The ES-1027 curves, on pages 2-10.10 to 2-10.24, assume that the watershed is defined by the relationship:

$l/w = a^{0.2}$, where

l = hydraulic length of the watershed, in feet,
w = average watershed width, in feet, and
a = area, in acres.

For any given watershed area, then, there is one hydraulic length which will yield the same peak flow from both the t_c method presented in EFM-2 and the ES-1027 curves. Those lengths and the corresponding ratios l/w are given in Table IL 2-10.1.

Acres in Watershed	Hydraulic Length in Feet	l/w
10	832	1.6
20	1261	1.8
40	1912	2.1
60	2438	2.3
80	2897	2.4
100	3312	2.5
160	4391	2.8
240	5601	3.0
320	6656	3.2
400	7610	3.3
480	8490	3.4
560	9312	3.5
640	10089	3.6

Table IL 2-10.1 - l and l/w vs ADA, when $l/w = a^{0.2}$.

For watersheds with drainage areas less than one square mile and where no hazard is associated with any structures to be designed, ES-1027 curves may be used to predict peak rates of runoff. If the actual watershed l/w varies by more than 25% from the value in Table IL 2-10.1, the t_c method in EFM 2, TR-55 or other more sophisticated procedures should be used to compute peak rate of runoff.

AVERAGE WATERSHED SLOPE

The average watershed slope, which is the slope of the land and no the watercourse, is available at most work unit locations from existing soil survey data. The hillside slopes can be measured with an Abney le in the direction of overland flow and averaged to obtain the watershed slope. This slope can be estimated accurately enough by SCS personnel familiar with the area to place it in one of the three categories - Fla Moderate or Steep - in Table 2-1. It may be necessary to determine the average slope of the watershed within a greater degree of accuracy in o der to obtain a closer estimate of the peak discharge for special measu In this case, the peak discharge for a specific slope can be interpolat on log-log graph paper as demonstrated in Figure 2-1, for Examples 2-2 2-3.

Table 2-1 Slope factors for peak discharge

Slope Factor	Average Slope Range in percent	Actual Slope Used in ES-1026 and 1027 Computations, in percent
Flat 1/	0 - 3	1
Moderate	3 - 8	4
Steep	8 and above	16

1/ Level to nearly level.

PEAK DISCHARGE

The peak discharge can be obtained from the Peak Rates for Dischar charts, ES-1026, ES-1027 and ES-1029. ES-1027 is included in the natic distribution of the Engineering Field Manual as Exhibit 2-10. Users re quiring ES-1026, and/or ES-1029 may obtain same from the SCS Regional Technical Service Center, Portland, Oregon.

Example 2-1

Given an 80-acre watershed in an area using the Type II storm dist bution. The Soil Scientist has classified the soils as belonging to Hy logic soil group B. The average watershed slope is estimated to be bet 3 and 8 percent. It is intensively cultivated without conservation tre ment. The peak discharge rate from a 25-year frequency storm is desire the design of a concrete channel at the watershed outlet.

1. Curve number 81 is obtained from Exhibit 2-2 and rounded to 8(

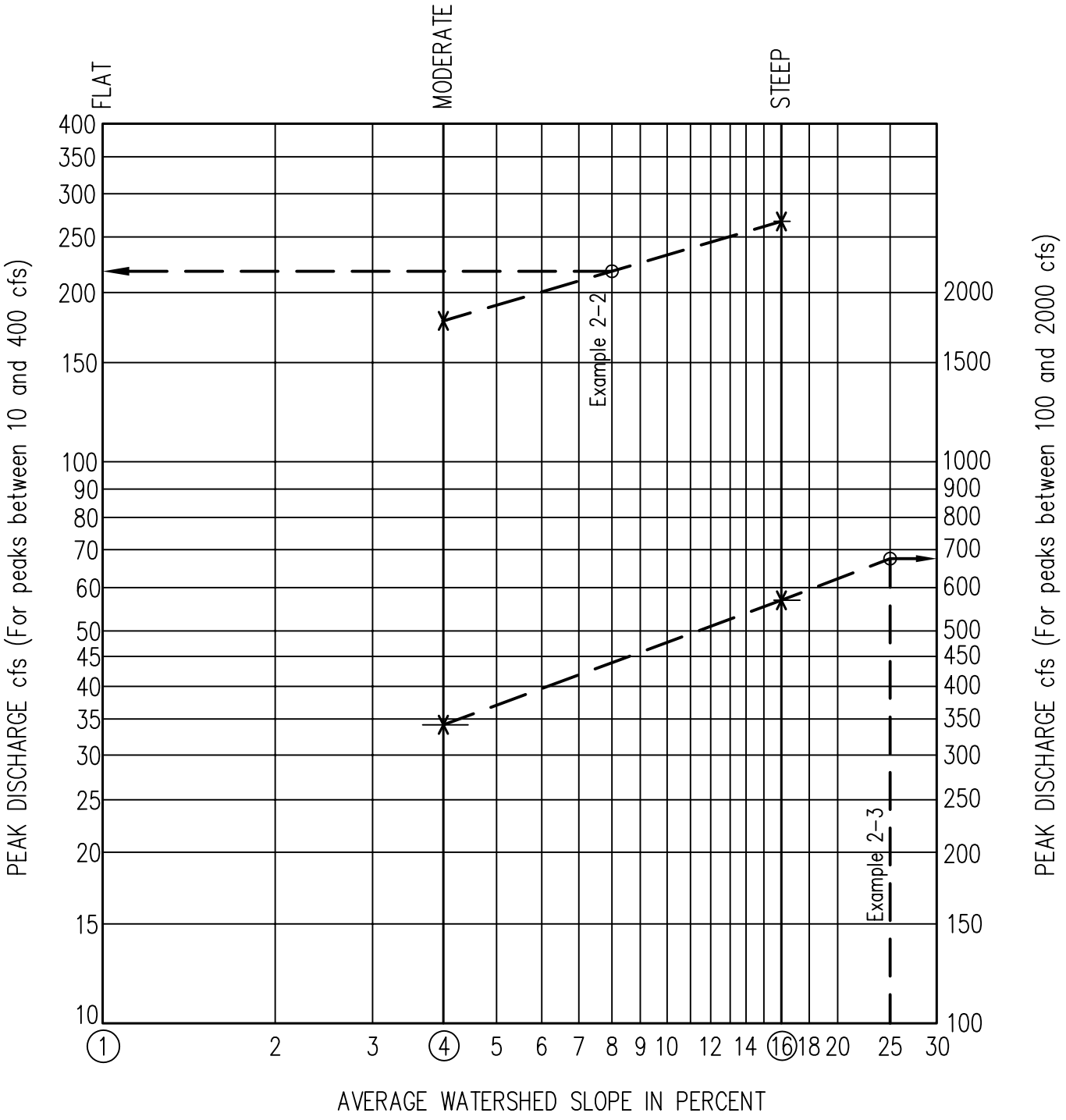

Figure 2–1.––Examples of interpolating peak discharge for average watershed slopes between and greater than Flat, Moderate, and Steep

2. Slope factor is Moderate because of the 3 to 8 percent average watershed slope . See Table 2-1.

3. Storm rainfall for the location of the watershed is obtained from Exhibit 2-3, sheet 4 of 5. For this example, assume the storm rainfall is 8 inches.

4. See Exhibit 2-10, sheet 12 of 21, for Type II, CN-80. Read 315 cfs for the peak runoff from an 8-inch rainfall on the 80 acre watershed.

Example 2-2.

Given a 100-acre watershed in the Type II rainfall area. The soil scientists has classified the soils as belonging mostly in hydrologic soil group C with an average slope of 8 percent. The watershed is in poor pasture. The volume and peak rate of runoff from a 24-hour, 50-year frequency storm is desired for the design of a pipe drop-inlet structure.

1. Curve number 86 is obtained from Exhibit 2-2 and rounded to 85.

2. The 50-year frequency storm rainfall is found in Exhibit 2-3 sheet 5 of 5. Assume a depth of 4 inches.

3. Volume of runoff from Exhibit 2-7 is 2.46 inches for a rainfall of 4 inches and CN 85.

4. From Exhibit 2-10, the peak rate of runoff, CN-85, 100 acre watershed and 4 inch rainfall is read as follows:
   Steep Slope (16%), sheet 20 of 21 $q_p = 264$
   Moderate Slope (4%), sheet 13 of 21 $q_p = 180$

5. Using Figure 2-1, the peak discharge is interpolated to be 220 cfs for an 8% slope.

Example 2-3

Given a 1,000 acre watershed in the Type II storm distribution area. About 600 acres of the watershed is in hydrologic soil group B, within which two-thirds of the area is cultivated with good conservation treatment and the other one-third is in good pasture. The remaining 400 acres of the watershed is in hydrologic soil group C, all of which is well cultivated with good conservation treatment. The average watershed slope is about 25 percent. The peak discharge rate for a 10-year frequency storm is desired for the design of a diversion channel at the outlet.

1. A weighted CN is required:
   2/3 of 600 Ac = 400 ac @ CN 71 and (400/1000) 71 = 28.4
   1/3 of 600 Ac = 200 ac @ CN 61 and (200/1000) 61 = 12.2
   400 ac @ CN 78 and (400/1000) 78 = 31.2
   weighted CN = 71.8
   (Round to 72)

2. The storm rainfall is obtained from Exhibits 2-3, sheet 3 of 5. Assume 4 inches.

3. The peak discharge for a Moderate slope, 1000-acre watershed, 4-inch rainfall and CN 72 is calculated as follows:
   CN 70 (Exhibit 2-10, sheet 10 of 21) = 290 cfs.
   CN 75 (Exhibit 2-10, sheet 11 of 21) = 430 cfs.
   CN 72 = 290 + 2/5(430-290) = 346 cfs (4% slope)

4. The peak discharge for a Steep slope, 1000-acre watershed, 4 inch rainfall and CN 72 is calculated as follows
   CN 70 (Exhibit 2-10, sheet 17 of 21) = 489 cfs.
   CN 75 (Exhibit 2-10, sheet 18 of 21) = 711 cfs.
   CN 72 = 489 + 2/5(711-489) = 578 cfs (16% slope).

5. Using Figure 2-1 the peak discharge is interpolated to be 670 cfs.

5. ESTIMATING SEASONAL YIELD FROM SMALL UNGAGED WATERSHEDS

There is no precise analytical method of determining the amount of runoff that might be expected to occur at least every year or every two years on the average in an ungaged watershed. The same factors affecting runoff on an individual storm basis previously described affect the seasonal yield of runoff, but in a much broader degree. A procedure for approximating the seasonal yield of surface runoff is demonstrated by ES-1014, Exhibit 2-8. The limitations and examples of its application to watershed areas between 10 and 2,000 acres are described and demonstrated. This approximation should not be used for watersheds in which most of the soil is classified under hydrologic soil group A. It will be noted that no direct distinction is made between soils in Exhibit 2-8.

Exhibit 2-8 should not be used for estimating seasonal yields in mountainous and Northern areas where the major volume of runoff is the result of snowmelt.

In some areas a better estimate of average annual yield may be obtained from other sources. Other sources include data correlated with gaged streams and published generalized maps of annual runoff. The graph on the right-hand side of Exhibit 2-8 may be used to estimate volumes of runoff for frequencies other than those available through these sources. The inset Table on sheet 2 of 2, Exhibit 2-8, can be used similarly to estimate seasonal yield from other sources of annual yield data.

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS
TYPE II STORM DISTRIBUTION

SLOPES – FLAT
CURVE NUMBER – 60

24 HOUR RAINFALL

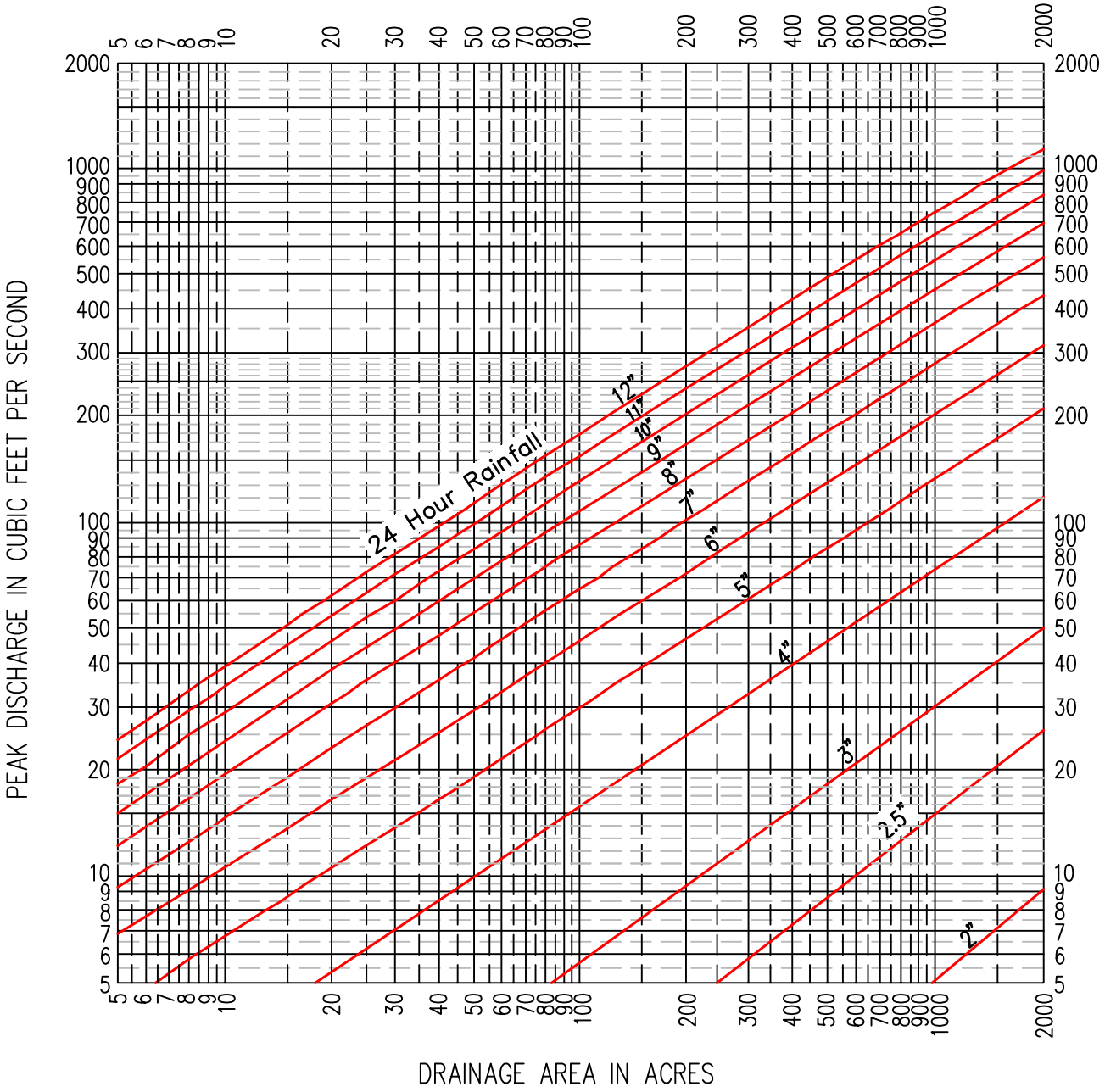

EXHIBIT 2–10

File No. 2–10.14

United States Department Of Agriculture Soil Conservation Service Engineering Division – Hydrology Branch	Chapter 2, Engineering Field Manual for Construction Practices	Standard DWG No **ES 1027** Sheet 1 Of 21 Date 2–15–71

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS
TYPE II STORM DISTRIBUTION

SLOPES – FLAT
CURVE NUMBER – 65

24 HOUR RAINFALL

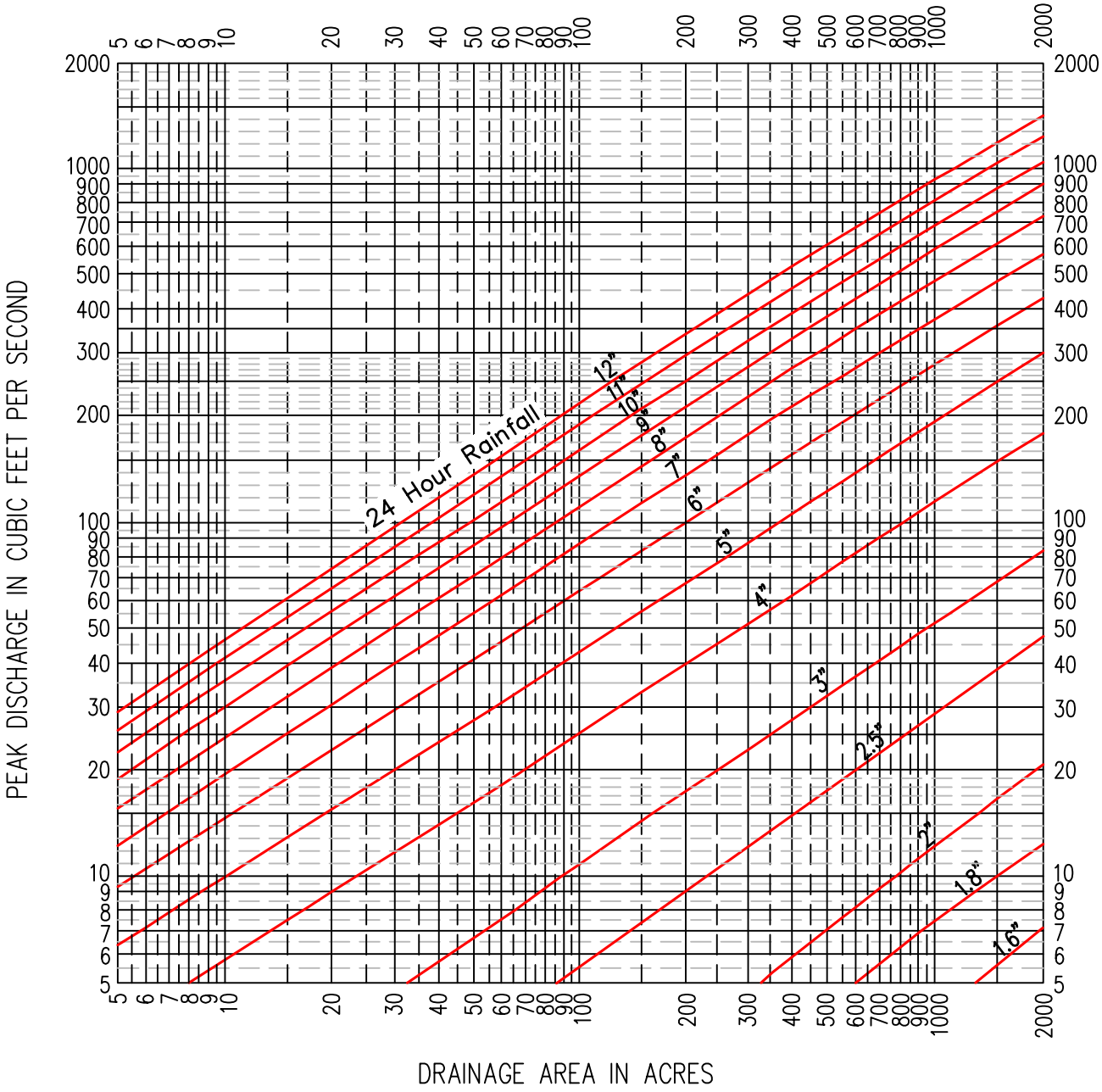

EXHIBIT 2–10

File No. 2–10.15

United States Department Of Agriculture Soil Conservation Service Engineering Division – Hydrology Branch	Chapter 2, Engineering Field Manual for Construction Practices	Standard DWG No **ES 1027** Sheet 2 Of 21 Date 2–15–71

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS
TYPE II STORM DISTRIBUTION

SLOPES – FLAT
CURVE NUMBER – 70

24 HOUR RAINFALL

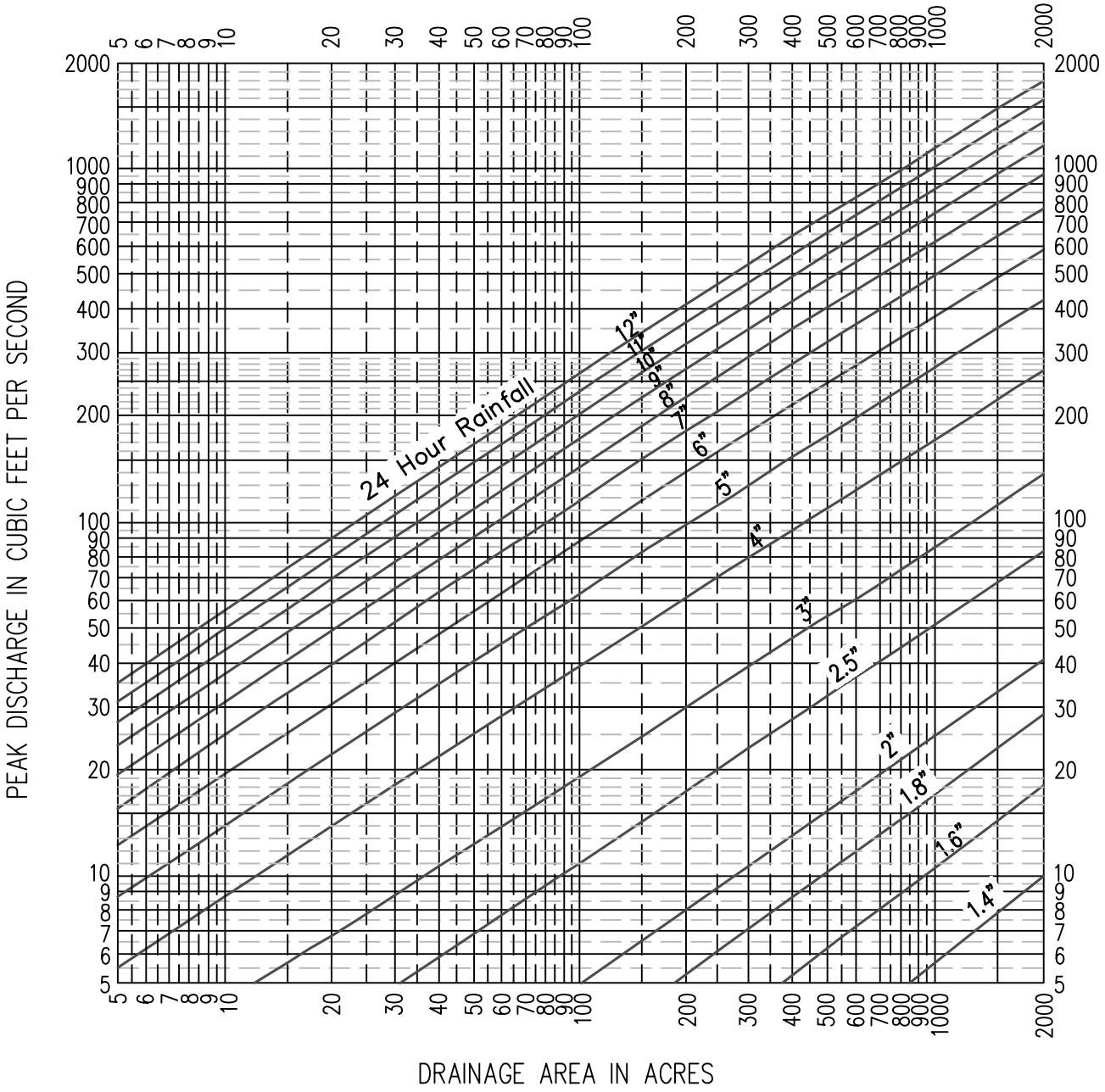

EXHIBIT 2–10

File No. 2–10.16

United States Department Of Agriculture Soil Conservation Service Engineering Division – Hydrology Branch	Chapter 2, Engineering Field Manual for Construction Practices	Standard DWG No **ES 1027** Sheet 3 Of 21 Date 2–15–71

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS
TYPE II STORM DISTRIBUTION

SLOPES – FLAT
CURVE NUMBER – 75

24 HOUR RAINFALL

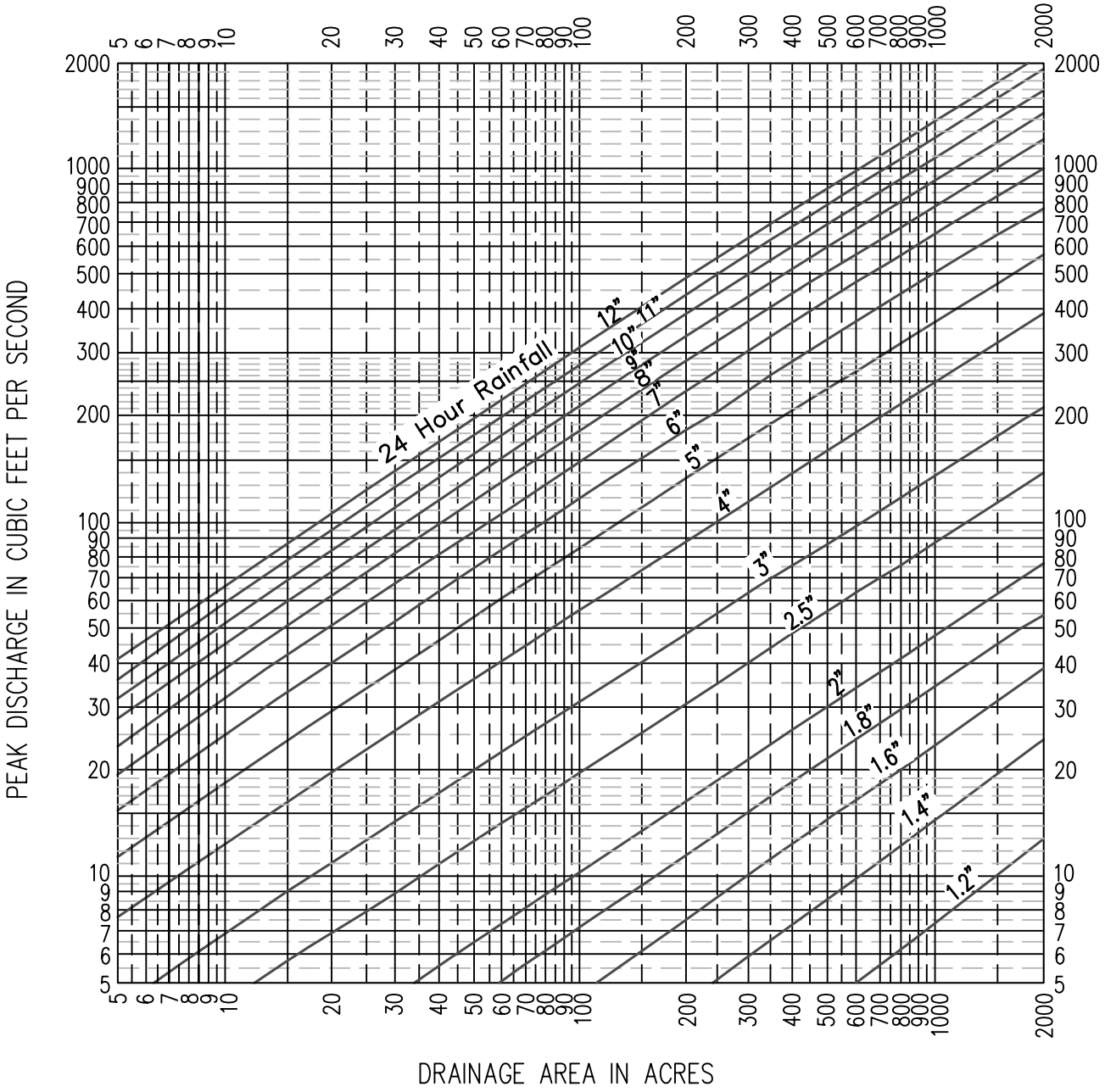

EXHIBIT 2–10

File No. 2–10.17

United States Department Of Agriculture Soil Conservation Service Engineering Division – Hydrology Branch	Chapter 2, Engineering Field Manual for Construction Practices	Standard DWG No **ES 1027** Sheet 4 Of 21 Date 2–15–71

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS
TYPE II STORM DISTRIBUTION

SLOPES – FLAT
CURVE NUMBER – 80

24 HOUR RAINFALL

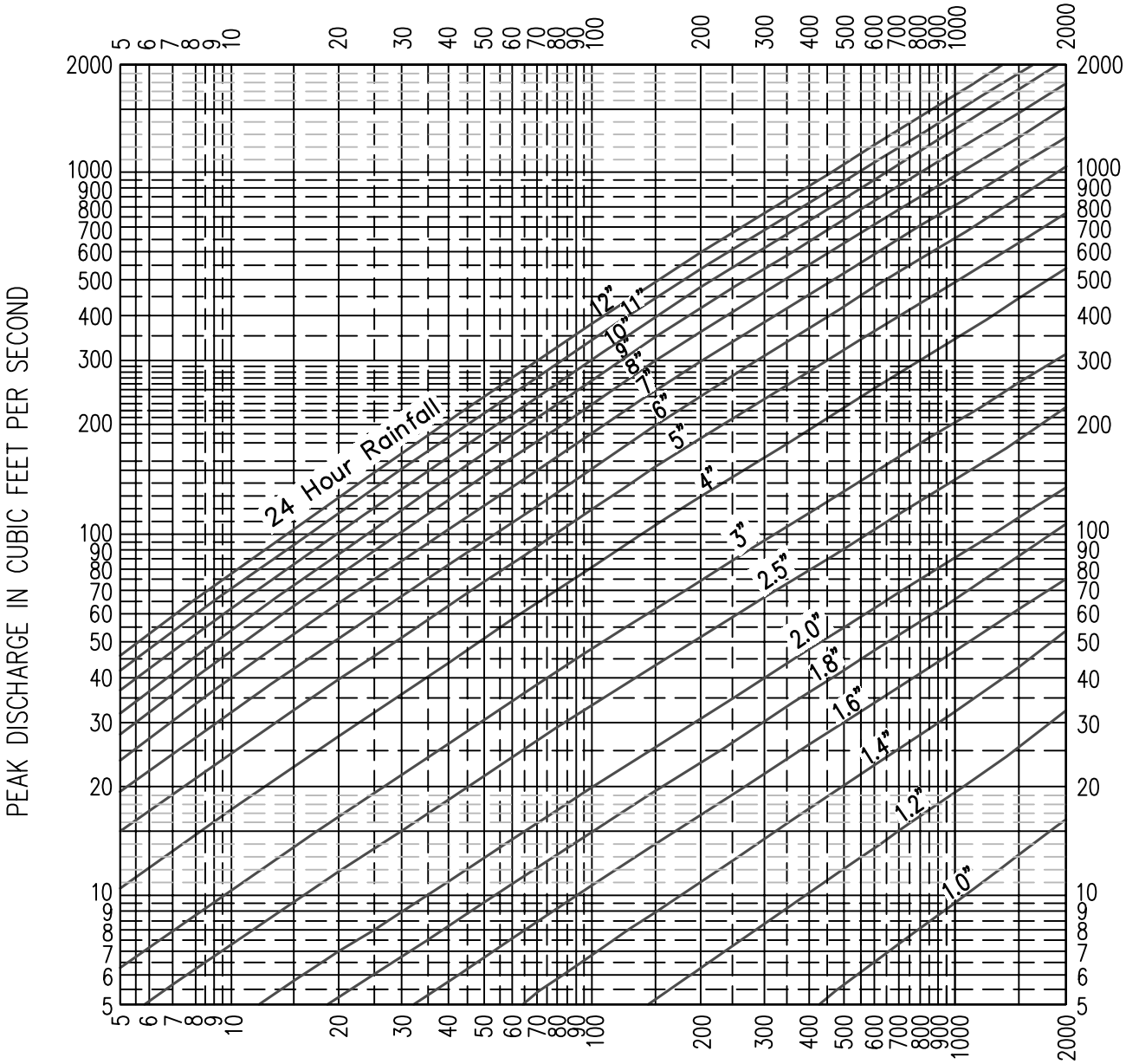

EXHIBIT 2–10

File No. 2–10.18

United States Department Of Agriculture Soil Conservation Service Engineering Division – Hydrology Branch	Chapter 2, Engineering Field Manual for Construction Practices	Standard DWG No **ES 1027** Sheet 5 Of 21 Date 2–15–71

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS
TYPE II STORM DISTRIBUTION

SLOPES – FLAT
CURVE NUMBER – 85

24 HOUR RAINFALL

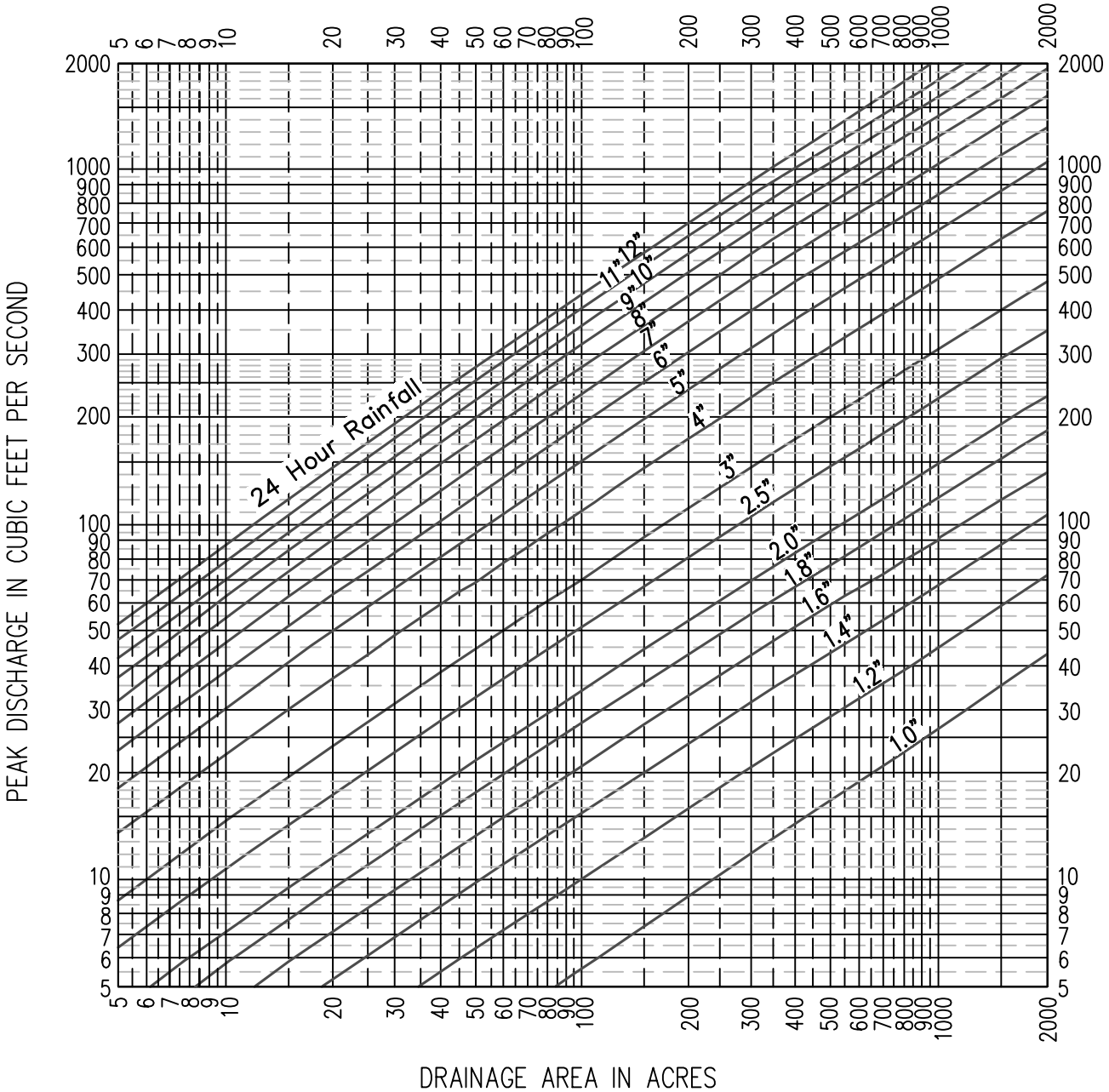

EXHIBIT 2–10

File No. 2–10.19

United States Department Of Agriculture Soil Conservation Service Engineering Division – Hydrology Branch	Chapter 2, Engineering Field Manual for Construction Practices	Standard DWG No **ES 1027** Sheet 6 Of 21 Date 2–15–71

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS
TYPE II STORM DISTRIBUTION

SLOPES – FLAT
CURVE NUMBER – 90

24 HOUR RAINFALL

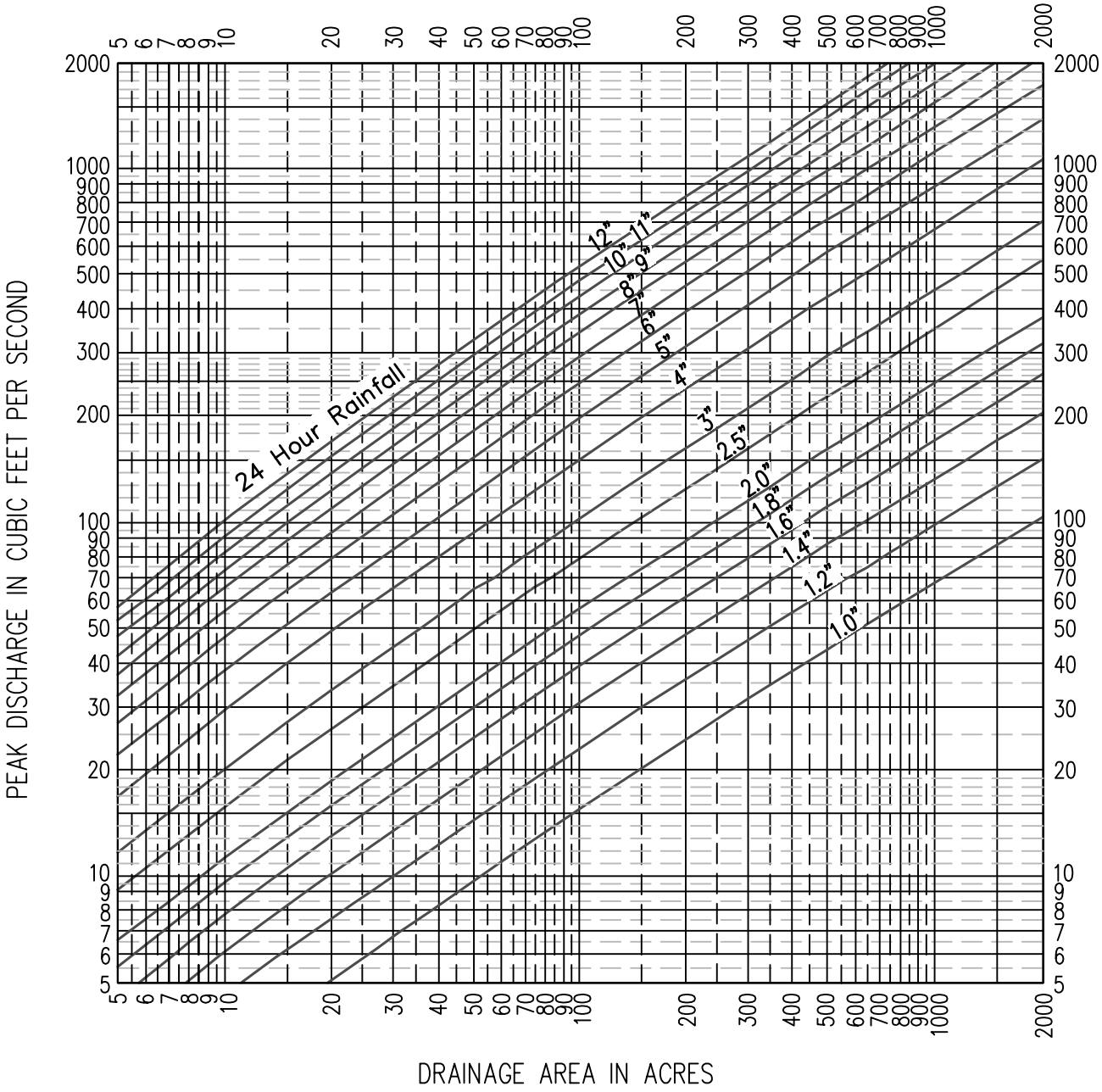

EXHIBIT 2–10

File No. 2–10.20

United States Department Of Agriculture Soil Conservation Service Engineering Division – Hydrology Branch	Chapter 2, Engineering Field Manual for Construction Practices	Standard DWG No **ES 1027** Sheet 7 Of 21 Date 2–15–71

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS
TYPE II STORM DISTRIBUTION

SLOPES – MODERATE
CURVE NUMBER – 60

24 HOUR RAINFALL

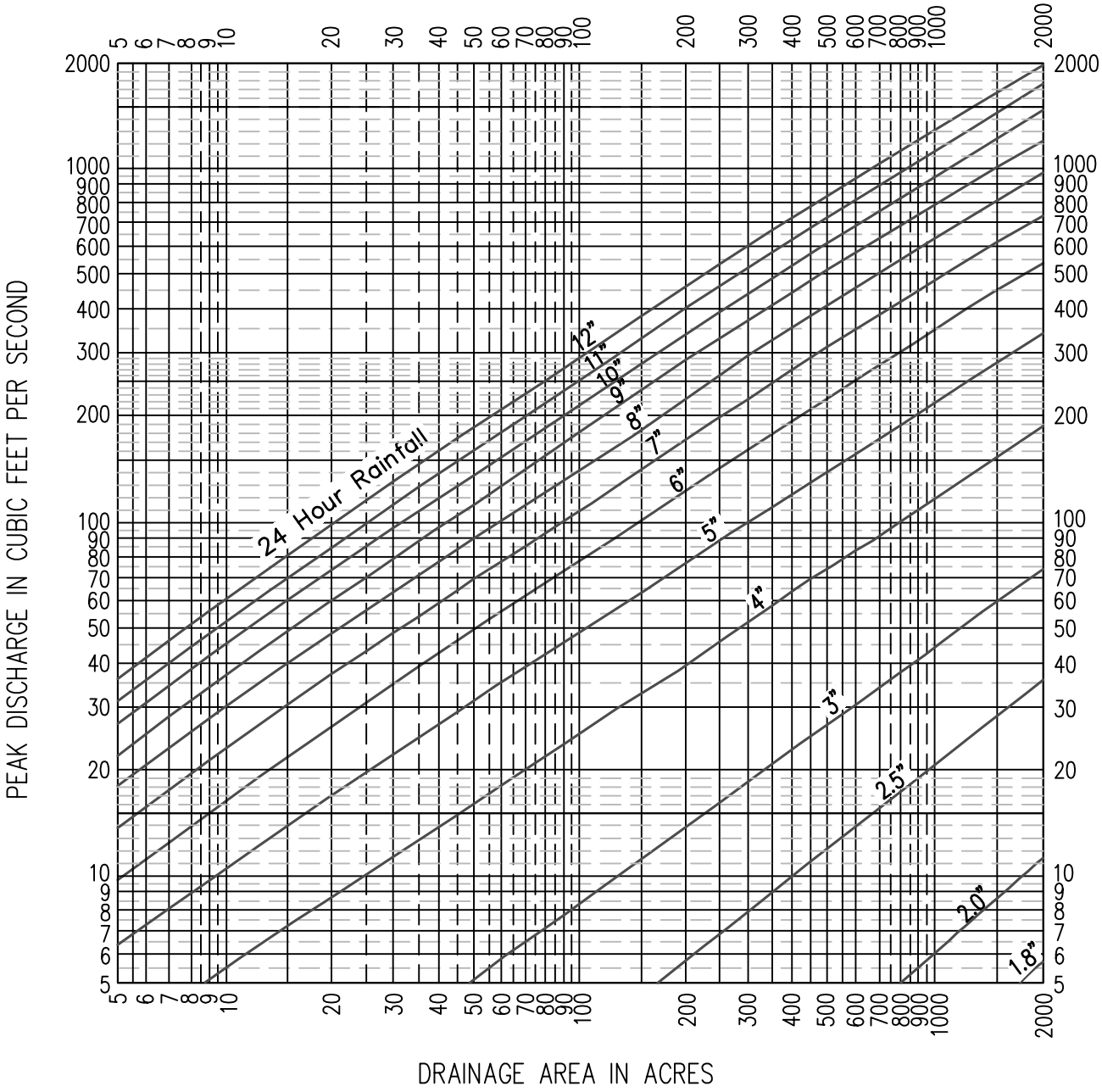

EXHIBIT 2–10

File No. 2–10.21

United States Department Of Agriculture Soil Conservation Service Engineering Division – Hydrology Branch	Chapter 2, Engineering Field Manual for Construction Practices	Standard DWG No **ES 1027** Sheet 8 Of 21 Date 2–15–71

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS
TYPE II STORM DISTRIBUTION

SLOPES – MODERATE
CURVE NUMBER – 65

24 HOUR RAINFALL

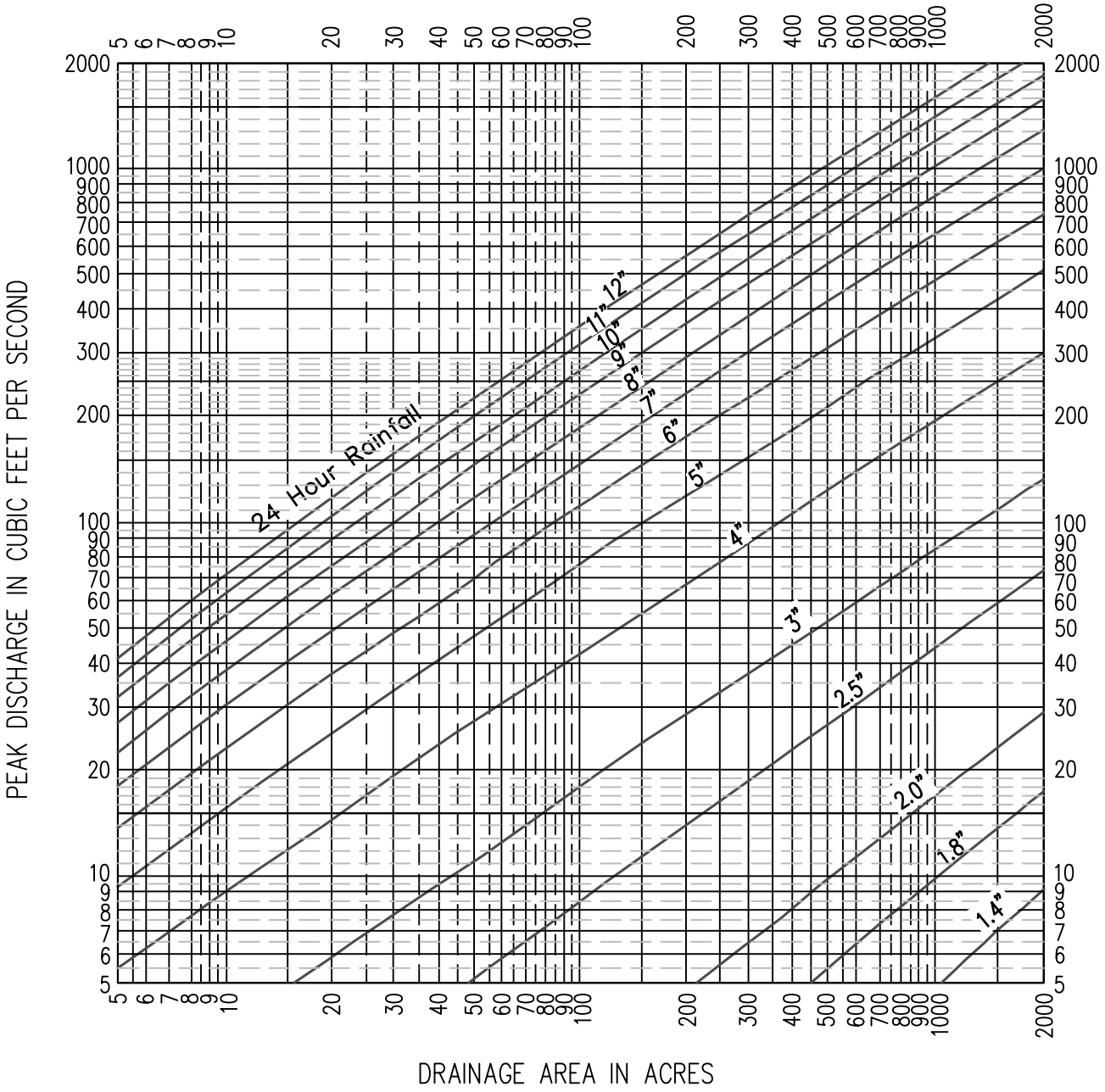

EXHIBIT 2–10

File No. 2–10.22

United States Department Of Agriculture Soil Conservation Service Engineering Division – Hydrology Branch	Chapter 2, Engineering Field Manual for Construction Practices	Standard DWG No **ES 1027** Sheet 9 Of 21 Date 2–15–71

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS
TYPE II STORM DISTRIBUTION

SLOPES – MODERATE
CURVE NUMBER – 70

24 HOUR RAINFALL

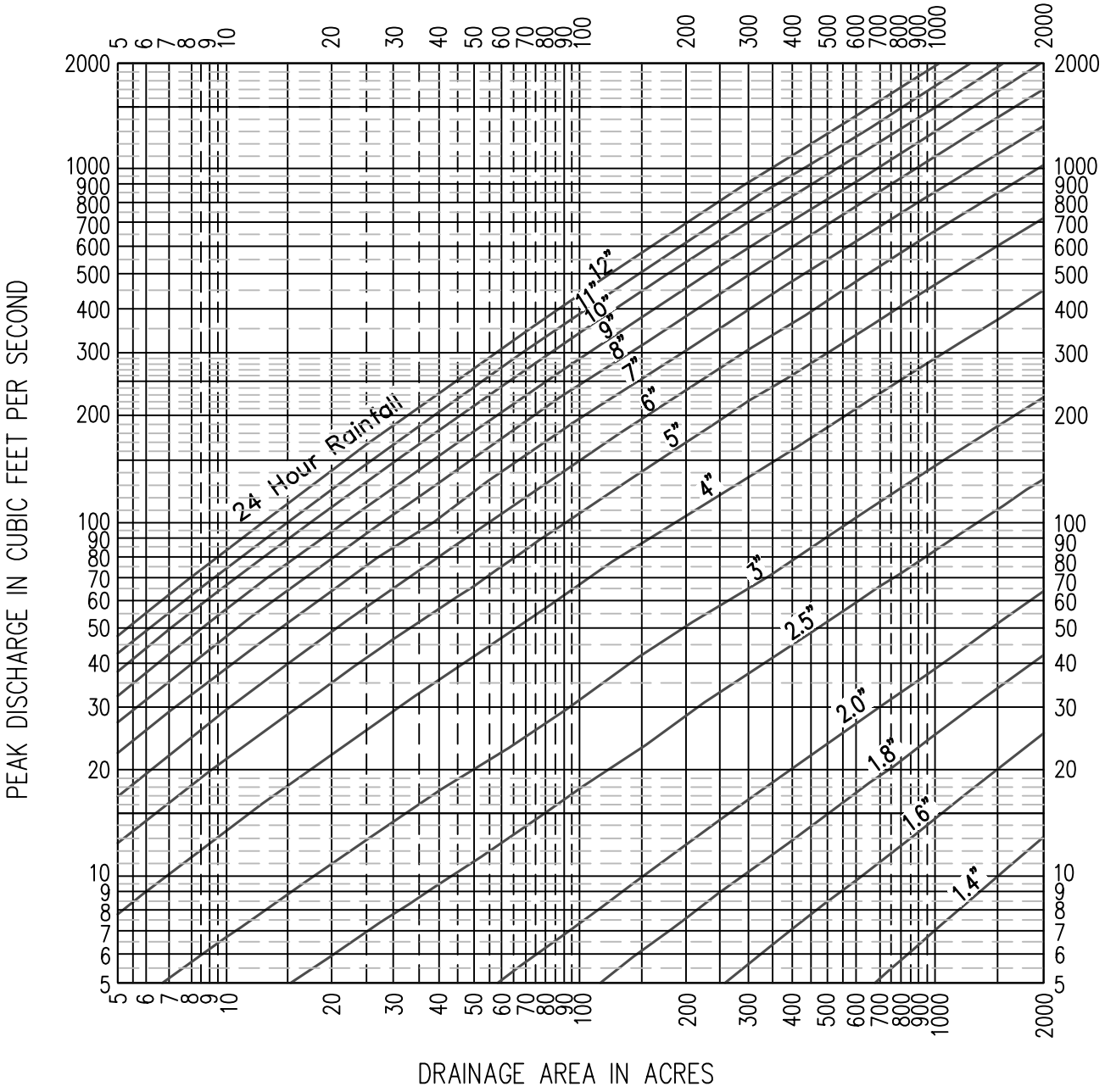

EXHIBIT 2–10

File No. 2–10.23

United States Department Of Agriculture Soil Conservation Service Engineering Division – Hydrology Branch	Chapter 2, Engineering Field Manual for Construction Practices	Standard DWG No **ES 1027** Sheet 10 Of 21 Date 2–15–71

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS
TYPE II STORM DISTRIBUTION

SLOPES – MODERATE
CURVE NUMBER – 75

24 HOUR RAINFALL

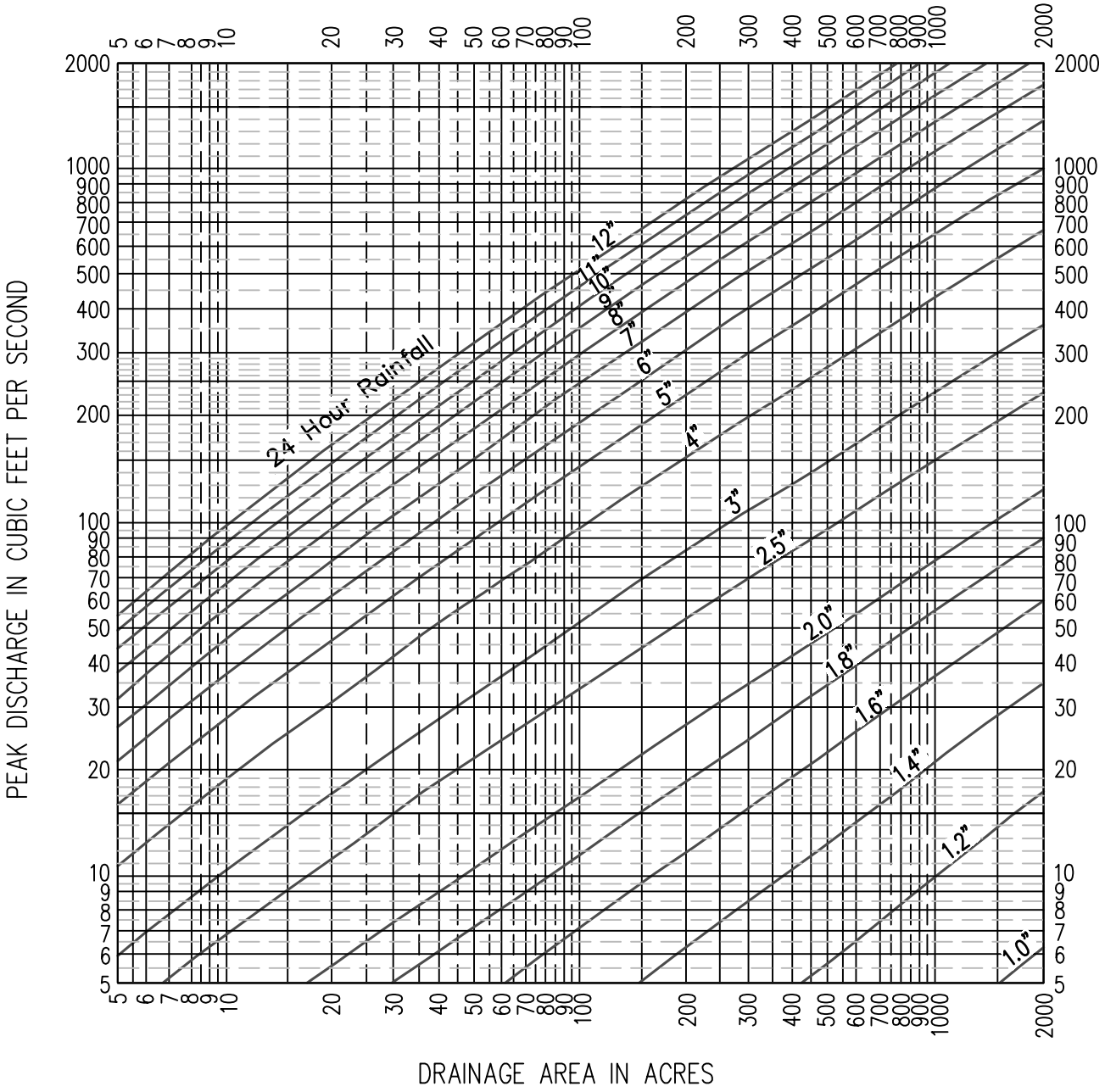

EXHIBIT 2–10

File No. 2–10.24

United States Department Of Agriculture Soil Conservation Service Engineering Division – Hydrology Branch	Chapter 2, Engineering Field Manual for Construction Practices	Standard DWG No **ES 1027** Sheet 11 Of 21 Date 2–15–71

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS
TYPE II STORM DISTRIBUTION

SLOPES – MODERATE
CURVE NUMBER – 80

24 HOUR RAINFALL

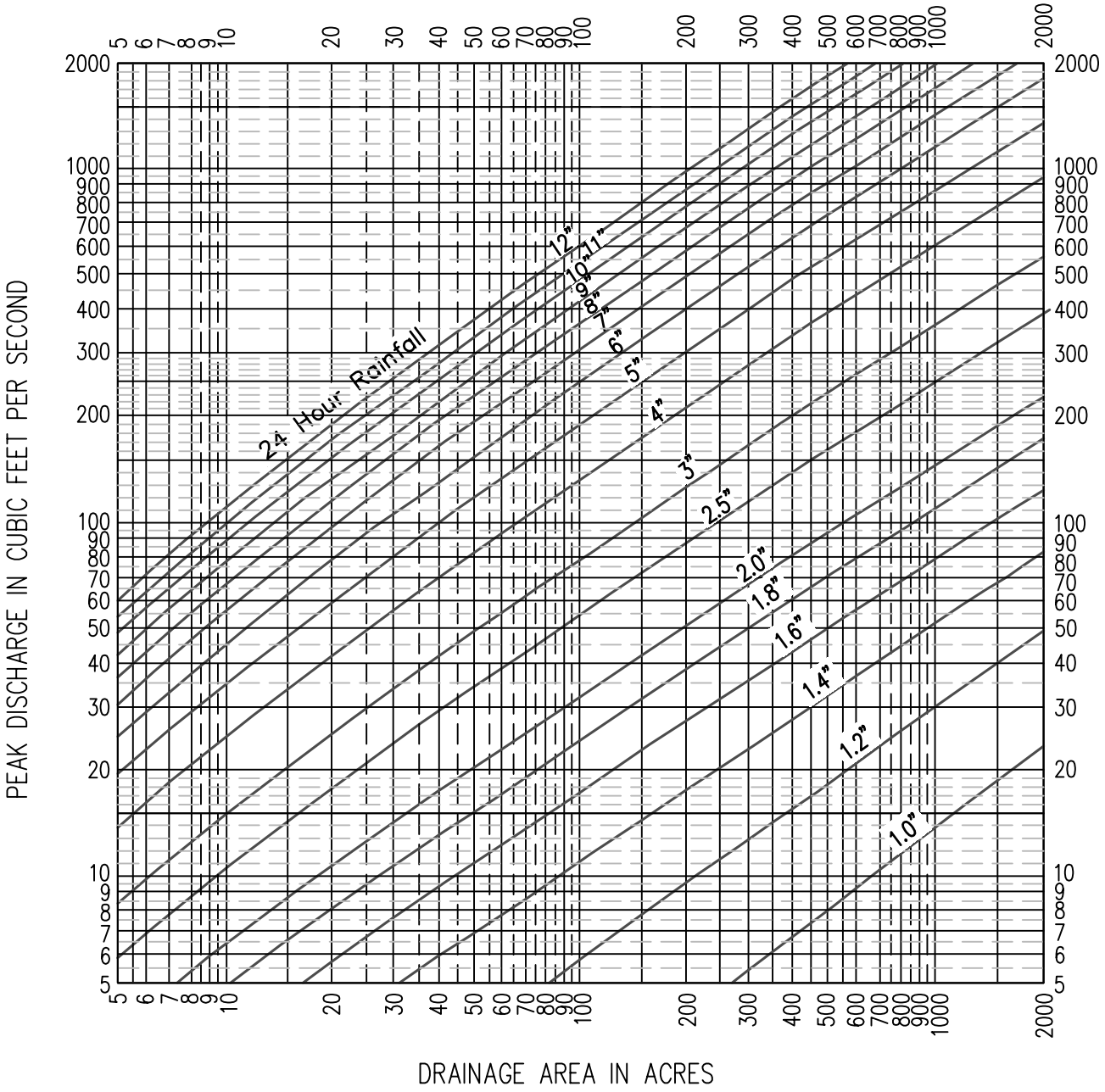

EXHIBIT 2–10

File No. 2–10.25

United States Department Of Agriculture Soil Conservation Service Engineering Division – Hydrology Branch	Chapter 2, Engineering Field Manual for Construction Practices	Standard DWG No **ES 1027** Sheet 12 Of 21 Date 2–15–71

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS
TYPE II STORM DISTRIBUTION

SLOPES – MODERATE
CURVE NUMBER – 85

24 HOUR RAINFALL

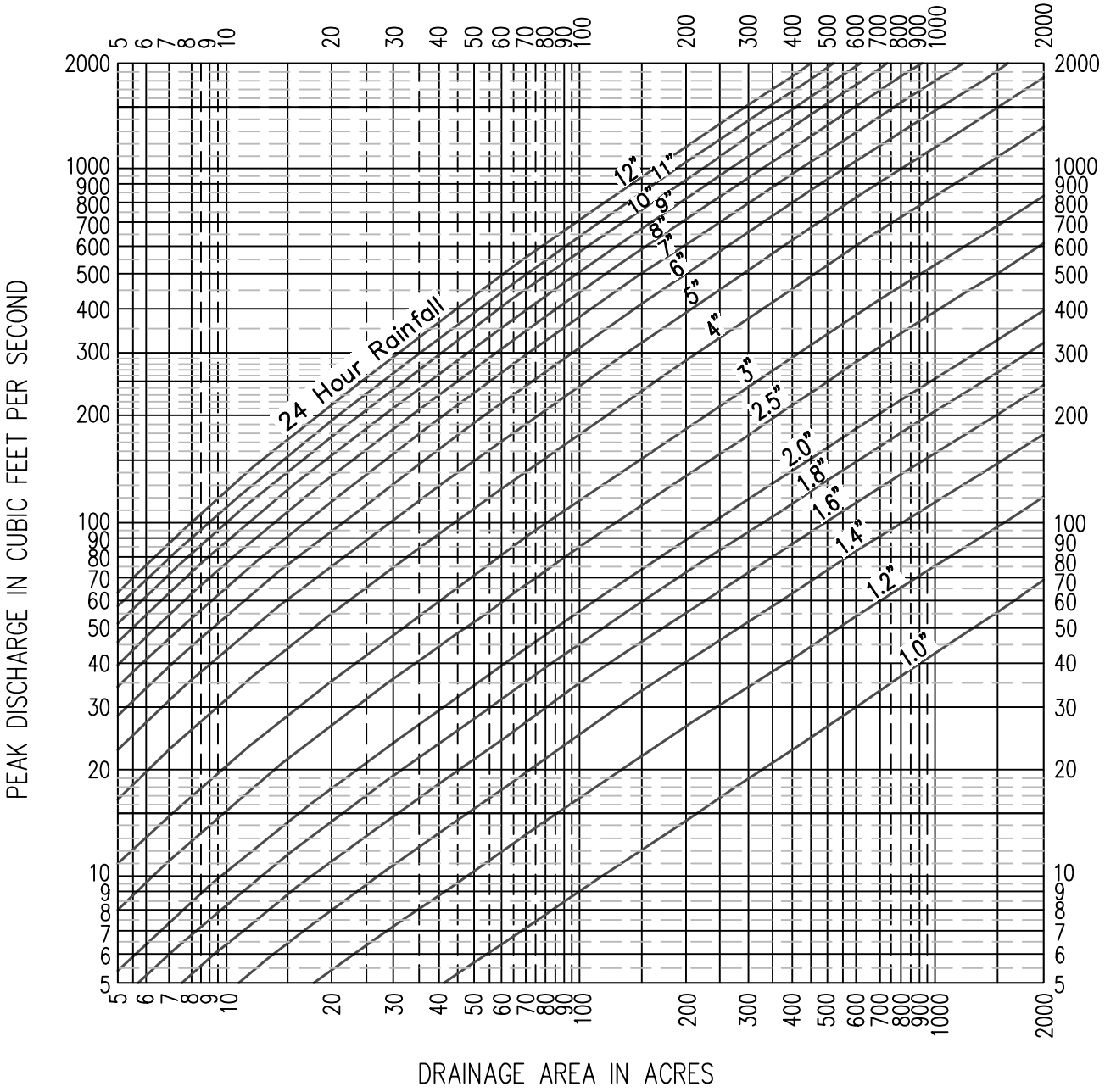

EXHIBIT 2–10

File No. 2–10.26

United States Department Of Agriculture Soil Conservation Service Engineering Division – Hydrology Branch	Chapter 2, Engineering Field Manual for Construction Practices	Standard DWG No **ES 1027** Sheet 13 Of 21 Date 2–15–71

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS
TYPE II STORM DISTRIBUTION

SLOPES – MODERATE
CURVE NUMBER – 90

24 HOUR RAINFALL

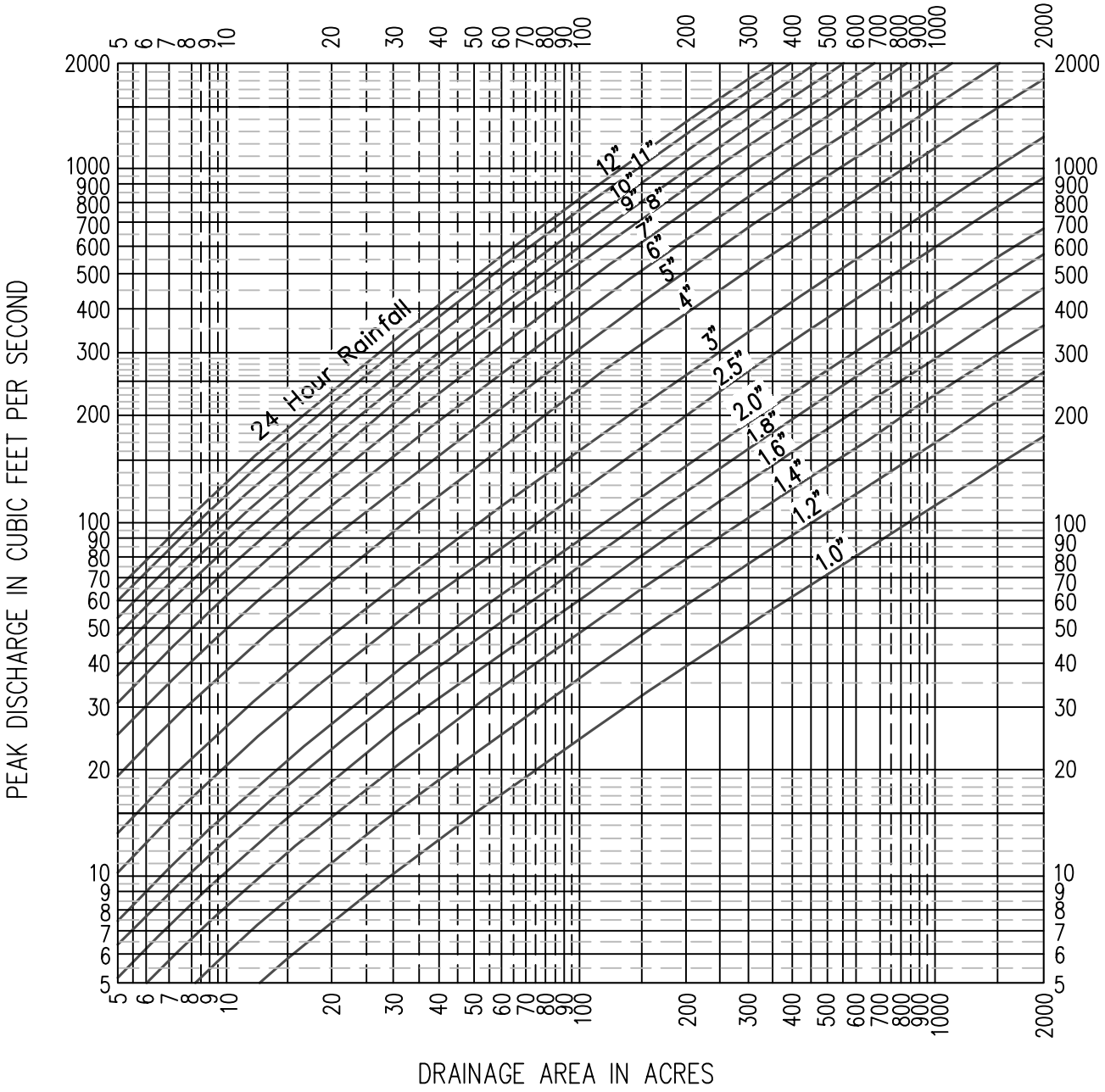

EXHIBIT 2–10

File No. 2–10.27

United States Department Of Agriculture Soil Conservation Service Engineering Division – Hydrology Branch	Chapter 2, Engineering Field Manual for Construction Practices	Standard DWG No **ES 1027** Sheet 14 Of 21 Date 2–15–71

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS
TYPE II STORM DISTRIBUTION

SLOPES – STEEP
CURVE NUMBER – 60

24 HOUR RAINFALL

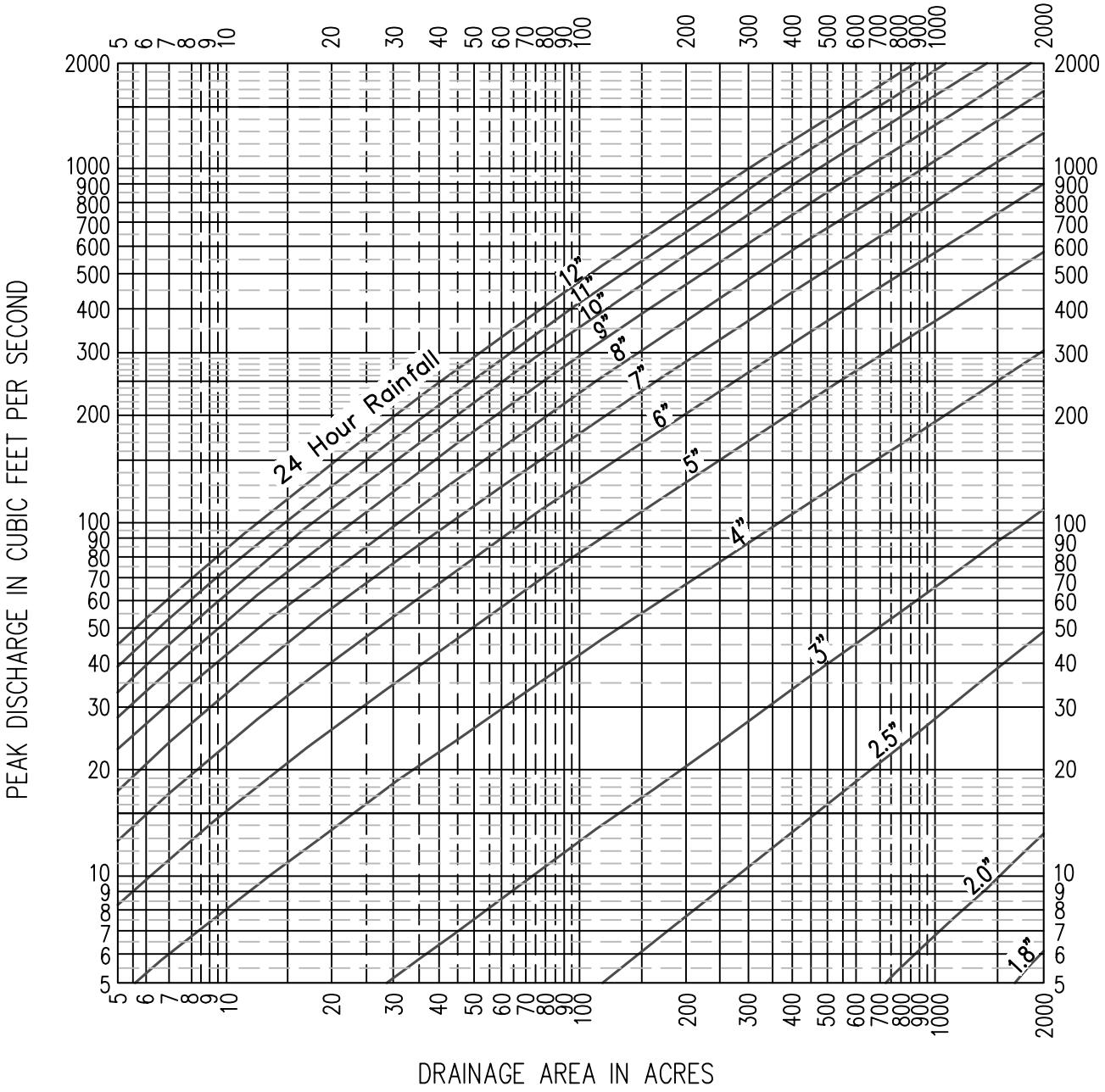

EXHIBIT 2–10

File No. 2–10.28

United States Department Of Agriculture Soil Conservation Service Engineering Division – Hydrology Branch	Chapter 2, Engineering Field Manual for Construction Practices	Standard DWG No **ES 1027** Sheet 15 Of 21 Date 2–15–71

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS
TYPE II STORM DISTRIBUTION

SLOPES – STEEP
CURVE NUMBER – 65

24 HOUR RAINFALL

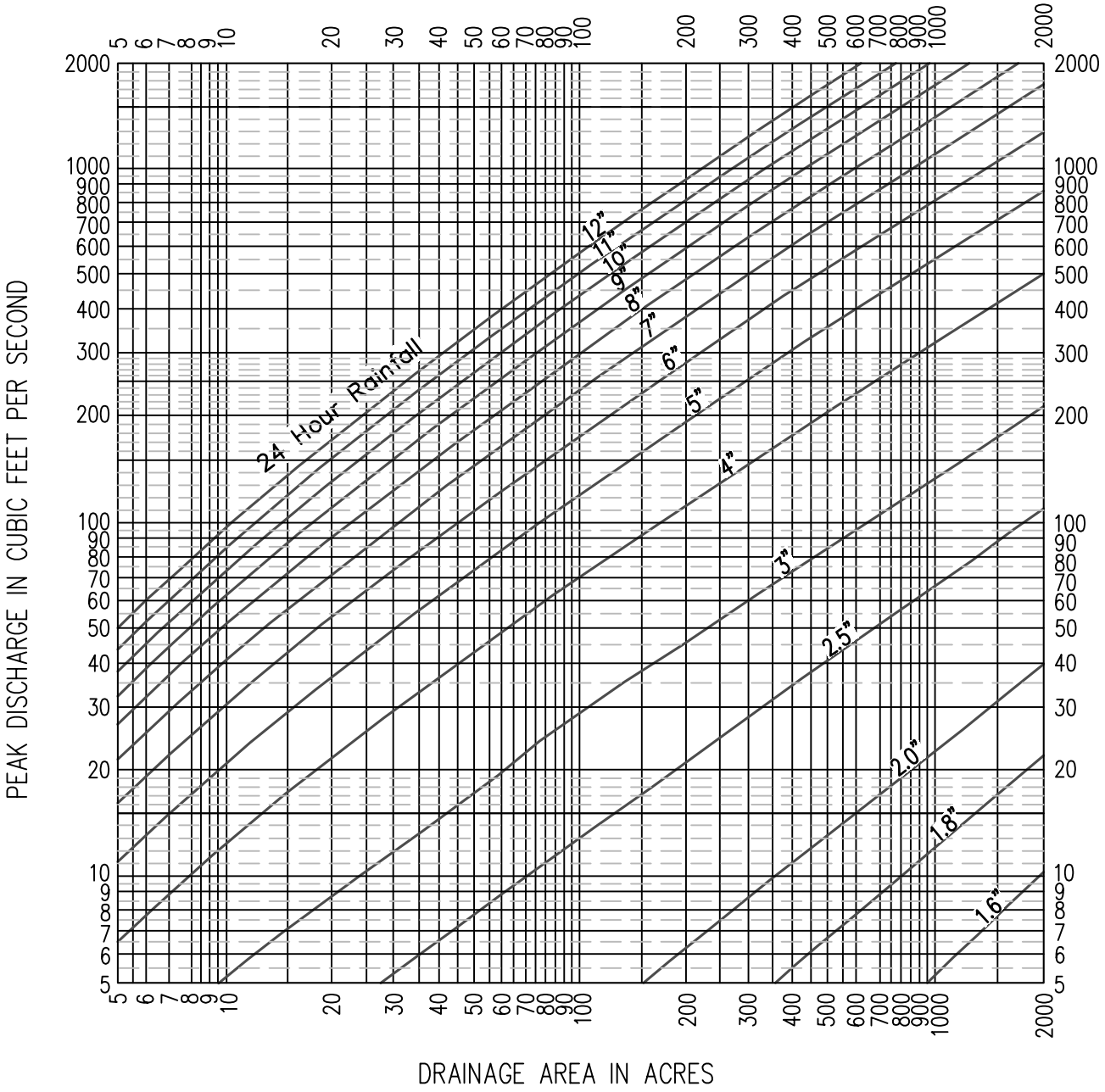

EXHIBIT 2–10

File No. 2–10.29

United States Department Of Agriculture Soil Conservation Service Engineering Division – Hydrology Branch	Chapter 2, Engineering Field Manual for Construction Practices	Standard DWG No **ES 1027** Sheet 16 Of 21 Date 2–15–71

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS
TYPE II STORM DISTRIBUTION

SLOPES – STEEP
CURVE NUMBER – 70

24 HOUR RAINFALL

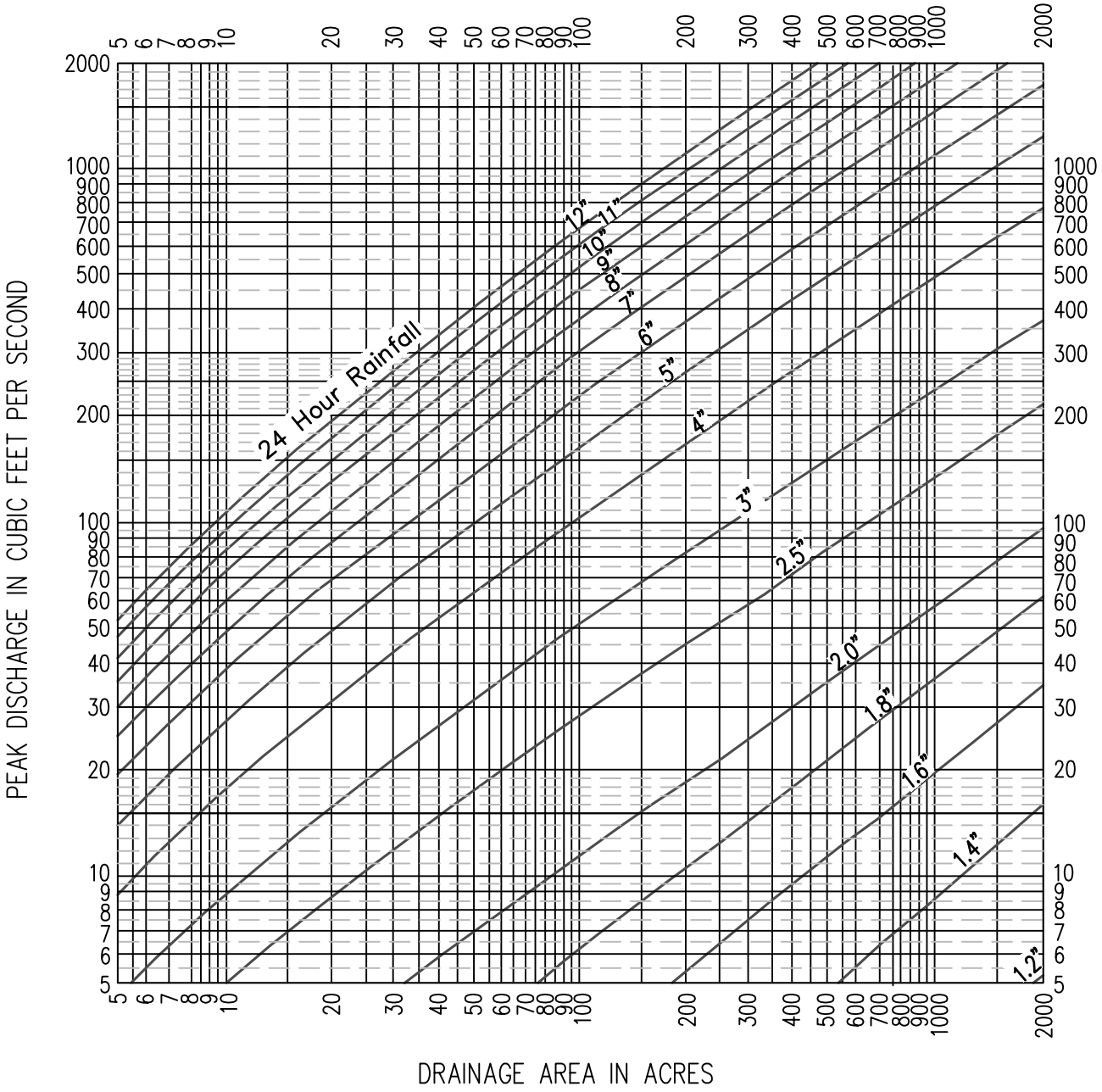

EXHIBIT 2–10

File No. 2–10.30

United States Department Of Agriculture Soil Conservation Service Engineering Division – Hydrology Branch	Chapter 2, Engineering Field Manual for Construction Practices	Standard DWG No **ES 1027** Sheet 17 Of 21 Date 2–15–71

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS
TYPE II STORM DISTRIBUTION

SLOPES – STEEP
CURVE NUMBER – 75

24 HOUR RAINFALL

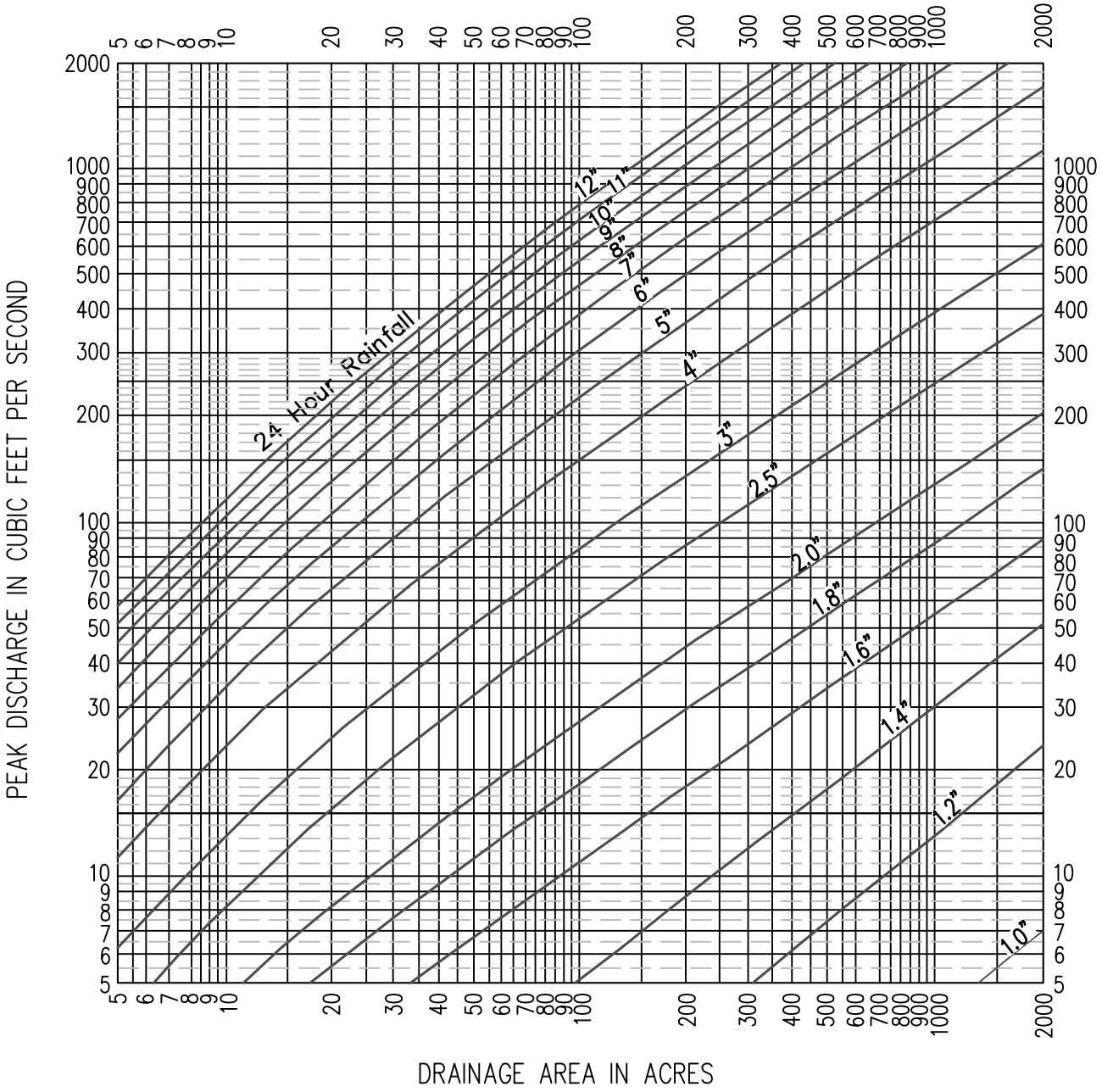

EXHIBIT 2–10

File No. 2–10.31

United States Department Of Agriculture Soil Conservation Service Engineering Division – Hydrology Branch	Chapter 2, Engineering Field Manual for Construction Practices	Standard DWG No **ES 1027** Sheet 18 Of 21 Date 2–15–71

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS
TYPE II STORM DISTRIBUTION

SLOPES – STEEP
CURVE NUMBER – 80

24 HOUR RAINFALL

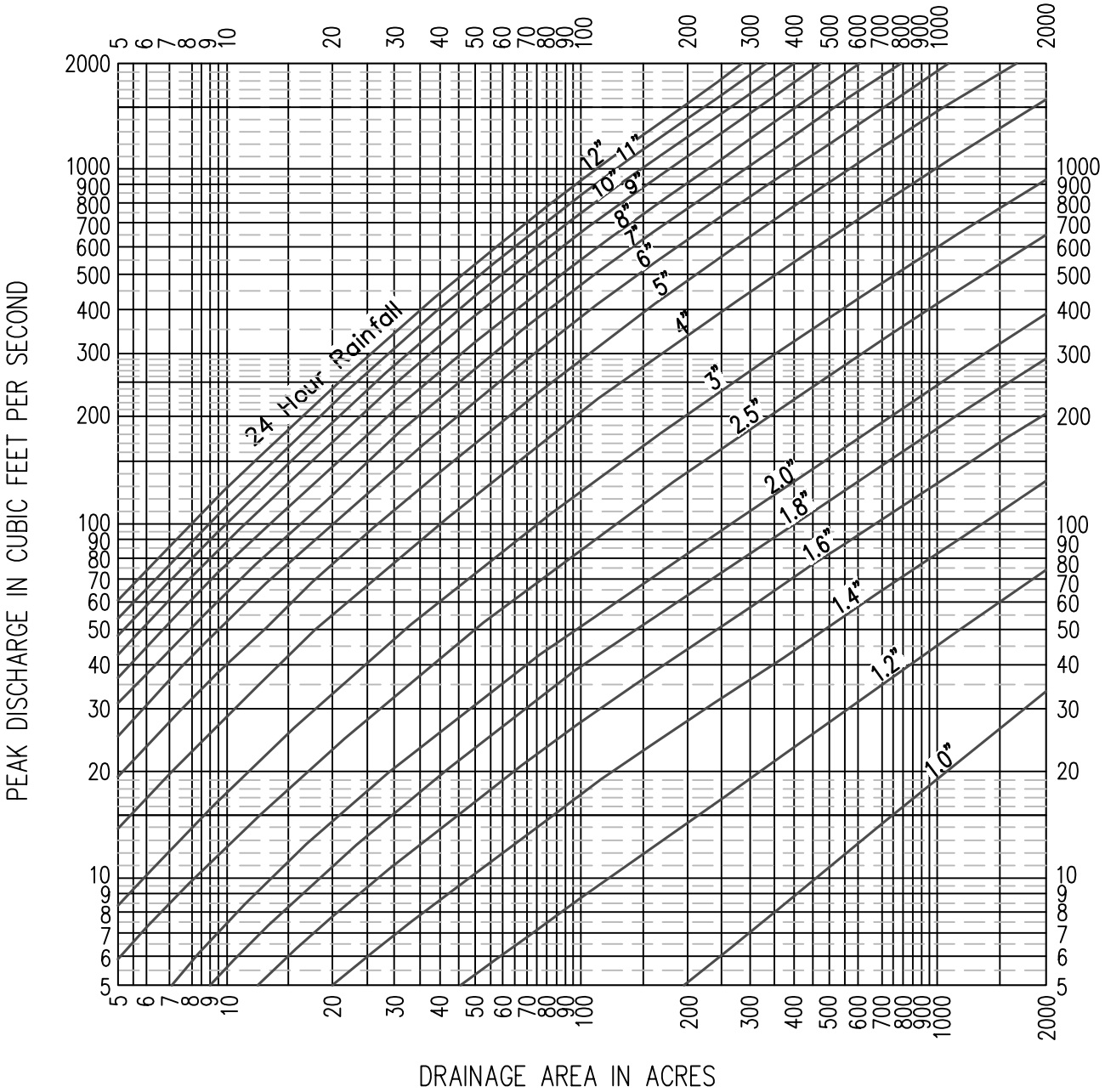

EXHIBIT 2–10

File No. 2–10.32

United States Department Of Agriculture Soil Conservation Service Engineering Division – Hydrology Branch	Chapter 2, Engineering Field Manual for Construction Practices	Standard DWG No **ES 1027** Sheet 19 Of 21 Date 2–15–71

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS
TYPE II STORM DISTRIBUTION

SLOPES – STEEP
CURVE NUMBER – 85

24 HOUR RAINFALL

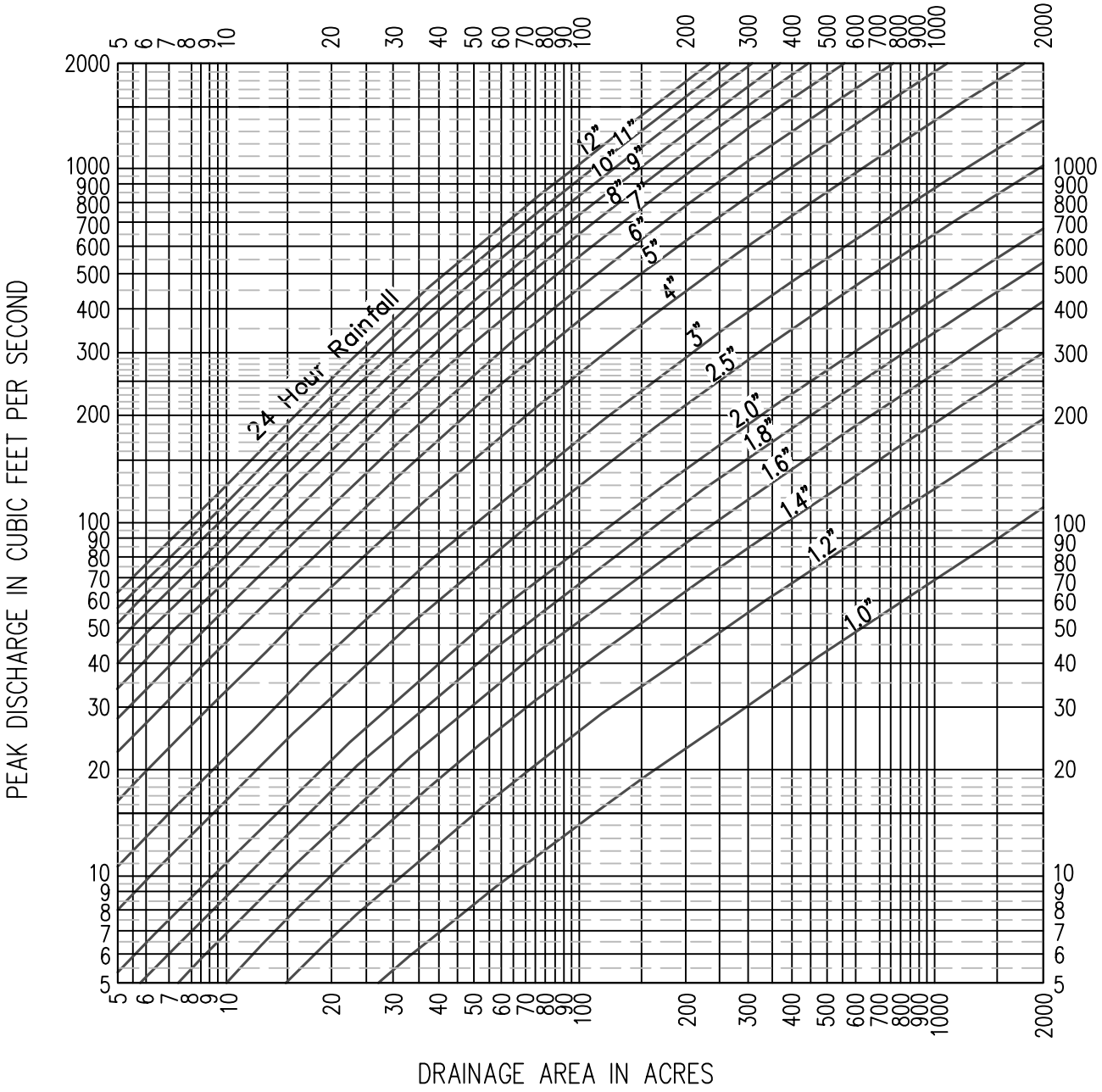

EXHIBIT 2–10

File No. 2–10.33

United States Department Of Agriculture Soil Conservation Service Engineering Division – Hydrology Branch	Chapter 2, Engineering Field Manual for Construction Practices	Standard DWG No **ES 1027** Sheet 20 Of 21 Date 2–15–71

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS
TYPE II STORM DISTRIBUTION

SLOPES – STEEP
CURVE NUMBER – 90

24 HOUR RAINFALL

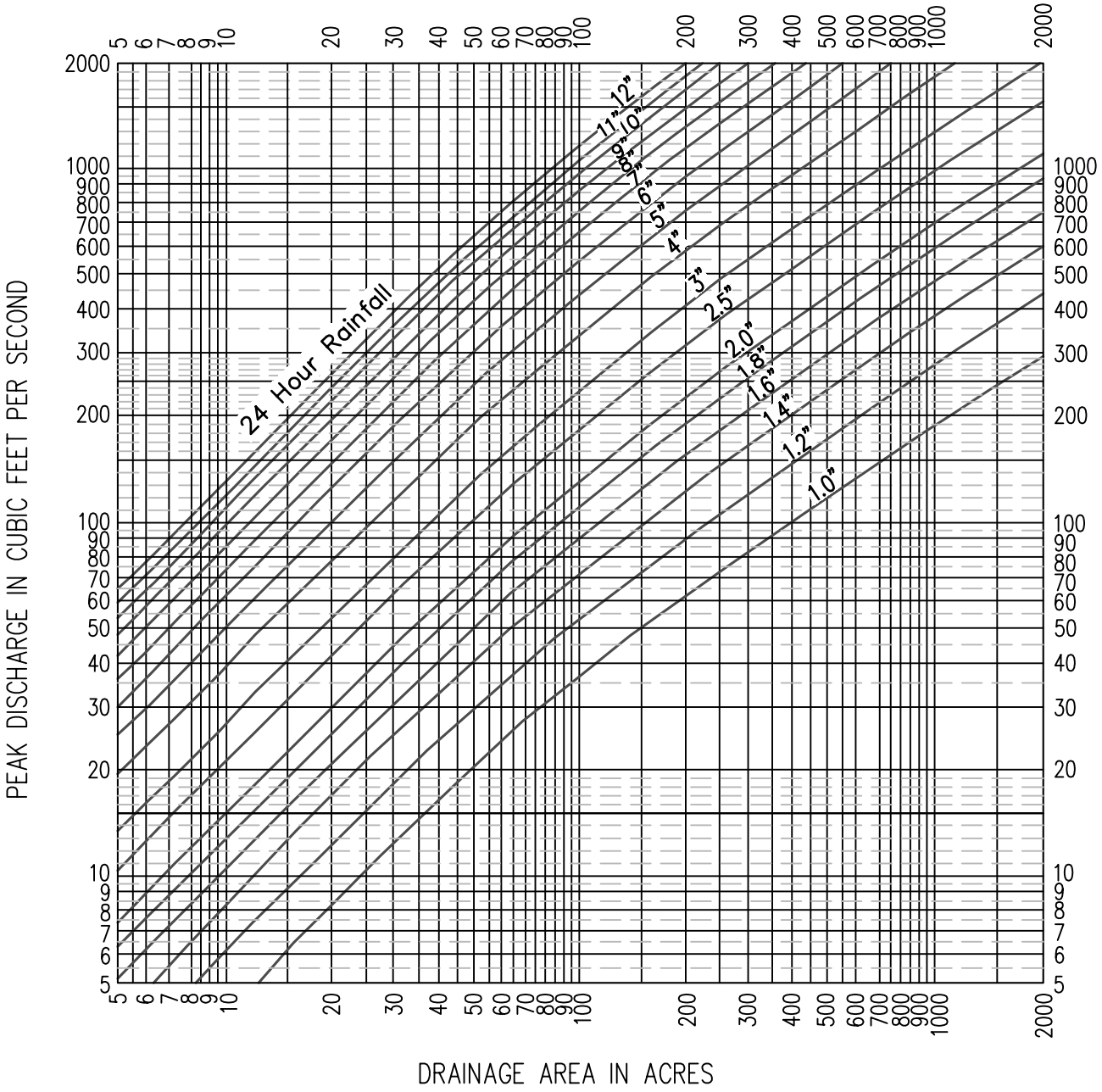

EXHIBIT 2–10

File No. 2–10.34

United States Department Of Agriculture Soil Conservation Service Engineering Division – Hydrology Branch	Chapter 2, Engineering Field Manual for Construction Practices	Standard DWG No **ES 1027** Sheet 21 Of 21 Date 2–15–71