Title 210 – Engineering

PART 630 – Hydrology

Subpart E – Runoff Curve Numbers

Amended June 2025

630.60 General

A combination of a hydrologic soil group (soil) and a land use and treatment class (cover) is a hydrologic soil-cover complex. This chapter gives tables and graphs of runoff curve numbers (CNs) assigned to such complexes. The CN indicates the runoff potential of a complex during periods when the soil is not frozen. A higher CN indicates a higher runoff potential and specifies which runoff curve of figure 630H-2 in Title 210 National Engineering Handbook Part 630, Subpart H, "Estimation of Direct Runoff from Storm Rainfall," to use in estimating runoff for the complex. 210 NEH 630, Subpart H and 210 NEH 630, Subpart J, "Hydrologic Effects of Land Use and Treatment," provide applications and further descriptions of CNs.

630.61 Determinations of Complexes and Curve Numbers

A. Agricultural Land

1. Figure 630E-1 provides complexes and assigned CNs for combinations of soil groups defined in 210 NEH 630, Subpart C, "Hydrologic Soil Groups," and land use and treatment classes of 210 NEH 630, Subpart D, "Land Use and Treatment Classes." Figure 630E-1 also provides some complexes that make application of the table more direct. Impervious areas and water surfaces not listed are always assigned a CN of 98.

2. Assignment of CNs to Complexes

   a. The steps followed to develop figure 630E-1 were:
      (1) The data literature was searched for watersheds in single complexes (one soil group and one cover); watersheds were found for most of the listed complexes.
      (2) An average CN for each watershed was obtained using rainfall-runoff data for storms producing the annual floods. The watersheds were generally less than 1 square mile in size, the number of watersheds for a complex varied, and the storms were of 1 day or less duration.
      (3) The CNs of watersheds in the same complex were averaged and all CNs for a cover were plotted. A curve for each cover was drawn with greater weight given to CNs based on data from more than one watershed, and each curve was extended as far as necessary to provide

CNs for ungagged complexes. All but the last three lines of CN entries in figure 630E-1 are taken from these curves.

(4) For the complexes in the last three lines of figure 630E-1, the proportions of different covers were estimated and the weighted CNs computed from previously derived CNs.

b. There have been no significant changes to figure 630E-1 since its construction in 1954 although CNs for crop residue cover treatment has been added. Supplementary tables for special regions were developed and some are shown later in this chapter. Some states may use special tables developed by the Soil Conservation Service or NRCS for use specifically within their state.

3. Use of Figure 630E-1

210 NEH 630, Subpart C and 120 NEH 630, Subpart D describe field classification of soils and covers of watersheds or other land areas. After the classification is completed, CNs are read from figure 630E-1 and applied as described in 120 NEH 630, Subpart H. Because the principal use of CNs is for estimating runoff from rainfall, 120 NEH 630, Subpart H provides examples of applications.

B. National and Commercial Forest: Forest-Range

1. Forest-Range in the Western United States

a. In the forest-range regions of the Western United States, soil group, cover type, and cover density are the principal factors used in estimating CNs. Figures 630E-2 and 630E-3 show the relationships between these factors and CNs for soil-cover complexes used to date. The figures are based on information in table 2-1, part 2, of the USDA Forest Service's Handbook, "Methods of Hydrologic Analysis" (USDA 1959b). The amount of litter is taken into account when estimating the density of cover.

b. Present hydrologic conditions are determined from existing surveys or by reconnaissance, and future conditions from the estimate of cover and density changes resulting from proper use and treatment. Figure 630E-4 lists CNs for arid and semiarid rangelands.

Figure 630E-1: Runoff Curve Numbers for Agricultural Lands [1/]

Cover type	Treatment [2/]	Hydrologic condition [3/]	A	B	C	D
Fallow	Bare Soil Crop residue cover (CR)	None	77	86	91	94
Fallow	Bare Soil Crop residue cover (CR	Poor	76	85	90	93
Fallow	Bare Soil Crop residue cover (CR	Good	74	83	88	90
Row crops	Straight row (SR)	Poor	72	81	88	91
Row crops	Straight row (SR)	Good	67	78	85	89
Row crops	SR + CR	Poor	71	80	87	90
Row crops	SR + CR	Good	64	75	82	85

Cover type	Treatment [2/]	Hydrologic condition [3/]	A	B	C	D
Row crops	Contoured (C)	Poor	70	79	84	88
Row crops	Contoured (C)	Good	65	75	82	86
Row crops	C + CR	Poor	69	78	83	87
Row crops	C + CR	Good	64	74	81	85
Row crops	Contoured & terraced (C &T)	Poor	66	74	80	82
Row crops	Contoured & terraced (C &T)	Good	62	71	78	81
Row crops	C & T + CR	Poor	65	73	79	81
Row crops	C & T + CR	Good	61	70	77	80
Small grain	SR	Poor	65	76	84	88
Small grain		Good	63	75	83	87
Small grain	SR + CR	Poor	64	75	83	86
Small grain		Good	60	72	80	84
Small grain	C	Poor	63	74	82	85
Small grain		Good	61	73	81	84
Small grain	C + CR	Poor	62	73	81	84
Small grain		Good	60	72	80	83
Small grain	C & T	Poor	61	72	79	82
Small grain		Good	59	70	78	81
Small grain	C & T + CR	Poor	60	71	78	81
Small grain		Good	58	69	77	80
Close-seeded or broadcast legumes or rotation meadow	SR	Poor	66	77	85	74
Close-seeded or broadcast legumes or rotation meadow	SR	Good	58	72	81	85
Close-seeded or broadcast legumes or rotation meadow	C	Poor	64	75	83	85
Close-seeded or broadcast legumes or rotation meadow	C	Good	55	69	78	83
Close-seeded or broadcast legumes or rotation meadow	C & T	Poor	63	73	80	83
Close-seeded or broadcast	C & T	Good	51	67	76	80

Cover type	Treatment [2/]	Hydrologic condition [3/]	A	B	C	D
legumes or rotation meadow						
Pasture, grassland, or range - continuous forage for grazing [4/]	None	Poor	68	79	86	89
Pasture, grassland, or range - continuous forage for grazing 4/	None	Fair	49	69	79	84
Pasture, grassland, or range - continuous forage for grazing 4/	None	Good	39	61	74	80
Meadow - continuous grass, protected from grazing and generally mowed for hay	None	Good	30	58	71	78
Brush - brush - forbs - grass mixture with brush the major element [5/]	None	Poor	48	67	77	83
Brush - brush - forbs - grass mixture with brush the major element 5/	None	Fair	35	56	70	77
Brush - brush - forbs - grass mixture with brush the major element 5/	None	Good	30 [6/]	48	65	73
Wood - grass combination (orchard or tree farm) [7/]	None	Poor	57	73	82	86
Wood - grass combination (orchard or tree farm) 7/	None	Fair	43	65	76	82

Cover type	Treatment 2/	Hydrologic condition 3/	A	B	C	D
Wood - grass combination (orchard or tree farm) 7/	None	Good	32	58	72	79
Woods 8/	None	Poor	45	66	77	83
Woods 8/	None	Fair	36	60	73	79
Woods 8/	None	Good	30	55	70	77
Farmstead - buildings, lanes, driveways, and surrounding lots	None	None	59	74	82	86
Roads (including right of way)	Dirt	None	72	82	87	89
Roads (including right of way)	Gravel	None	76	85	89	91

Figure 630E-2: Estimating Runoff Curve Numbers of Forest-Range Complexes in Western United States: Herbaceous and Oak-Aspen Complexes

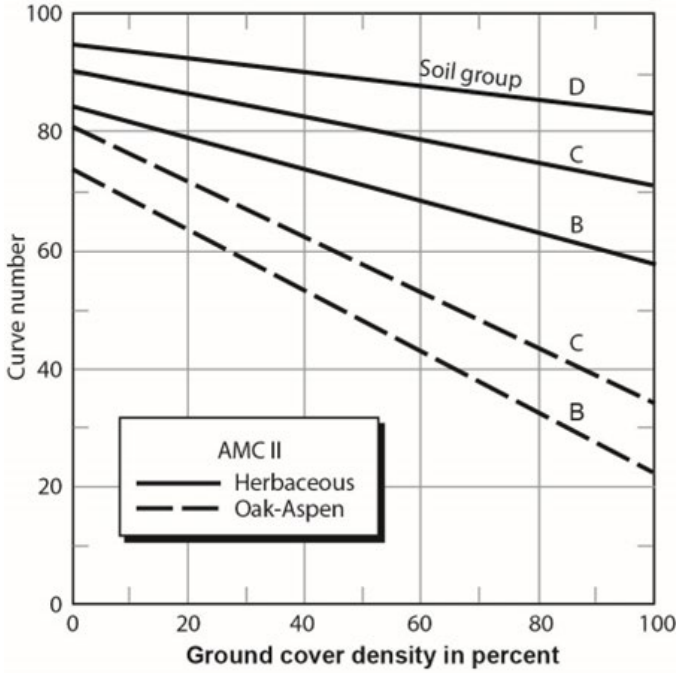


Figure 630E-3: Estimating Runoff Curve Numbers of Forest-Range Complexes in Western United States: Juniper-grass and Sage-grass Complexes

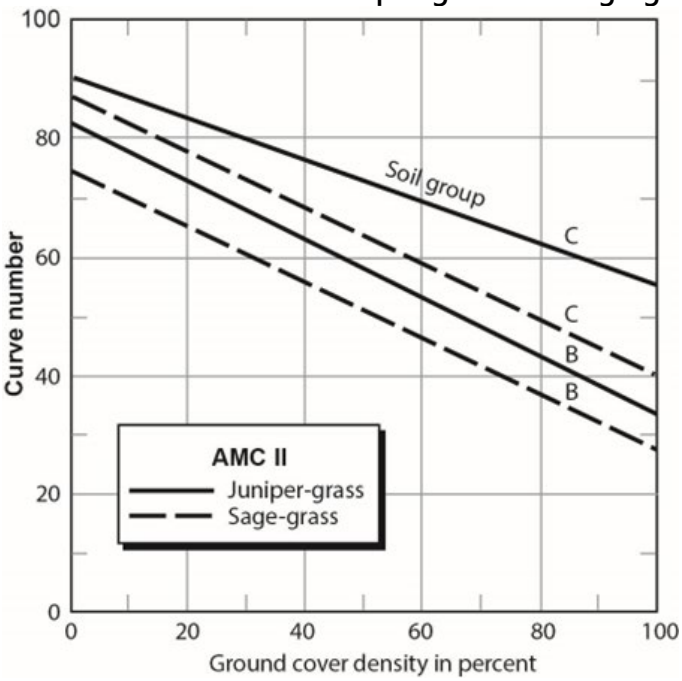


Figure 630E-4: Runoff Curve Numbers for Arid and Semiarid Rangelands [1/]

Cover Type	Hydrologic Condition[2/]	A[3/]	B	C	D
Herbaceous—mixture of grass, weeds, and low-growing brush, with brush the minor element	Poor	None	80	87	93
Herbaceous—mixture of grass, weeds, and low-growing brush, with brush the minor element	Fair	None	71	81	89
Herbaceous—mixture of grass, weeds, and low-growing brush, with brush the minor element	Good	None	62	74	85
Oak-aspen—mountain brush mixture of oak brush, aspen, mountain mahogany, bitter brush, maple, and other brush	Poor	None	66	74	79
Oak-aspen—mountain brush mixture of oak brush, aspen, mountain mahogany, bitter brush, maple, and other brush	Fair	None	48	57	63
Oak-aspen—mountain brush mixture of oak brush, aspen, mountain mahogany, bitter brush, maple, and other brush	Good	None	30	41	48
Pinyon-juniper—pinyon, juniper, or both; grass understory	Poor	None	75	85	89
Pinyon-juniper—pinyon, juniper, or both; grass understory	Fair	None	58	73	80
Pinyon-juniper—pinyon, juniper, or both; grass understory	Good	None	41	61	71
Sage-grass—sage with an understory of grass	Poor	None	67	80	85

Cover Type	Hydrologic Condition[2/]	A[3/]	B	C	D
Sage-grass—sage with an understory of grass	Fair	None	51	63	70
Sage-grass—sage with an understory of grass	Good	None	35	47	55
Desert shrub—major plants include saltbush, greasewood, creosote bush, blackbrush, bursage, paloverde, mesquite, and cactus	Poor	63	77	85	88
Desert shrub—major plants include saltbush, greasewood, creosote bush, blackbrush, bursage, paloverde, mesquite, and cactus	Fair	55	72	81	86
Desert shrub—major plants include saltbush, greasewood, creosote bush, blackbrush, bursage, paloverde, mesquite, and cactus	Good	49	68	79	84

1/ Average runoff condition, and I_a = 0.2s. For range in humid regions, use figure 630E-1.
2/ Poor: <30% ground cover (litter, grass, and brush overstory).
Fair: 30 to 70% ground cover.
Good: >70% ground cover.
3/ Curve numbers for group A have been developed only for desert shrub.

C. Urban and Residential Land

2. Several factors, such as the percentage of impervious area and the means of conveying runoff from impervious areas to the drainage system, should be considered in computing CNs for urban areas (Rawls et al., 1981). For example, do the impervious areas connect directly to the drainage system, or do they outlet onto lawns or other pervious areas where infiltration can occur?

3. The urban and residential CNs given in figure 630E-5 were developed for typical land use relationships based on specific assumed percentages of impervious area. These CN values were developed on the assumptions that -

   a. pervious urban areas are equivalent to pasture in good hydrologic condition,
   b. impervious areas have a CN of 98 and are directly connected to the drainage system, and
   c. the cover types listed have assumed percentages of impervious area as shown in figure 630E-5.

Figure 630E-5: Runoff Curve Numbers for Urban Areas [1/]

Cover Description **Cover type and hydrologic condition**	**Average percent impervious area [2/]**	**A[5/]**	**B[5/]**	**C[5/]**	**D[5/]**
Fully developed urban areas open spaces Poor condition (grass cover < 50%)3	None	68	79	86	89
Fully developed urban areas open spaces Fair condition (grass cover 50% to 75%)3	None	49	69	79	84
Fully developed urban areas open spaces Good condition (grass cover > 75%)3	None	39	61	74	80
Impervious area paved parking lots, roofs, driveways, etc. (excluding right-of-way)	None	98	98	98	98

Cover Description Cover type and hydrologic condition	Average percent impervious area 2/	A5/	B5/	C5/	D5/
Impervious area streets and roads paved; curbs and storm sewers (excluding right of way)	None	98	98	98	98
Impervious area streets and roads paved; open ditches (including right of way)	83	89	92	93	97
Impervious area streets and roads gravel (including right of way)	76	85	89	91	88
Impervious area streets and roads dirt (including right of way)	72	82	87	89	85
Western desert urban areas natural desert landscaping (pervious areas only)4/	None	63	77	85	88
Western desert urban area artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)	None	96	96	96	96
Urban districts commercial and business	85	89	92	94	95
Urban districts industrial	72	81	88	91	93
Residential districts by average lot size 1/8 acre or less (town houses)	65	77	85	90	92
Residential districts by average lot size 1/4 acre	38	61	75	83	87
Residential districts by average lot size 1/3 acre	30	57	72	81	86
Residential districts by average lot size 1/2 acre	25	54	70	80	85
Residential districts by average lot size 1 acre	20	51	68	79	84
Residential districts by average lot size 2 acres	12	46	65	77	82
Developing urban areas. Newly graded areas (pervious areas only, no Vegetation)	None	77	86	91	94

1/ Average runoff condition, and Ia = 0.2S.

2/ The average percent impervious area shown was used to develop the composite CNs. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition.

3/ CNs shown are equivalent to those of pasture. as well as open spaces such as lawns, parks, golf courses, etc. Composite CNs may be computed for other combinations of open space type.

4/ Composite CNs for natural desert landscaping should be computed using figures 9–3 or 9–4 based on the impervious area percentage (CN=98) and the pervious area CN. The pervious area CNs are assumed equivalent to desert shrub in poor hydrologic condition.

5/ CN for Hydrologic Soil Group

D. Connected Impervious Areas

1. An impervious area is considered connected if runoff from it flows directly into the drainage system. It is also considered connected if runoff from it occurs as shallow concentrated flow that runs over a pervious area and then into a drainage system.

2. If all of the impervious area is directly connected to the drainage system, but the impervious area percentages in figure 630E-5 or the pervious land use assumptions are not applicable, use equation 630E-1 or figure 630E-6 to compute a composite CN.

$$CN_c = CN_p + \left(\frac{P_{imp}}{100}\right)(98 - CN_p)$$

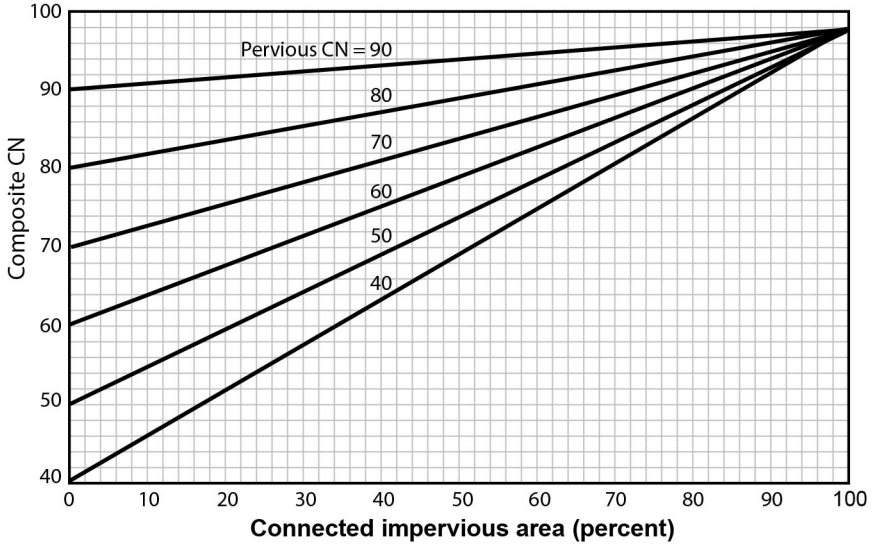
(eq. 630E-1)

where: CN_c = composite runoff curve number
CN_p = pervious runoff curve number
P_{imp} = percent imperviousness

3. Figure 630E-07 provides an example of calculating a composite urban residential CN with different percentage of impervious area than assumed in figure 630E-5.

4. Figure 630E-08 provides an example of calculating a composite urban residential CN with different CN for the pervious area than that assumed in figure 630E-5.

Figure 630E-6: Composite CN with Connected Impervious Area



5. Example calculation of composite urban residential CN with different percentage of impervious area than assumed in figure 630E-5.

   a. **Given:** Figure 630E-5 gives a CN of 70 for a ½-acre lot in HSG B with an assumed impervious area of 25 precent. The pervious area CN is 61.
   b. **Problem:** Find the CN to use if the lot has 20 precent impervious area.
   c. **Solution:**
      (1) **Method 1**. Solve equation 630E-1 with CNp the previous runoff curve number, equal to 61 and Pimp, the percent impervious, equal to 20:

$$\mathrm{CN_c} = 61 + \left(\frac{20}{100}\right)(98 - 61) = 68.4, \text{Round to } 68$$

      The CN difference between 70 in figure 630E-5 and the computer values of 68 reflects the difference in impervious area.

      (2) **Method 2**. Enter figure 630E-6 with the percentage of impervious area equal to 20 and move up to a point a little above the curve representing

a pervious curve number of 60 to find the point for a pervious CN of 61. Read the Composite CN of 68 on the left axis.

The CN difference between the 70 in figure 630E-5 and 68 from the figure 630E-6 reflects the difference in percent impervious area.

6. Example - Calculation of a composite urban residential CN with different CN for the pervious area than that assumed in figure 630E-5.

   a. **Given**: Figure 630E-5 gives a CN of 70 for a ½ acre lot in HSG B with an assumed impervious area of 25 percent. The pervious area CN is 61.
   b. **Problem:** Find the CN to use if the lot's pervious area CN of 69 indicating fair condition instead of good condition.
   c. **Solution:**

      (1) **Method 1**. Solve equation 630E-1 with $CN_{p\ the}$ pervious runoff curve number equal to 69 and P_{imp} the percent imperviousness equal to 25.

$$CN_c = 66 + \left(\frac{25}{100}\right)(98 - 69) = 76.25, \text{Round to } 76$$

      The CN difference between 70 in figure 630E-5 and the computed value of 76 reflects the differences in the previous area CN.

      (2) **Method 2**. Enter figure 630E-6 with the percentage of impervious area equal to 25 and move up to a point a little below the curve representing a pervious curve number of 70 to find the point for a pervious CN of 69. Read the composite CN of 76 on the left axis.

      The CN difference between 70 in figure 630E-5 and 76 from figure 603E-6 reflects the difference in the pervious area.

7. Unconnected Impervious Areas

   d. If runoff from impervious areas occurs over a pervious area as sheet flow prior to entering the drainage system, the impervious area is unconnected. To determine CN when all or part of the impervious area is not directly connected to the drainage system:
      (1) use equation 630E-2 or figure 630E-9 if the total impervious area is less than 30 percent of the total area or
      (2) use equation 630E-1 or figure 630.096H-6 if the total impervious area is equal to or greater than 30 percent of the total area, because the absorptive capacity of the remaining pervious areas will not significantly affect runoff.

$$CN_c = CN_p + \left(\frac{P_{imp}}{100}\right)(98 - CN_p)(1 - 0.5R)$$

(eq. 630E-2)

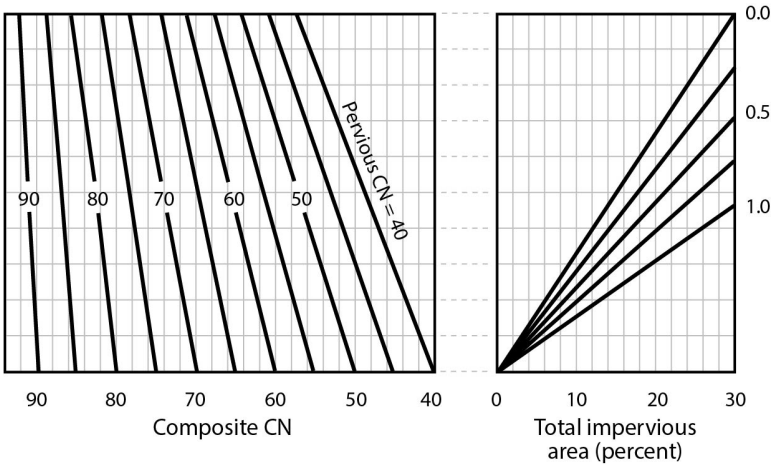
where: CN_c = composite runoff curve number
CN_p = pervious runoff curve number
P_{imp} = percent imperviousness

R = ratio of unconnected impervious area to total impervious area

e. When impervious area is less than 30 percent, obtain the composite CN by entering the right half of figure 630E-9 with the percentage of total impervious area and the ratio of total unconnected impervious area to total impervious area. Then move left to the appropriate pervious CN and read down to find the composite CN.

f. Figure 630E-10 provide an example of calculating a composite CN with unconnected impervious area and total impervious area less than 30 percent.

Figure 630E-9: Composite CN with Unconnected Impervious Areas and Total Impervious Area Less than 30 Percent



8. Example - Determine the composite CN with unconnected impervious area and total impervious area less than 30 percent.

   a. **Given:** A ½ acre lot in HSG B with an assumed impervious area of 20 precent 75 percent of which is unconnected. The pervious area CN is 61.

   b. **Problem:** Find the CN to use for the lot.

   c. **Solution:**

      (1) **Method 1**. Solve equation 630E-2 with CN_p the percent imperviousness equal to 20 and R the ration of the unconnected impervious area to total impervious are equal to 0.75

$$CN_c = 61 + \left(\frac{2520}{100}\right)(98 - 61)\left(1 - 0.5(0.75)\right) = 65.62, \text{Round to } 66$$

      (2) **Method 2**. Enter the right half of figure 630E-7 with the percentage of impervious area equal to 20 and move up to the 0.75 line for the ration of unconnected impervious area total impervious area. Then move to the left part of the figure left to the appropriate pervious CN 61 and read down to find the composite CN 66,

The CN considering all the impervious areas to be connected as in example 630E-1 is 68. This example shows that if 75 percentage of the impervious area in unconnected the CN is reduced to 66.

630.62 Acknowledgements

A. The USDA Soil Conservation Service (SCS) published the National Engineering Handbook, Section 4, Chapter 9, "Hydrologic Soil-Cover Complexes", prepared by Victor Mockus (deceased), in 1964. SCS reprinted Chapter 9 with minor revisions in 1969.

B. In July 2004, the USDA Natural Resources Conservation Service (NRCS, formerly SCS) published Title 210, National Engineering Handbook (NEH), Part 630, Hydrology, Chapter 9. The following individuals from the NRCS/ARS (Agricultural Research Service) Curve number Work group developed the 2004 version:

   1. From NRCS: Donald E. Woodward (retired); Robert D. Nielsen (retired); Robert Kluth (retired); Arlis Plummer (retired); Joe Van Mullem (retired); Gary Conaway (retired); Helen Fox Moody (deceased)
   2. From ARS: William J. Gburek (retired); Keith Cooley (retired); Allen T. Hjelmfelt, Jr. (retired); Virginia A. Ferreira (retired)
   3. University of Arizona: Richard H. Hawkins, Ph.D., professor emeritus, Tucson, Arizona

C. The Curve Number Task Group of the Watershed Management Technical Committee, Environmental Water Resources Institute (EWRI) of the American Society of Civil Engineers (ASCE) prepared a draft version of Subpart E (Chapter 9) through an agreement with the NRCS. The draft version proposed a series of revisions to the initial abstract ratio and curve number method. Ultimately, NRCS chose not to implement those revisions. NRCS is grateful to the major authors and contributors of the ASCE CN Task Group. In alphabetical order those individuals were Hunter Birckhead, P.E., M.ASCE; James V. Bonta, Ph.D., P.E., F.ASCE; Donald Frevert, Ph.D., P.E., D.WRE(Ret), F.ASCE; Claudia C. Hoeft, P.E., F.ASCE (USDA NRCS liaison - retired); Richard H. Hawkins, Ph.D., P.E., F.EWRI, F.ASCE (Task Group chair); Rosanna La Plante, P.E., M.ASCE; Michael E. Meadows, Ph.D., P.E., F.ASCE; Julianne Miller, A.M.ASCE; Steven C. McCutcheon, Ph.D., P.E., D.WRE(Ret), F.EWRI, F.ASCE; Glenn Moglen, Ph.D., P.E., F.EWRI, F.ASCE; David Powers, P.E., D.WRE, F.ASCE; John Ramirez-Avila, Ph.D., ING., M.ASCE; William Tollner, Ph.D., P.E., M.ASCE, F.ASABE (American Society of Agricultural and Biological Engineers [ASABE] representative); Joseph A. Van Mullem, P.E., M.ASCE; Tim J. Ward, Ph.D., P.E., F.EWRI, F.ASCE (Task Group co-chair); and Donald E. Woodward, P.E., F.ASCE (Task Group co-chair).

D. Claudia C. Hoeft (retired, ACES) prepared this version of Chapter 9 implementing formatting changes required by NRCS for manuals and handbooks

and very minor revisions, under the direction of Hong Wang, Ph.D., National Hydraulic Engineer, Washington D.C.

630.63 References

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