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MEMORANDUM

To: James W. Ware, Deputy Director
Transportation Planning And Land Development
County Of El Dorado
2850 Fairlane Court
Placerville, CA 95667

From: Johannes J. DeVries, PE, PhD

Date: December 10, 2007

Subject: Procedure for computing the rational method C from NRCS (SCS) curve numbers for El Dorado County

REGISTERED PROFESSIONAL ENGINEER JOHANNES J. DeVRIES RCE 014195 exp. 3/09 STATE OF CALIFORNIA

Background

The El Dorado County Drainage Manual has charts that relate the parameter known as the NRCS (SCS) curve number (CN) to the rational method runoff coefficient C. These charts are useful in selecting an appropriate value of C for specific watershed soil type and land use. In these charts, C values are based on watershed CN and time of concentration. This procedure was originally developed by McKuen and Bondelid (R.H. McKuen and T.R. Bondelid 1981, "Relationship between curve number and runoff coefficient," *Journal of the Irrigation and Drainage Division*, ASCE, 107 (IR4), 395-400).

The County of El Dorado requested David Ford Consulting Engineers, Inc., to update the charts currently in the manual and to add curves for times of concentration of 5 min and 7.5 min. This memorandum describes the procedure used to develop these curves.

Rainfall data

We set up a hydrologic model for watersheds below 1640 ft using the NRCS type 1, 24-hr rainfall distribution for the 10-yr and the 100-yr rainfall based on a mean annual precipitation (MAP) of 30 in. (10-yr, 24-hr rain of 4.111 in. and 100-yr 24-hr rain of 5.828 in.). For watersheds below 1640 ft in elevation, this is the rainfall distribution adopted by the county and is a representative rainfall depth within the elevation range.

We also set up a hydrologic model for watersheds above 1640 ft using the NRCS type 1A, 24-hr rainfall distribution for the 10-yr and the 100-yr rainfall based on an MAP of 46 in. (10-yr 24-hr rain of 5.711 in. and 100-yr 24-hr rain of 8.096 in.). For watersheds above 1640 ft in elevation, this is the rainfall distribution adopted by the county and is a representative rainfall depth within the elevation range.

Rainfall depth

Figure 1 and Figure 2 show the relationship between rainfall depth for 10-yr and 100-yr storms as a function of rainfall duration for an MAP value of 30 in. (representative of elevations in El Dorado County below 1640 ft in elevation) and a MAP of 46 in. (representative of elevations in El Dorado County above 1640 ft in elevation). These figures use depths for 5-min, 10-min, and longer durations from the Drainage Manual; these depths were developed by Jim Goodridge in 1992, using available rainfall data and standard-of-practice statistical analyses. We obtained the 7.5-min rainfall depths by log-log interpolation.

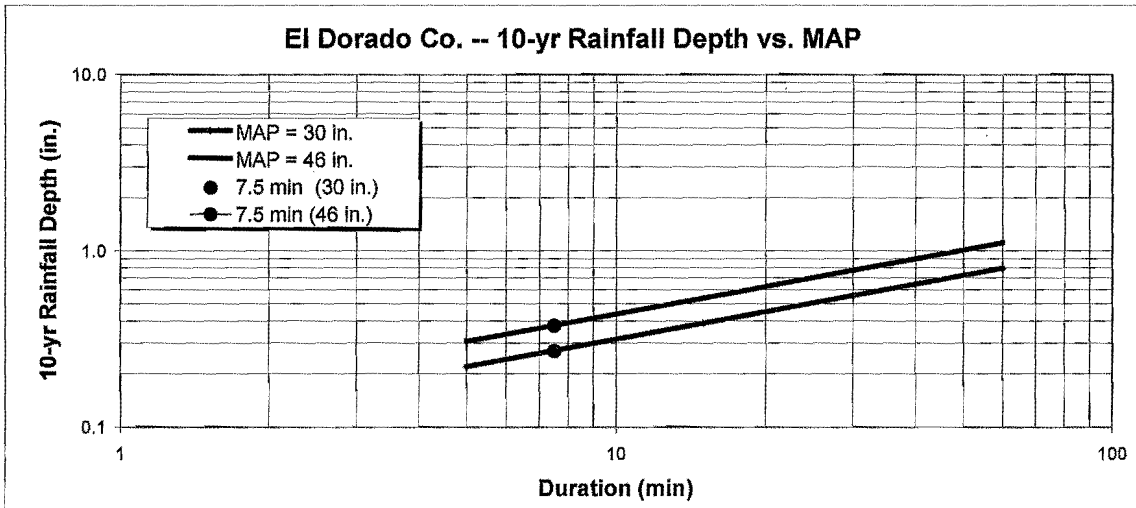

Figure 1. 10-yr rainfall depth and duration for MAP of 30 in. and 46 in.

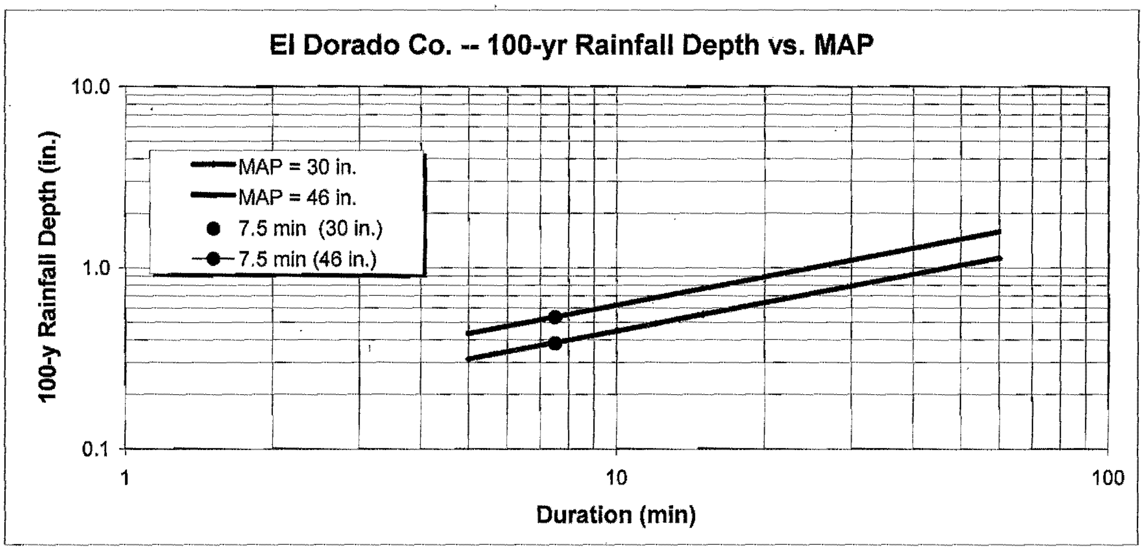

Figure 2. 100-yr rainfall depth and duration for MAP of 30 in. and 46 in.

Rainfall intensity

Rainfall intensity values from the El Dorado County Drainage Manual are presented in Table 1. Figure 3 is a plot of the rainfall intensities from the table.

Table 1. Rainfall intensity for 10-yr and 100-yr return periods as a function of time of concentration and MAP

10-yr return period				
	MAP = 30 in.		**MAP = 46 in.**	
tc (min) (1)	**P (in.) (2)**	**I (in./hr) (3)**	**P (in.) (4)**	**I (in./hr) (5)**
5	0.220	2.640	0.306	3.672
7.5	0.271	2.170	0.377	3.016
10	0.315	1.890	0.437	2.622
15	0.388	1.552	0.539	2.156
30	0.556	1.112	0.772	1.544

100-yr return period				
	MAP = 30 in.		**MAP = 46 in.**	
tc (min)	**P (in.)**	**I (in./hr)**	**P (in.)**	**I (in./hr)**
5	0.312	3.744	0.433	5.196
7.5	0.385	3.077	0.534	4.275
10	0.446	2.676	0.620	3.720
15	0.550	2.200	0.765	3.060
30	0.788	1.576	1.094	2.188

Hydrologic models

For rational method calculations, the peak discharge is a function of the rainfall intensity associated with the time of concentration, tc. A watershed area of 0.1 sq mi (64 acres) was used for all computations. Loss calculations for individual subbasins were based on CN values ranging from 40 to 95 with CN increments of 5, and in addition we used a CN value of 98 to represent the highest CN. Time of concentration values (tc) of 5, 7.5, 10, 15, and 30 minutes were used to develop the relationship between tc, CN, and peak discharge.

We ran the HEC-HMS models to compute the peak flows for the various values of tc, CN, 10-yr and 100-yr storm rainfall, and for the appropriate rainfall distribution pattern (type 1 below elevation 1640 and type 1A above elevation 1640).

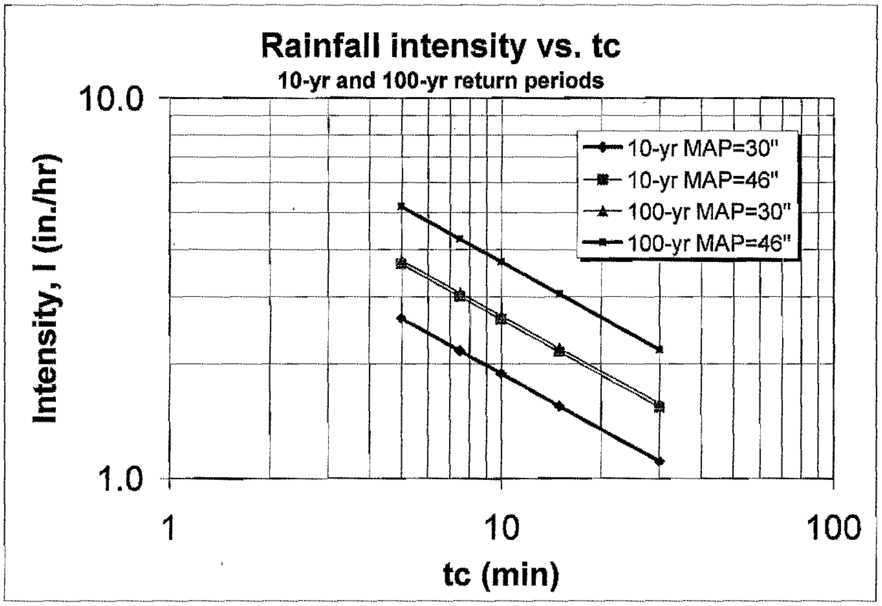

Figure 3. Rainfall intensity and time of concentration for 10-yr and 100-yr return periods and MAP = 30 in. and 46 in.

Calculation of C from CN

The peak flows calculated in the above step were divided by the product of area and intensity to give the runoff coefficient C. The maximum coefficient was limited to a value of 1.00.

Results

The results of these calculations are shown in Table 2 and Table 3 and in Figure 4–Figure 7. Columns 4 and 7 of each table show the hydrograph peaks computed with HEC-HMS, with curve numbers shown in column 2 and times of concentration shown in column 1. The corresponding rainfall intensities above and below 1640 ft for durations equal the time of concentration are shown in columns 3 and 6, respectively. The computed rational equation coefficients corresponding to the times of concentration and curve numbers are shown in columns 5 and 8.

Table 2. Runoff from 10-yr, 24-hr storm

tc (min) (1)	CN (2)	Below 1640 ft/MAP=30 in. I for tc (in./hr) (3)[1]	HEC-HMS peak w/ type 1, cfs (4)[2]	Runoff coeff. type 1 (5)[3]	Above 1640 ft/MAP=46 in. I for tc (in./hr) (6)[1]	HEC-HMS peak w/ type 1A, cfs (7)[2]	Runoff coeff. type 1A (8)[3]
5	40	2.640	0.6	0.00	3.672	2.3	0.01
5	45	2.640	1.2	0.01	3.672	3.3	0.01
5	50	2.640	2.1	0.01	3.672	5.6	0.02
5	55	2.640	11.3	0.07	3.672	12.8	0.05
5	60	2.640	26.6	0.16	3.672	21.0	0.09
5	65	2.640	44.2	0.26	3.672	29.4	0.13
5	70	2.640	64.1	0.38	3.672	38.5	0.16
5	75	2.640	86.2	0.51	3.672	48.1	0.20
5	80	2.640	110.6	0.65	3.672	58.0	0.25
5	85	2.640	136.2	0.81	3.672	67.9	0.29
5	90	2.640	161.7	0.96	3.672	77.2	0.33
5	95	2.640	183.9	1.00	3.672	84.8	0.36
5	98	2.640	193.2	1.00	3.672	88.0	0.37
7.5	40	2.170	0.6	0.00	3.016	2.3	0.01
7.5	45	2.170	1.2	0.01	3.016	3.2	0.02
7.5	50	2.170	2.1	0.02	3.016	5.4	0.03
7.5	55	2.170	10.3	0.07	3.016	12.5	0.06
7.5	60	2.170	24.8	0.18	3.016	20.6	0.11
7.5	65	2.170	41.5	0.30	3.016	29.0	0.15
7.5	70	2.170	60.5	0.44	3.016	38.1	0.20
7.5	75	2.170	81.5	0.59	3.016	47.6	0.25
7.5	80	2.170	104.4	0.75	3.016	57.6	0.30
7.5	85	2.170	128.4	0.92	3.016	67.5	0.35
7.5	90	2.170	153.0	1.00	3.016	76.9	0.40
7.5	95	2.170	174.7	1.00	3.016	84.5	0.44
7.5	98	2.170	183.4	1.00	3.016	87.4	0.45
10	40	1.890	0.6	0.00	2.622	2.3	0.01
10	45	1.890	1.2	0.01	2.622	3.2	0.02
10	50	1.890	2.1	0.02	2.622	5.1	0.03
10	55	1.890	9.4	0.08	2.622	12.1	0.07
10	60	1.890	23.1	0.19	2.622	20.1	0.12
10	65	1.890	38.8	0.32	2.622	28.5	0.17
10	70	1.890	56.9	0.47	2.622	37.5	0.22
10	75	1.890	76.6	0.63	2.622	47.1	0.28
10	80	1.890	98.3	0.81	2.622	57.1	0.34
10	85	1.890	121.4	1.00	2.622	67.1	0.40
10	90	1.890	144.5	1.00	2.622	76.5	0.46
10	95	1.890	164.9	1.00	2.622	84.2	0.50
10	98	1.890	173.0	1.00	2.622	87.1	0.52

tc (min) (1)	CN (2)	Below 1640 ft/MAP=30 in. I for tc (in./hr) (3) [1]	HEC-HMS peak w/ type 1, cfs (4)[2]	Runoff coeff. type 1 (5)[3]	Above 1640 ft/MAP=46 in. I for tc (in./hr) (6) [1]	HEC-HMS peak w/ type 1A, cfs (7) [2]	Runoff coeff. type 1A (8) [3]
15	40	1.552	0.6	0.01	2.156	2.2	0.02
15	45	1.552	1.1	0.01	2.156	3.2	0.02
15	50	1.552	2.1	0.02	2.156	4.7	0.03
15	55	1.552	7.9	0.08	2.156	11.4	0.08
15	60	1.552	19.9	0.20	2.156	19.2	0.14
15	65	1.552	34.1	0.34	2.156	27.4	0.20
15	70	1.552	50.3	0.51	2.156	36.3	0.26
15	75	1.552	67.9	0.68	2.156	45.8	0.33
15	80	1.552	87.4	0.88	2.156	55.7	0.40
15	85	1.552	108.1	1.00	2.156	65.7	0.48
15	90	1.552	128.9	1.00	2.156	75.2	0.54
15	95	1.552	147.3	1.00	2.156	83.0	0.60
15	98	1.552	154.8	1.00	2.156	85.9	0.62
30	40	1.112	0.6	0.01	1.544	2.2	0.02
30	45	1.112	1.1	0.02	1.544	3.2	0.03
30	50	1.112	2.0	0.03	1.544	4.4	0.04
30	55	1.112	5.7	0.08	1.544	9.6	0.10
30	60	1.112	13.8	0.19	1.544	16.5	0.17
30	65	1.112	24.2	0.34	1.544	23.9	0.24
30	70	1.112	36.1	0.51	1.544	32.0	0.32
30	75	1.112	49.3	0.69	1.544	40.6	0.41
30	80	1.112	63.8	0.90	1.544	49.7	0.50
30	85	1.112	79.3	1.00	1.544	59.0	0.60
30	90	1.112	95.0	1.00	1.544	67.8	0.69
30	95	1.112	109.2	1.00	1.544	75.2	0.76
30	98	1.112	115.1	1.00	1.544	78.0	0.79

Notes:
1. From Goodridge tables for MAP 30 in. and 46 in., respectively.
2. Computed with HEC-HMS.
3. Computed coefficients for 64 acres.

Table 3. Runoff from 100-yr, 24-hr storm

tc (min) (1)	CN (2)	Below 1640 ft/MAP=30 in. I for tc (in./hr) (3)[1]	HEC-HMS peak w/ type 1, cfs (4)[2]	Runoff coeff. type 1 (5)[3]	Above 1640 ft/MAP=46 in. I for tc (in./hr) (6)[1]	HEC-HMS peak w/ type 1A, cfs (7)[2]	Runoff coeff. type 1A (8)[3]
5	40	3.744	2.5	0.01	5.196	5.7	0.02
5	45	3.744	11.7	0.05	5.196	15.6	0.05
5	50	3.744	31.1	0.13	5.196	26.5	0.08
5	55	3.744	54.1	0.23	5.196	37.8	0.11
5	60	3.744	79.7	0.33	5.196	49.5	0.15
5	65	3.744	106.0	0.44	5.196	61.3	0.18
5	70	3.744	134.3	0.56	5.196	73.2	0.22
5	75	3.744	163.4	0.68	5.196	84.9	0.26
5	80	3.744	192.9	0.81	5.196	96.3	0.29
5	85	3.744	221.6	0.92	5.196	106.8	0.32
5	90	3.744	247.5	1.00	5.196	115.8	0.35
5	95	3.744	267.9	1.00	5.196	122.7	0.37
5	98	3.744	275.4	1.00	5.196	125.6	0.38
7.5	40	3.077	2.5	0.01	4.275	5.6	0.02
7.5	45	3.077	10.7	0.05	4.275	15.1	0.06
7.5	50	3.077	29.1	0.15	4.275	25.9	0.09
7.5	55	3.077	50.9	0.26	4.275	37.2	0.14
7.5	60	3.077	75.0	0.38	4.275	48.9	0.18
7.5	65	3.077	100.3	0.51	4.275	60.6	0.22
7.5	70	3.077	126.9	0.64	4.275	72.6	0.27
7.5	75	3.077	154.3	0.78	4.275	84.3	0.31
7.5	80	3.077	182.0	0.92	4.275	95.7	0.35
7.5	85	3.077	209.6	1.00	4.275	106.3	0.39
7.5	90	3.077	234.7	1.00	4.275	115.3	0.42
7.5	95	3.077	254.4	1.00	4.275	122.0	0.45
7.5	98	3.077	261.4	1.00	4.275	124.4	0.45
10	40	2.676	2.5	0.01	3.720	5.6	0.02
10	45	2.676	9.6	0.06	3.720	14.6	0.06
10	50	2.676	26.9	0.16	3.720	25.3	0.11
10	55	2.676	47.6	0.28	3.720	36.5	0.15
10	60	2.676	70.6	0.41	3.720	48.2	0.20
10	65	2.676	94.3	0.55	3.720	59.9	0.25
10	70	2.676	119.2	0.70	3.720	71.8	0.30
10	75	2.676	145.4	0.85	3.720	83.6	0.35
10	80	2.676	172.1	1.00	3.720	95.1	0.40
10	85	2.676	198.0	1.00	3.720	105.7	0.44
10	90	2.676	221.6	1.00	3.720	114.9	0.48
10	95	2.676	240.1	1.00	3.720	121.7	0.51
10	98	2.676	246.6	1.00	3.720	123.9	0.52

tc (min) (1)	CN (2)	Below 1640 ft/MAP=30 in. I for tc (in./hr) (3)[1]	HEC-HMS peak w/ type 1, cfs (4)[2]	Runoff coeff. type 1 (5)[3]	Above 1640 ft/MAP=46 in. I for tc (in./hr) (6)[1]	HEC-HMS peak w/ type 1A, cfs (7)[2]	Runoff coeff. type 1A (8)[3]
15	40	2.200	2.4	0.02	3.060	5.6	0.03
15	45	2.200	8.0	0.06	3.060	13.7	0.07
15	50	2.200	23.1	0.16	3.060	24.1	0.12
15	55	2.200	41.6	0.30	3.060	35.0	0.18
15	60	2.200	62.2	0.44	3.060	46.5	0.24
15	65	2.200	83.4	0.59	3.060	58.1	0.30
15	70	2.200	105.9	0.75	3.060	69.9	0.36
15	75	2.200	129.3	0.92	3.060	81.6	0.42
15	80	2.200	153.2	1.00	3.060	93.1	0.48
15	85	2.200	176.6	1.00	3.060	103.8	0.53
15	90	2.200	197.9	1.00	3.060	113.1	0.58
15	95	2.200	214.6	1.00	3.060	119.9	0.61
15	98	2.200	220.6	1.00	3.060	122.2	0.62
30	40	1.576	2.4	0.02	2.188	5.5	0.04
30	45	1.576	6.1	0.06	2.188	11.5	0.08
30	50	1.576	15.9	0.16	2.188	20.6	0.15
30	55	1.576	29.3	0.29	2.188	30.4	0.22
30	60	1.576	44.4	0.44	2.188	40.8	0.29
30	65	1.576	60.2	0.60	2.188	51.3	0.37
30	70	1.576	77.0	0.76	2.188	62.2	0.44
30	75	1.576	94.5	0.94	2.188	73.0	0.52
30	80	1.576	112.4	1.00	2.188	83.6	0.60
30	85	1.576	130.0	1.00	2.188	93.6	0.67
30	90	1.576	146.3	1.00	2.188	102.3	0.73
30	95	1.576	159.4	1.00	2.188	108.7	0.78
30	98	1.576	164.1	1.00	2.188	110.9	0.79

Notes:

1. From Goodridge tables for MAP 30 in. and 46 in., respectively.
2. Computed with HEC-HMS.
3. Computed coefficients for 64 acres.

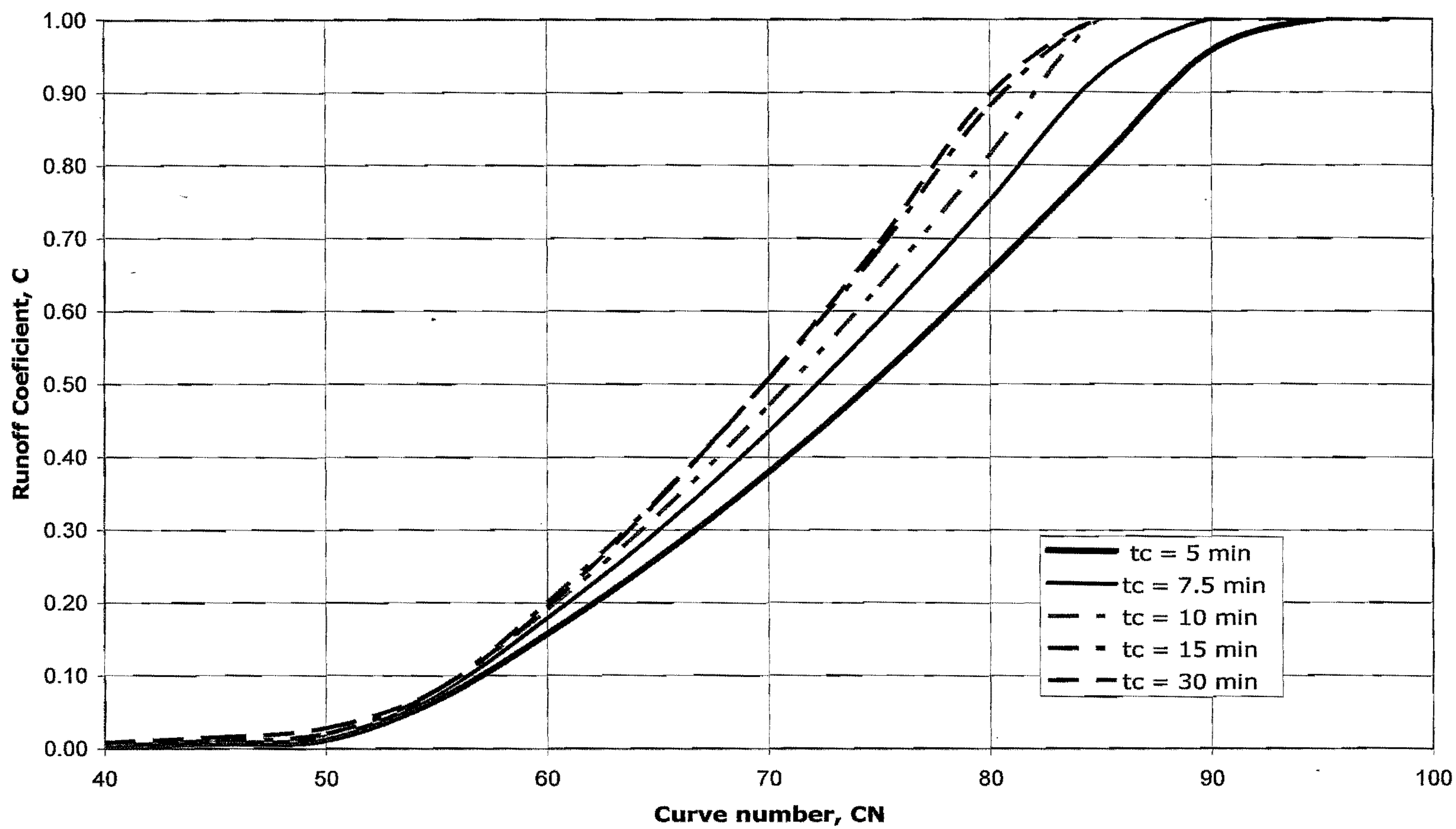

Figure 4. Runoff coefficients for 10-yr event below 1,640 ft (NRCS type 1 storm)

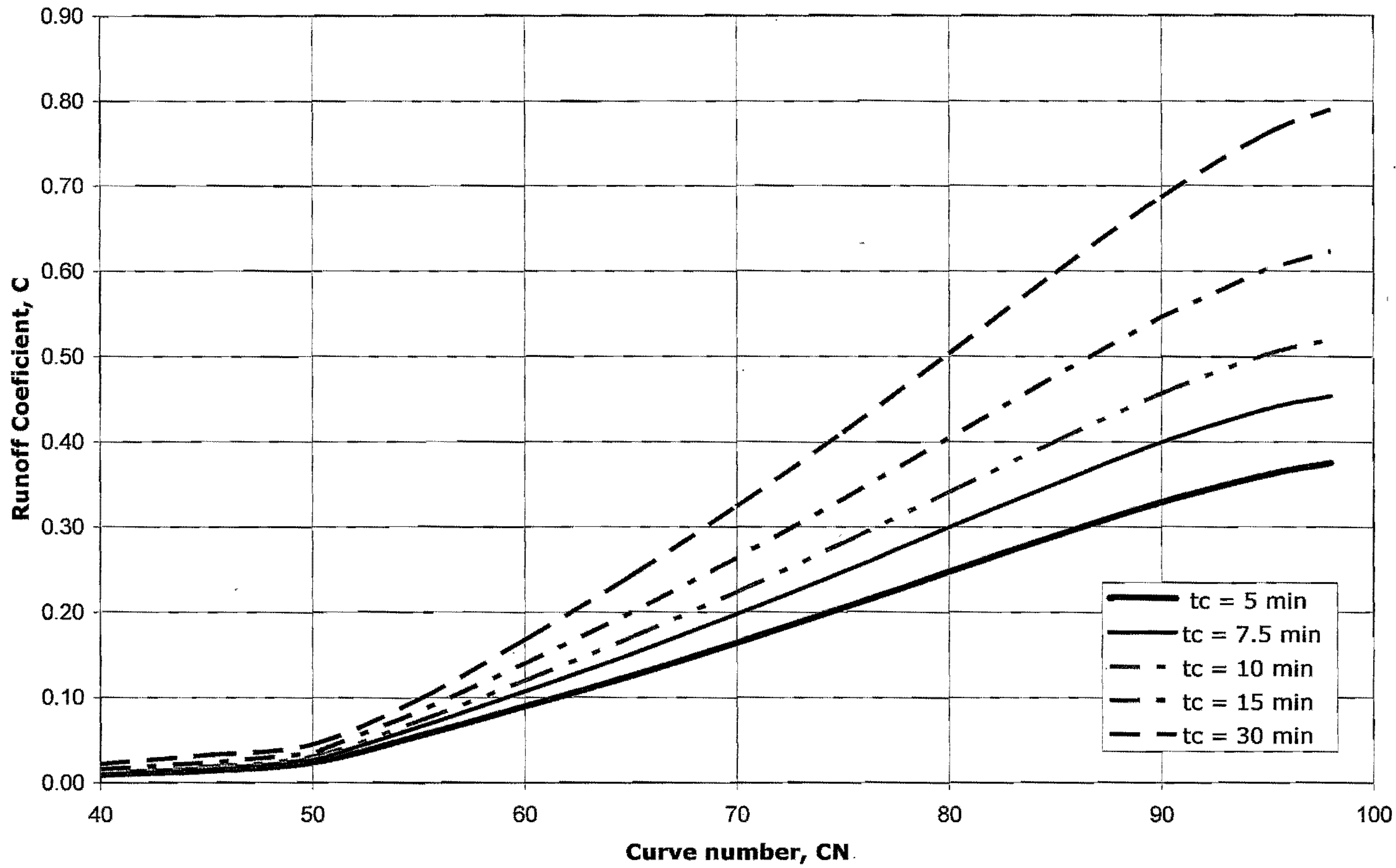

Figure 5. Runoff coefficients for 10-yr event above 1,640 ft (NRCS type 1A storm)

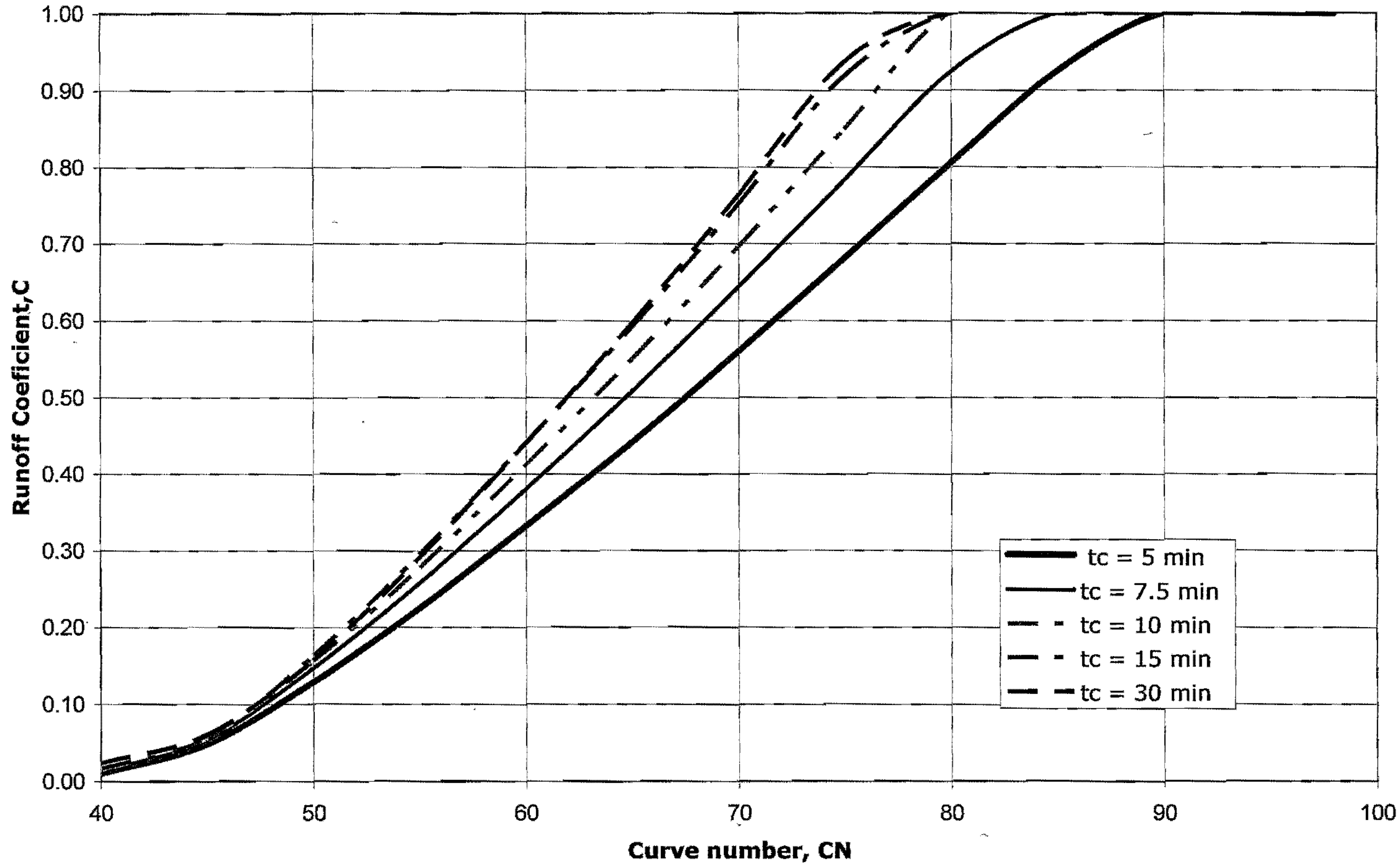

Figure 6. Runoff coefficients for 100-yr event below 1,640 ft (NRCS type 1 storm)

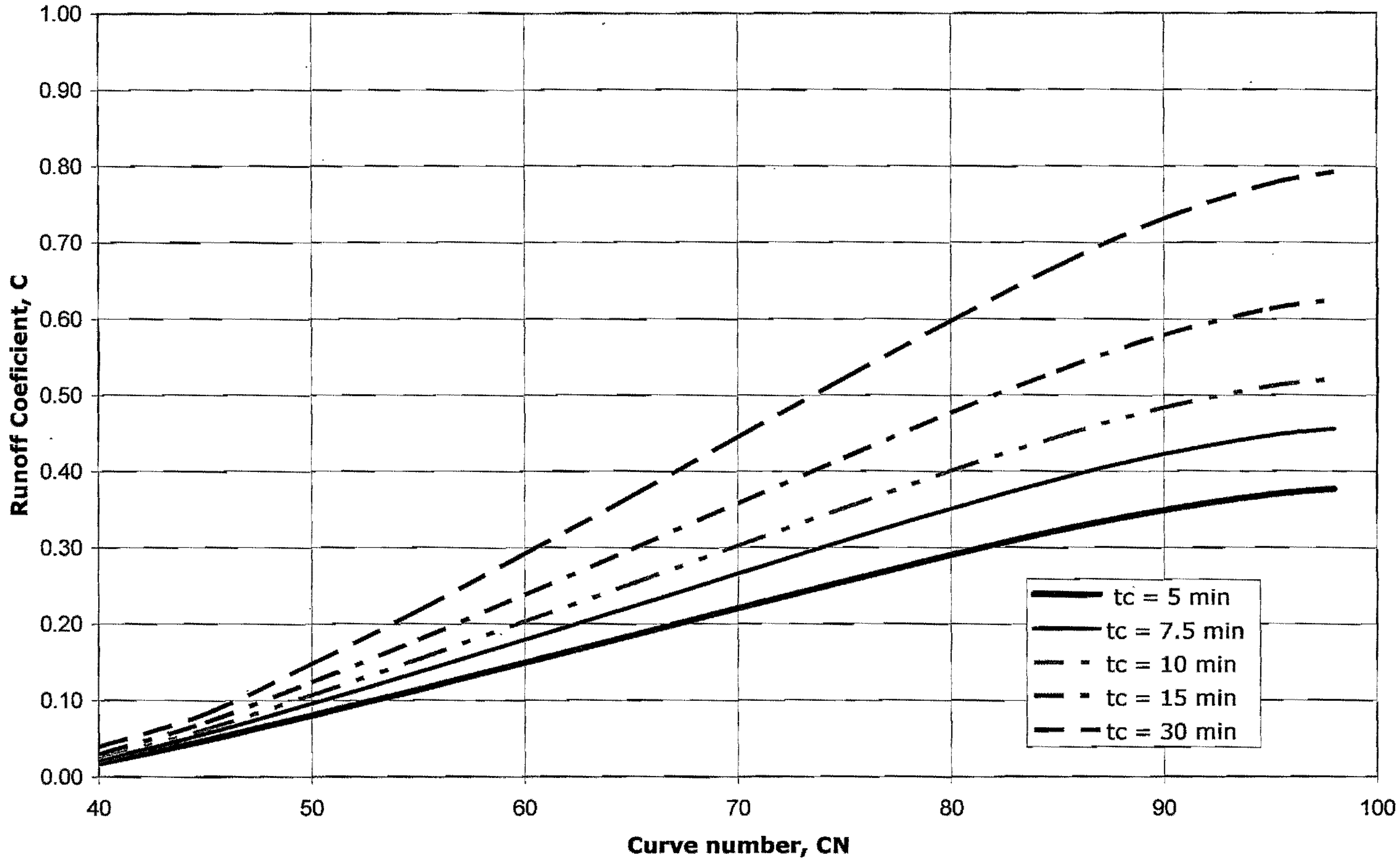

Figure 7. Runoff coefficients for 100-yr event above 1,640 ft (NRCS type 1A storm)