Proposed Conditions: Use c = 0.75 for multi-family development

I. Determination of Allowable Release Rate - Existing Site

Total site area	28.37	acres
Detained Time of Concentration (T_c)	20	minutes
Rainfall intensity for 2 year storm (T_c=20 min)	3.90	inches/hr
Detained runoff coefficient	0.35	
Max. Allowable release rate	38.73	cfs
Area of site draining through detention pond	23.75	acres
Area of site draining undetained	4.62	acres
Undetained Time of Concentration (T_c)	10	minutes
Rainfall intensity for 2 year storm (T_c=10 min)	5.20	inches/hr
Runoff coefficient for developed conditions	0.75	
Runoff from undetained area	18.02	cfs
Total off-site area passed through	0.00	acres
Time of Concentration (T_c)	20	minutes
Rainfall intensity for 2 year storm (T_c=15 min)	3.90	inches/hr
Runoff coefficient	0.35	
Off-site pass-through rate	0.00	cfs
Total Allowable release rate from detention pond	20.71	cfs

II. Required Storage Calculations, Return Period = 2 years

Duration (hours)	Duration (min)	Rainfall Intensity (in/hr)	Inflow Rate (cfs)	Inflow Volume (cf)	Outflow Rate (cfs)	Outflow Volume (cf)	Inflow - Outflow Volume (cf)	Required Storage (ac-ft)
0.17	10	5.20	92.6	55,575	20.71	12,424	43,151	0.991
0.25	15	4.50	80.2	72,141	20.71	15,530	56,610	1.300
0.33	20	3.90	69.5	83,363	20.71	18,636	64,726	1.486
0.50	30	3.15	56.1	100,997	20.71	24,848	76,148	1.748
0.67	40	2.65	47.2	113,288	20.71	31,061	82,227	1.888
0.83	50	2.27	40.4	121,303	20.71	37,273	84,030	1.929
1.00	**60**	**2.00**	**35.6**	**128,250**	**20.71**	**43,485**	**84,765**	**1.946**
2.00	120	1.25	22.3	160,313	20.71	80,757	79,555	1.826
3.00	180	0.88	15.7	169,290	20.71	118,030	51,260	1.177
4.00	240	0.71	12.6	182,115	20.71	155,303	26,812	0.616
5.00	300	0.60	10.7	192,375	20.71	192,576	-201	-0.005
6.00	360	0.52	9.3	200,070	20.71	229,848	-29,778	-0.684
12.00	720	0.30	5.3	230,850	20.71	453,484	-222,634	-5.111



Graphical Hydrograph Method for Stormwater Detention
Mansions Family - Rockwall, Texas
10 Year Detention Calculations

Purpose: Use the graphical hydrograph method to determine the volume of stormwater storage needed to compensate for increased runoff due to development.

Method: Use the Rational Method to determine maximum rate of runoff

Q = c*I*A Where: c = Runoff Coefficient; I = Rainfall Intensity (in/hr); A = Drainage Area (acres)

Assumptions: Rainfall Intensity determined from attached graph given Time of Concentration (Tc) or Duration and the Return Period of the storm.

For Existing Conditions: Allowable release rate is based upon 20 minute, 10 year storm event for undeveloped flows where c = 0.35, I = 5.80 in./hr.

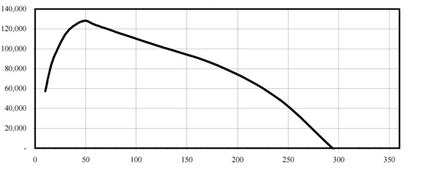
For Proposed Conditions: Use c = 0.75 for multi-family development

I. Determination of Allowable Release Rate - Existing Site

Total site area	28.37	acres
Detained Time of Concentration (T_c)	20	minutes
Rainfall intensity for 10 year storm (T_c=20 min)	5.80	inches/hr
Detained runoff coefficient	0.35	
Max. Allowable release rate	57.59	cfs
Area of site draining through detention pond	23.75	acres
Area of site draining undetained	4.62	acres
Undetained Time of Concentration (T_c)	10	minutes
Rainfall intensity for 10 year storm (T_c=10 min)	7.20	inches/hr
Runoff coefficient for developed conditions	0.75	
Runoff from undetained area	24.95	cfs
Total off-site area passed through	0.00	acres
Time of Concentration (T_c)	20	minutes
Rainfall intensity for 10 year storm (T_c=15 min)	5.80	inches/hr
Runoff coefficient	0.35	
Off-site pass-through rate	0.00	cfs
Total Allowable release rate from detention pond	32.64	cfs

II. Required Storage Calculations, Return Period = 10 years

Duration (hours)	Duration (min)	Rainfall Intensity (in/hr)	Inflow Rate (cfs)	Inflow Volume (cf)	Outflow Rate (cfs)	Outflow Volume (cf)	Inflow - Outflow Volume (cf)	Required Storage (ac-ft)
0.17	10	7.20	128.3	76,950	32.64	19,586	57,364	1.317
0.25	15	6.50	115.8	104,203	32.64	24,482	79,721	1.830
0.33	20	5.80	103.3	123,975	32.64	29,379	94,596	2.172
0.50	30	4.80	85.5	153,900	32.64	39,172	114,728	2.634
0.67	40	4.05	72.1	173,138	32.64	48,965	124,173	2.851
0.83	**50**	**3.50**	**62.3**	**187,031**	**32.64**	**58,758**	**128,274**	**2.945**
1.00	60	3.00	53.4	192,375	32.64	68,551	123,824	2.843
2.00	120	1.80	32.1	230,850	32.64	127,308	103,542	2.377
3.00	180	1.40	24.9	269,325	32.64	186,066	83,259	1.911
4.00	240	1.15	20.5	294,975	32.64	244,823	50,152	1.151
5.00	300	0.93	16.6	298,181	32.64	303,581	-5,400	-0.124
6.00	360	0.80	14.3	307,800	32.64	362,338	-54,538	-1.252
12.00	720	0.47	8.4	361,665	32.64	714,884	-353,219	-8.109



Graphical Hydrograph Method for Stormwater Detention
Mansions Family - Rockwall, Texas
25 Year Detention Calculations

Purpose: Use the graphical hydrograph method to determine the volume of stormwater storage needed to compensate for increased runoff due to development.

Method: Use the Rational Method to determine maximum rate of runoff

Q = c*I*A Where: c = Runoff Coefficient; I = Rainfall Intensity (in/hr); A = Drainage Area (acres)

Assumptions: Rainfall Intensity determined from attached graph given Time of Concentration (Tc) or Duration and the Return Period of the storm.

For Existing Conditions: Allowable release rate is based upon 20 minute, 25 year storm event for undeveloped flows where c = 0.35, I = 6.75 in./hr.

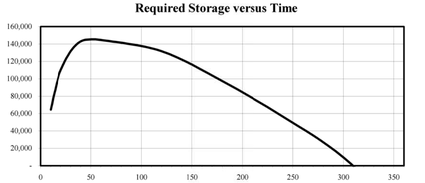
For Proposed Conditions: Use c = 0.75 for multi-family development

I. Determination of Allowable Release Rate - Existing Site

Total site area	28.37	acres
Detained Time of Concentration (T_c)	20	minutes
Rainfall intensity for 25 year storm (T_c=20 min)	6.75	inches/hr
Detained runoff coefficient	0.35	
Max. Allowable release rate	67.02	cfs
Area of site draining through detention pond	23.75	acres
Area of site draining undetained	4.62	acres
Undetained Time of Concentration (T_c)	10	minutes
Rainfall intensity for 25 year storm (T_c=10 min)	8.20	inches/hr
Runoff coefficient for developed conditions	0.75	
Runoff from undetained area	28.41	cfs
Total off-site area passed through	0.00	acres
Time of Concentration (T_c)	20	minutes
Rainfall intensity for 25 year storm (T_c=15 min)	6.75	inches/hr
Runoff coefficient	0.35	
Off-site pass-through rate	0.00	cfs
Total Allowable release rate from detention pond	38.61	cfs

II. Required Storage Calculations, Return Period = 25 years

Duration (hours)	Duration (min)	Rainfall Intensity (in/hr)	Inflow Rate (cfs)	Inflow Volume (cf)	Outflow Rate (cfs)	Outflow Volume (cf)	Inflow - Outflow Volume (cf)	Required Storage (ac-ft)
0.17	10	8.20	146.1	87,638	38.61	23,167	64,471	1.480
0.25	15	7.40	131.8	118,631	38.61	28,958	89,673	2.059
0.33	20	6.75	120.2	144,281	38.61	34,750	109,531	2.514
0.50	30	5.65	98.9	177,947	38.61	46,333	131,614	3.021
0.67	40	4.70	83.7	200,925	38.61	57,917	143,008	3.283
0.83	**50**	**4.02**	**71.6**	**214,819**	**38.61**	**69,500**	**145,319**	**3.336**
1.00	60	3.52	62.7	225,720	38.61	81,083	144,637	3.320
2.00	120	2.20	39.2	282,150	38.61	150,583	131,567	3.020
3.00	180	1.65	29.4	317,419	38.61	220,083	97,335	2.235
4.00	240	1.35	24.0	346,275	38.61	289,583	56,692	1.301
5.00	300	1.15	20.5	368,719	38.61	359,083	9,635	0.221
6.00	360	0.96	17.1	369,360	38.61	428,583	-59,223	-1.360
12.00	720	0.55	9.8	423,225	38.61	845,584	-422,359	-9.696



Graphical Hydrograph Method for Stormwater Detention
Mansions Family - Rockwall, Texas
50 Year Detention Calculations

Purpose: Use the graphical hydrograph method to determine the volume of stormwater storage needed to compensate for increased runoff due to development.

Method: Use the Rational Method to determine maximum rate of runoff

Q = c*I*A Where: c = Runoff Coefficient; I = Rainfall Intensity (in/hr); A = Drainage Area (acres)

Assumptions: Rainfall Intensity determined from attached graph given Time of Concentration (Tc) or Duration and the Return Period of the storm.

For Existing Conditions: Allowable release rate is based upon 20 minute, 50 year storm event for undeveloped flows where c = 0.35, I = 7.40 in./hr.

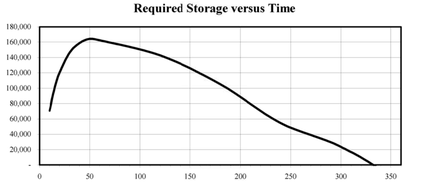
For Proposed Conditions: Use c = 0.75 for multi-family development

I. Determination of Allowable Release Rate - Existing Site

Total site area	28.37	acres
Detained Time of Concentration (T_c)	20	minutes
Rainfall intensity for 50 year storm (T_c=20 min)	7.40	inches/hr
Detained runoff coefficient	0.35	
Max. Allowable release rate	73.48	cfs
Area of site draining through detention pond	23.75	acres
Area of site draining undetained	4.62	acres
Undetained Time of Concentration (T_c)	10	minutes
Rainfall intensity for 50 year storm (T_c=10 min)	9.00	inches/hr
Runoff coefficient for developed conditions	0.75	
Runoff from undetained area	31.19	cfs
Total off-site area passed through	0.00	acres
Time of Concentration (T_c)	20	minutes
Rainfall intensity for 50 year storm (T_c=15 min)	7.40	inches/hr
Runoff coefficient	0.35	
Off-site pass-through rate	0.00	cfs
Total Allowable release rate from detention pond	42.29	cfs
Actual Metered release rate from detention pond	38.97	cfs

II. Required Storage Calculations, Return Period = 50 years

Duration (hours)	Duration (min)	Rainfall Intensity (in/hr)	Inflow Rate (cfs)	Inflow Volume (cf)	Outflow Rate (cfs)	Outflow Volume (cf)	Inflow - Outflow Volume (cf)	Required Storage (ac-ft)
0.17	10	9.00	160.3	96,188	42.29	25,376	70,812	1.626
0.25	15	8.20	146.1	131,456	42.29	31,720	99,736	2.290
0.33	20	7.40	131.8	158,175	42.29	38,064	120,111	2.757
0.50	30	6.15	109.5	197,184	42.29	50,752	146,432	3.362
0.67	40	5.20	92.6	222,300	42.29	63,440	158,860	3.647
0.83	**50**	**4.50**	**80.2**	**240,469**	**42.29**	**76,128**	**164,341**	**3.773**
1.00	60	3.92	69.8	251,370	42.29	88,816	162,554	3.732
2.00	120	2.40	42.8	307,800	42.29	164,944	142,856	3.280
3.00	180	1.80	32.1	346,275	42.29	241,072	105,203	2.415
4.00	240	1.45	25.8	371,925	42.29	317,200	54,725	1.256
5.00	300	1.30	23.2	416,813	42.29	393,328	23,485	0.539
6.00	360	1.15	20.5	442,463	42.29	469,456	-26,993	-0.620
12.00	720	0.63	11.2	484,785	42.29	926,223	-441,438	-10.134



Graphical Hydrograph Method for Stormwater Detention
Mansions Family - Rockwall, Texas
100 Year Detention Calculations

Purpose: Use the graphical hydrograph method to determine the volume of stormwater storage needed to compensate for increased runoff due to development.

Method: Use the Rational Method to determine maximum rate of runoff

Q = c*I*A Where: c = Runoff Coefficient; I = Rainfall Intensity (in/hr); A = Drainage Area (acres)

Assumptions: Rainfall Intensity determined from attached graph given Time of Concentration (Tc) or Duration and the Return Period of the storm.

For Existing Conditions: Allowable release rate is based upon 20 minute, 100 year storm event for undeveloped flows where c = 0.35, I = 8.30 in./hr.

For Proposed Conditions: Use c = 0.75 for multi-family development

I. Determination of Allowable Release Rate - Existing Site

Total site area	28.37	acres
Detained Time of Concentration (T_c)	20	minutes
Rainfall intensity for 100 year storm (T_c=20 min)	8.30	inches/hr
Detained runoff coefficient	0.35	
Max. Allowable release rate	82.41	cfs
Area of site draining through detention pond	23.75	acres
Area of site draining undetained	4.62	acres
Undetained Time of Concentration (T_c)	10	minutes
Rainfall intensity for 100 year storm (T_c=5 min)	9.80	inches/hr
Runoff coefficient for developed conditions	0.75	
Runoff from undetained area	33.96	cfs
Total off-site area passed through	0.00	acres
Time of Concentration (T_c)	20	minutes
Rainfall intensity for 100 year storm (T_c=20 min)	8.30	inches/hr
Runoff coefficient	0.35	
Off-site pass-through rate	0.00	cfs
Total Allowable release rate from detention pond	48.46	cfs

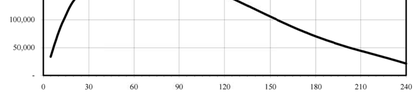
II. Required Storage Calculations, Return Period = 100 years

Duration (hours)	Duration (min)	Rainfall Intensity (in/hr)	Inflow Rate (cfs)	Inflow Volume (cf)	Outflow Rate (cfs)	Outflow Volume (cf)	Inflow - Outflow Volume (cf)	Required Storage (ac-ft)
0.08	5	10.37	184.7	55,415	48.46	21,806	33,609	0.772
0.17	10	9.80	174.6	104,738	48.46	29,075	75,663	1.737
0.25	15	9.00	160.3	144,281	48.46	36,343	107,938	2.478
0.33	20	8.30	147.8	177,413	48.46	43,612	133,800	3.072
0.50	30	6.90	122.9	221,231	48.46	58,149	163,082	3.744
0.67	40	5.80	103.3	247,950	48.46	72,687	175,263	4.023
0.83	50	5.00	89.1	267,188	48.46	87,224	179,963	4.131
1.00	60	4.50	80.2	288,563	48.46	101,761	186,801	4.288
1.17	70	4.10	73.0	306,731	48.46	116,299	190,432	4.372
1.33	80	3.90	69.5	333,450	48.46	130,836	202,614	4.651
1.50	90	3.60	64.1	346,275	48.46	145,374	200,901	4.612
1.67	**100**	**3.40**	**60.6**	**363,375**	**48.46**	**159,911**	**203,464**	**4.671**
1.83	110	2.80	49.9	329,175	48.46	174,448	154,727	3.552
2.00	120	2.60	46.3	333,450	48.46	188,986	144,464	3.316
3.00	180	1.80	32.1	346,275	48.46	276,210	70,065	1.608
4.00	240	1.50	26.7	384,750	48.46	363,434	21,316	0.489

III. Determine Approximate Pond Area

Assumptions: Assumed pond depth is **3.50** feet
Actual pond area = 120% of calculated area for landscaping, freeboard, slopes, ec.

Pond volume required	4.67	ac-ft	203,464 cf
Calculated pond surface area	1.33	acres	58,140 sf
Effective pond area	1.60	acres	69,768 sf



Pond Volume Calculations

Method: Use the average-end area method to determine volume of storage of the pond and determine the 100-year storm high water level

Where: Volume = (1/2)*(Area of top contour + Area of bottom contour)*depth increment

High Water Elevation	543.47	feet
High Water Elevation + 1' freeboard	544.47	feet
Invert elevation of outlet structure	540.00	feet

Goal: Calculated 100-yr storage 203,464 cubic feet

Calculations:

Elevation (feet)	Area (sq. ft.)	Incremental Volume (cubic ft.)	Incremental Volume (ac. ft.)	Total Volume (ac. ft.)	Total Volume (cubic ft.)
540.0	49,919.0	0.0	0.000	0.000	0
540.5	52,332.0	25,562.8	0.587	0.587	25,563
541.0	54,745.0	26,769.3	0.615	1.201	52,332
541.5	57,241.0	27,996.5	0.643	1.844	80,329
542.0	59,737.0	29,244.5	0.671	2.515	109,573
542.5	62,014.0	30,437.8	0.699	3.214	140,011
543.0	64,291.0	31,576.3	0.725	3.939	171,587
543.5	66,586.5	32,719.4	0.751	4.690	204,306
544.0	68,882.0	33,867.1	0.777	5.468	238,174

RECORD DRAWING
RECORD INFORMATION PROVIDED BY CONASTER CONSTRUCTION, FORT WORTH, TEXAS
ELEVATION VERIFICATION PERFORMED BY SURVEY CONSULTANTS, INC., PLANO, TEXAS

REV.	DATE	REMARKS	BY

DETENTION POND CALCULATIONS

MANSIONS FAMILY

CITY of ROCKWALL, TEXAS

RKM Consulting Engineers, Inc.
7616 LBJ Freeway, Suite 530
Dallas, Texas 75251
phone (214) 432-8070
fax (214) 432-8069
Firm No. F-7237

CHECKED	DESIGN	DRAWN	JOB	DATE	SCALE	SHEET
RKM	JRY	JRY	1026-005	05/27/09	N/A	11 OF 33

MANSIONS FAMILY - ROCKWALL, RKMCE PROJECT # 1026-005