

### A. Introduction

The Natural Resource Conservation Service (NRCS) hydrologic method requires basic data similar to the Rational method: drainage area, a runoff factor, time of concentration, and rainfall. The NRCS approach, however, is more sophisticated in that it also considers the time distribution of the rainfall, the initial rainfall losses to interception and depression storage, and an infiltration rate that decreases during the course of a storm. Details of the methodology can be found in the NRCS National Engineering Handbook, Section 4, Hydrology. A typical application of the NRCS method includes the following basic steps:

1. Determination of curve numbers that represent different land uses within the drainage area.
2. Calculation of time of concentration to the study point.
3. Using the Type II or Type III rainfall distribution, total and excess rainfall amounts are determined. See Figure C3-S5-1 for the geographic boundaries for the different NRCS rainfall distributions.
4. Using the unit hydrograph approach, the hydrograph of direct runoff from the drainage basin can be developed.

The NRCS method can be used for both the estimation of stormwater runoff peak rates and the generation of hydrographs for the routing of stormwater flows. The simplified method can be used for drainage areas up to 2,000 acres. The NRCS method can be used for most design applications, including storage facilities, outlet structures, storm drain systems, culverts, small drainage ditches, open channels, and energy dissipaters.

### B. Equations and concepts

The hydrograph of outflow from a drainage basin is the sum of the elemental hydrographs from all the sub-areas of the basin, modified by the effects of transit time through the basin and storage in the stream channels. Since the physical characteristics of the basin (shape, size, and slope) are constant, the unit hydrograph approach assumes that there is considerable similarity in the shape of hydrographs from storms of similar rainfall characteristics. Thus, the unit hydrograph is a typical hydrograph for the basin with a runoff volume under the hydrograph equal to 1 inch from a storm of specified duration. For a storm of the same duration, but with a different amount of runoff, the hydrograph of direct runoff can be expected to have the same time base as the unit hydrograph and ordinates of flow proportional to the runoff volume. Therefore, a storm that produces 2 inches of runoff would have a hydrograph with a flow equal to twice the flow of the unit hydrograph. With 0.5 inches of runoff, the flow of the hydrograph would be one-half of the flow of the unit hydrograph.

The following discussion outlines the equations and basin concepts used in the NRCS method:

1. **Drainage area.** The drainage area of a watershed is determined from topographic maps and field surveys. For large drainage areas, it might be necessary to divide the area into sub-drainage areas to account for major land use changes, obtain analysis results at different points within the drainage area, combine hydrographs from different subbasins as applicable, and/or route flows to points of interest.
2. **Rainfall.** The NRCS method applicable to the State of Iowa is based on a storm event that has a Type II time distribution. These distributions are used to distribute the 24-hour volume of rainfall for the different storm frequencies (Figure C3-S5-1).

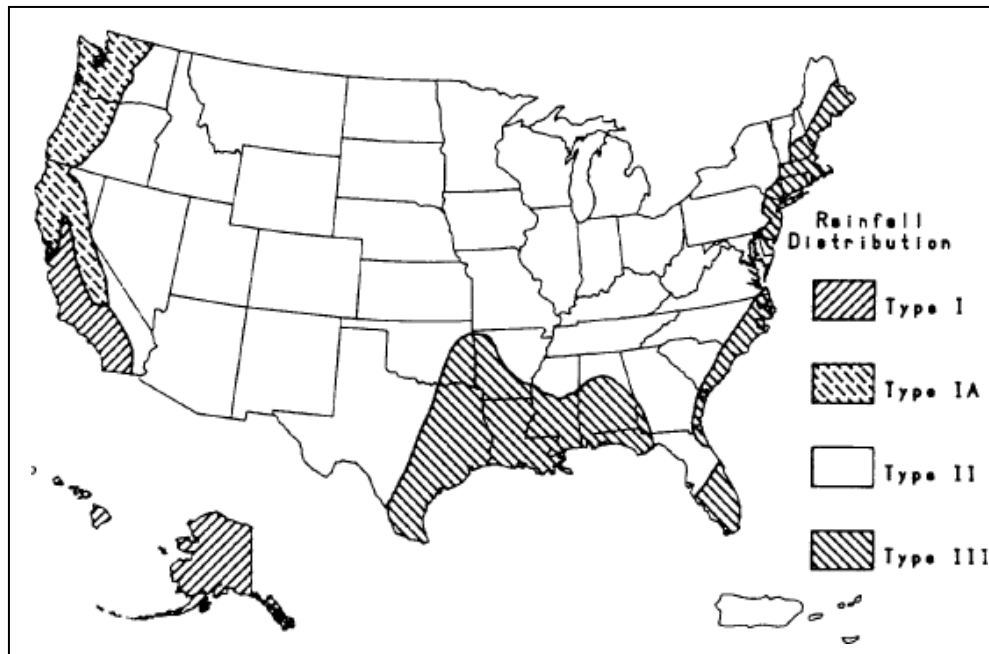


Figure C3-S5-1: Geographic boundaries for the NRCS rainfall distributions

3. **Rainfall-runoff equation.** A relationship between accumulated rainfall and accumulated runoff was derived by the NRCS from experimental plots for numerous soils and vegetative cover conditions. The NRCS runoff curve number (CN) method is described in detail in NEH-4 (NRCS 1985). The following NRCS runoff equation is used to estimate direct runoff from 24-hour or 1-day storm rainfall:

The equation is:

Equation C3-S5-1

$$Q = \frac{(P - I_a)^2}{P - I_a + S}$$

Where:

Q = volume of accumulated runoff (in)

P = accumulated rainfall (potential maximum runoff) (in)

S = potential maximum retention of rainfall on the watershed at the beginning of the storm (in)

$I_a$  = initial abstraction, including surface storage, interception, and evaporation

F = infiltration prior to runoff (in)

$I_a$  is highly variable, but generally is correlated with soil and cover parameters. Through studies of many small agricultural watersheds,  $I_a$  was found to be approximated by the following empirical equation:

Equation C3-S5-2

$$I_a = 0.2S$$

By removing  $I_a$  as an independent parameter, this approximation allows use of a combination of S and P to produce a unique runoff amount. Substituting Equation C3-S5-2 into Equation C3-S5-1 gives:

Equation C3-S5-3

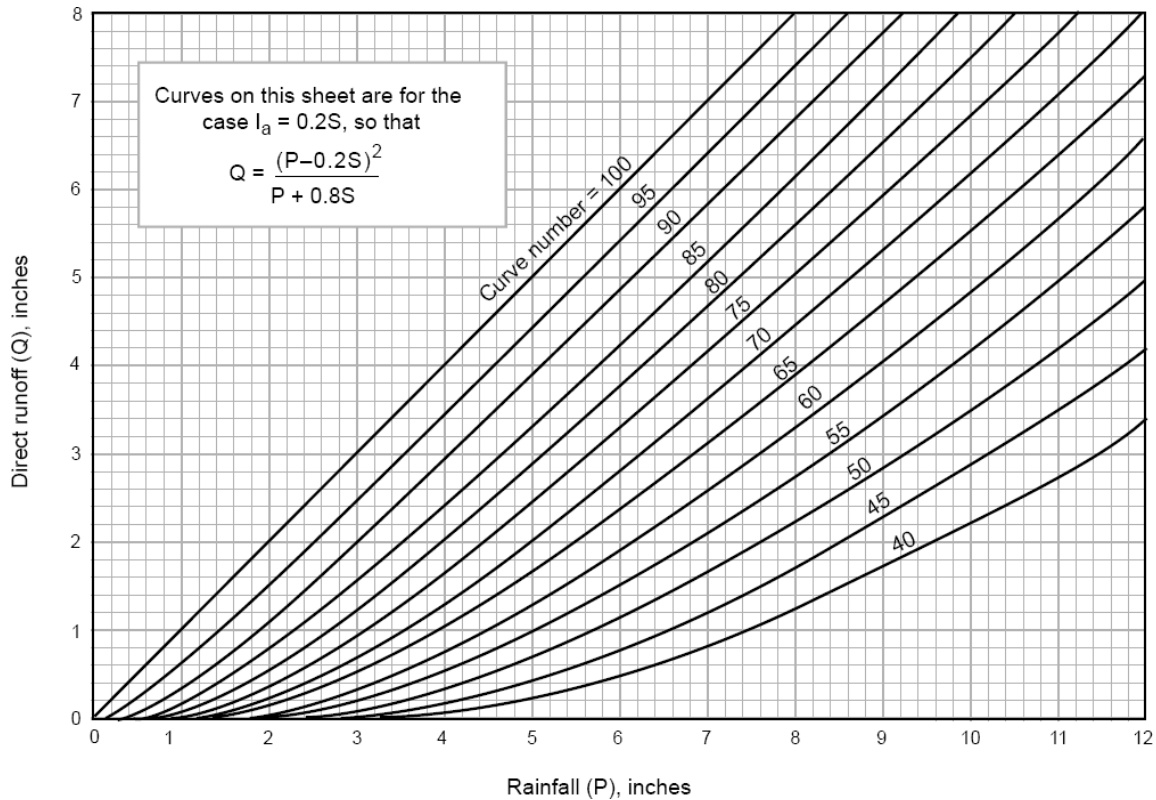
$$Q = \frac{(P - 0.2S)^2}{P + 0.8S}$$

S is related to the soil and cover conditions of the watershed through the curve number, CN. CN has a range of 0 to 100, and S is related to CN by:

**Equation C3-S5-4**

$$S = \frac{100}{CN} - 10$$

Figure C3-S5-2 and Table C3-S5-1 solve Equation C3-S5-3 and Equation C3-S5-4 for a range of CN's and rainfall.



**Figure C3-S5-2: Solution of the NRCS runoff equation**

Equation C3-S5-3 can be rearranged so the curve number can be estimated if rainfall and runoff volume are known. The equation then becomes (Pitt, 1994):

**Equation C3-S5-5**

$$CN = \frac{1000}{[10 + 5P + 10Q_a - 10(Q_a^2 + 1.25Q_aP)^{\frac{1}{2}}]}$$

Where:

P = rainfall (in)

Q<sub>a</sub> = runoff volume (in)

Table C3-S5-1: Runoff depth for selected CN's and rainfall amounts<sup>1</sup>

Runoff depth for curve number of:													
Rainfall	40	45	50	55	60	65	70	75	80	85	90	95	98
1.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.08	0.17	0.32	0.56	0.79
1.2	.00	.00	.00	.00	.00	.00	.03	.07	.10	.27	.46	.74	.99
1.4	.00	.00	.00	.00	.00	.02	.06	.13	.24	.39	.61	.92	1.18
1.6	.00	.00	.00	.00	.01	.05	.11	.20	.34	.52	.76	1.11	1.38
1.8	.00	.00	.00	.00	.03	.09	.17	.29	.44	.65	.93	1.29	1.58
2.0	.00	.00	.00	.02	.06	.14	.24	.38	.56	.80	1.09	1.48	1.77
2.5	.00	.00	.02	.08	.17	.30	.46	.65	.89	1.18	1.53	1.96	2.27
3.0	.00	.02	.09	.19	.33	.51	.71	.96	1.25	1.59	1.98	2.45	2.77
3.5	.02	.08	.20	.35	.53	.75	1.01	1.30	1.64	2.02	2.45	2.94	3.27
4.0	.06	.18	.33	.53	.76	1.03	1.33	1.67	2.04	2.46	2.92	3.43	3.77
4.5	.14	.30	.50	.74	1.02	1.33	1.67	2.05	2.46	2.91	3.40	3.92	4.26
5.0	.24	.44	.69	.98	1.30	1.65	2.04	2.45	2.89	3.37	3.88	4.42	4.76
6.0	.50	.80	1.14	1.52	1.92	2.35	2.81	3.28	3.78	4.30	4.85	5.41	5.76
7.0	.84	1.24	1.68	2.12	2.60	3.10	3.62	4.15	4.69	5.25	5.82	6.41	6.76
8.0	1.25	1.74	2.25	2.78	3.33	3.89	4.46	5.04	5.63	6.21	6.81	7.40	7.76
9.0	1.71	2.29	2.88	3.49	4.10	4.72	5.33	5.95	6.57	7.18	7.79	8.40	8.76
10.0	2.23	2.89	3.56	4.23	4.90	5.56	6.22	6.88	7.52	8.16	8.78	9.40	9.76
11.0	2.78	3.52	4.26	5.00	5.72	6.43	7.13	7.81	8.48	9.13	9.77	10.39	10.76
12.0	3.38	4.19	5.00	5.79	6.56	7.32	8.05	8.76	9.45	10.11	10.76	11.39	11.76
13.0	4.00	4.89	5.76	6.61	7.42	8.21	8.98	9.71	10.42	11.10	11.76	12.39	12.76
14.0	4.65	5.62	6.55	7.44	8.30	9.12	9.91	10.67	11.39	12.08	12.75	13.39	13.76
15.0	5.33	6.36	7.35	8.29	9.19	10.04	10.85	11.63	12.37	13.07	13.74	14.39	14.76

<sup>1</sup>Interpolate the values shown to obtain runoff depths for CNs or rainfall amounts not shown.

### C. Runoff factor

The principal physical watershed characteristics affecting the relationship between rainfall and runoff are land use, land treatment, soil types, and land slope. The NRCS method uses a combination of soil conditions and land uses (ground cover) to assign a runoff factor to an area. These runoff factors, called runoff curve numbers (CN), indicate the runoff potential of an area. The higher the CN, the higher the runoff potential. Soil properties influence the relationship between runoff and rainfall since soils have differing rates of infiltration. Based on infiltration rates, the NRCS has divided soils into four hydrologic soil groups:

1. **Group A soils.** Have a low runoff potential due to high infiltration rates. These soils consist primarily of deep, well- drained sands and gravels.
2. **Group B soils.** Have a moderately low runoff potential due to moderate infiltration rates. These soils consist primarily of moderately deep to deep, moderately well- to well-drained soils with moderately fine to moderately coarse textures.
3. **Group C soils.** Have a moderately high runoff potential due to slow infiltration rates. These soils consist primarily of soils in which a layer exists near the surface that impedes the downward movement of water or soils with moderately fine to fine texture.
4. **Group D soils.** Have a high runoff potential due to very slow infiltration rates. These soils consist primarily of clays with high swelling potential, soils with permanently high water tables, soils with a clay pan or clay layer at or near the surface, and shallow soils over nearly impervious parent material.

Information on all of the soils in Iowa can be located in the NRCS Soil Survey publications, and can be obtained

from the local NRCS offices for use in estimating soil type.

Consideration should be given to the effects of urbanization on the natural hydrologic soil group. If heavy equipment can be expected to compact the soil during construction, or if grading will mix the surface and subsurface soils, appropriate changes should be made in the soil group selected. Also, runoff curve numbers vary with the antecedent soil moisture conditions. Average antecedent soil moisture conditions (AMC II) are recommended for most hydrologic analysis, except in the design of state-regulated Category I dams where AMC III may be required. Areas with high water table conditions may want to consider using AMC III antecedent soil moisture conditions. Tables with recommended curve numbers for a range of urban, cultivated agriculture, and other rural land uses are provided in Table C3-S5-2 and included in the land use definition menu in WinTR-55.

When a drainage area has more than one land use, a composite curve number can be calculated and used in the analysis. It should be noted that when composite curve numbers are used, the analysis does not take into account the location of the specific land uses, but sees the drainage area as a uniform land use represented by the composite curve number. Composite curve numbers for a drainage area can be calculated by using the weighted method as presented below.

#### Composite Curve Number Calculation Example

Land use	% of total land area	Curve number	Weighted curve number (% area x CN)
Residential $1/8$ -acre soil group B	0.80	0.85	0.68
Meadow good condition soil group C	0.20	0.71	0.14

$$\text{Total Weighted CN} = 0.68 + 0.14 = 0.82$$

The different land uses within the drainage basin should reflect a uniform hydrologic group, represented by a single curve number. Any number of land uses can be included, but if their spatial distribution is important to the hydrologic analysis, then subbasins should be developed, and separate hydrographs developed and routed to the study point.

#### D. Urban modifications of the NRCS method

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 CN for developed areas. 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? The curve number values listed in the CN/land use tables are based on directly-connected impervious area. An impervious area is considered directly-connected if runoff from it flows directly into the drainage system. It is also considered directly-connected if runoff from it occurs as concentrated shallow flow that runs over pervious areas, and then into a drainage system. It is possible that curve number values from urban areas could be reduced by not directly connecting impervious surfaces to the drainage system, but allowing runoff to flow as sheet flow over significant pervious areas. The following discussion will give some guidance for adjusting curve numbers for different types of impervious areas.

1. **Connected impervious areas.** The CN's provided in the tables for the various land cover types 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

If all of the impervious area is directly-connected to the drainage system, but the impervious area percentages or the pervious land use assumptions in the table are not applicable, use Figure C3-S5-3 to compute a composite CN. For example, Table C3-S3-2 gives a CN of 70 for a  $1/2$ -acre lot in hydrologic soil group B, with an assumed impervious area of 25%. However, if the lot has 20% impervious area and a pervious area CN of 61, the composite CN obtained from Figure C3-S5-3 is 68. The CN difference between 70 and 68 reflects the difference in percent impervious area. In the current version of WinTR-55, the user may do this conversion quickly though

the interactive menu in the program. WinTR-55 will also allow the user to create custom CN's based on the site imperviousness and/or other site conditions.

**Table C3-S5-2: NRCS runoff curve numbers (CN) for selected urban land use<sup>1</sup>**

Cover description		Curve numbers for hydrologic soil group			
Cover type and hydrologic condition	Average impervious area <sup>2</sup>	A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) <sup>3</sup> :					
Poor condition (grass cover <50%)		68	79	86	89
Fair condition (grass cover 50-75%)		49	69	79	84
Good condition (grass cover >75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding ROW)		98	98	98	98
Streets and roads:					
Paved: curbs and storm sewers (excluding ROW)		98	98	98	98
Paved: open ditches (including ROW)		83	89	92	93
Gravel (including ROW)		76	85	89	91
Dirt (including ROW)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) <sup>4</sup>		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1-2 inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/8 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) <sup>5</sup>	77	86	91	94	
Idle lands (CN's are determined using cover types similar to those in Table C3-S5-3)					

<sup>1</sup>Average runoff condition and  $I_a=0.2S$ .

<sup>2</sup>The average percent impervious area shown was used to develop the composite CN's. 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. CN's for other combinations of conditions may be computed using Figure C3-S5-3 or Figure C3-S5-4.

<sup>3</sup>CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.

<sup>4</sup>Composite CN's for natural desert landscaping should be computed using Figure C3-S5-3 or Figure C3-S5-4; based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.

<sup>5</sup>Composite CN's to use for the design of temporary measures during grading and construction should be computed using Figure C3-S5-3 or Figure C3-S5-4 based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

**Table C3-S5-3: NRCS runoff curve numbers (CN) for selected cultivated agricultural land use<sup>1</sup>**

Cover description			Curve numbers for hydrologic soil group			
Cover type	Treatment <sup>2</sup>	Hydrologic condition <sup>3</sup>	A	B	C	D
Fallow	Bare soil	--	77	86	91	94
	Crop residue cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row crops	Straight row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR+CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C+CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured and terraced (C&T)	Poor	66	74	80	82
		Good	62	71	78	81
	C&T+CR	Poor	65	73	79	81
		Good	61	70	77	80
Small grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR+CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85
		Good	61	73	81	84
	C+CR	Poor	62	73	81	84
		Good	60	72	80	83
	C&T	Poor	61	72	79	82
		Good	59	70	78	81
	C&T+CR	Poor	60	71	78	81
		Good	58	69	77	80
Close- seeded or broadcast legumes or rotation meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C&T	Poor	63	73	80	83
		Good	51	67	76	80

<sup>1</sup>Average runoff condition and  $I_a=0.2S$ .

<sup>2</sup>Crop residue cover applies only if residue is on at least 5% of the surface throughout the year.

<sup>3</sup>Hydraulic condition is based on combination factors that affect infiltration and runoff, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close- seeded legumes, (d) percent of residue cover on the land surface (good  $\geq 20\%$ ), and (e) degree of surface roughness.

Poor: factors impair infiltration and tend to increase runoff.

Good: factors encourage average and better than average infiltration and tend to decrease runoff.

**Table C3-S5-4: NRCS runoff curve numbers (CN) for other agricultural land use<sup>1</sup>**

Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrologic condition	A	B	C	D
Pasture, grassland, or range - continuous forage for grazing <sup>2</sup>	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow - continuous grass, protected from grazing and generally mowed for hay	--	30	58	71	78
Brush - brush-weed-grass mixture with brush the major element <sup>3</sup>	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30 <sup>4</sup>	48	65	73
Woods - grass combination (orchard or tree farm) <sup>5</sup>	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods <sup>6</sup>	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30 <sup>4</sup>	55	70	77
Farmsteads - buildings, lanes, driveways, and surrounding lots	--	59	74	82	86

<sup>1</sup>Average runoff condition and  $I_a=0.2S$ .

<sup>2</sup>Poor: <50% ground cover or heavily grazed with no mulch. Fair: 50% to 75% ground cover and not heavily grazed.

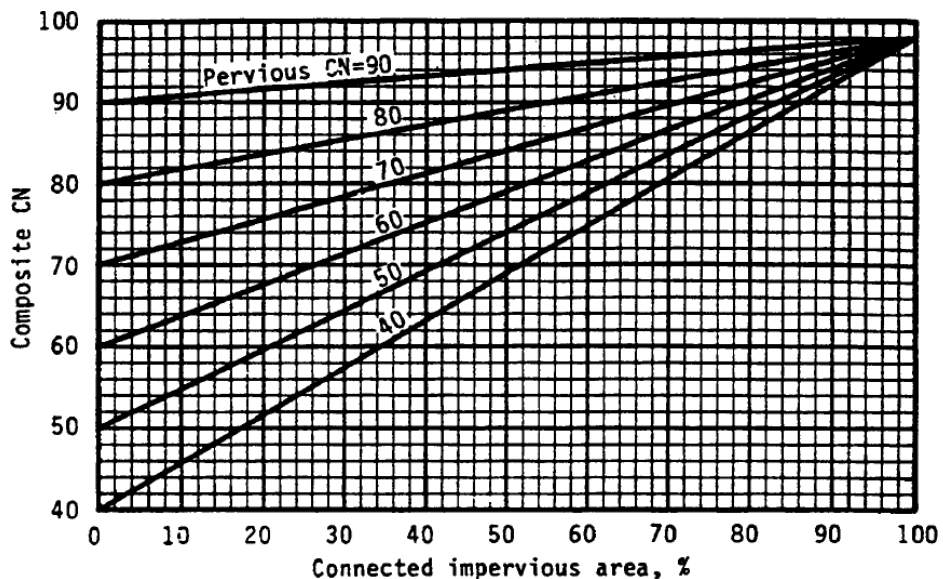
Good: >75% ground cover and lightly or only occasionally grazed.

<sup>3</sup>Poor: <50% ground cover; Fair: 50-75% ground cover; Good: >75% ground cover.

<sup>4</sup>Actual curve number is less than 30%; use CN=30 for runoff computations.

<sup>5</sup>CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.

<sup>6</sup>Poor: forest litter, small trees, and brush are destroyed by heavy grazing or regular burning. Fair: woods are grazed, but not burned, and some forest litter covers the soil. Good: woods are protected from grazing, and litter and brush adequately cover the soil.



**Figure C3-S5-3: Composite CN with connected impervious areas**



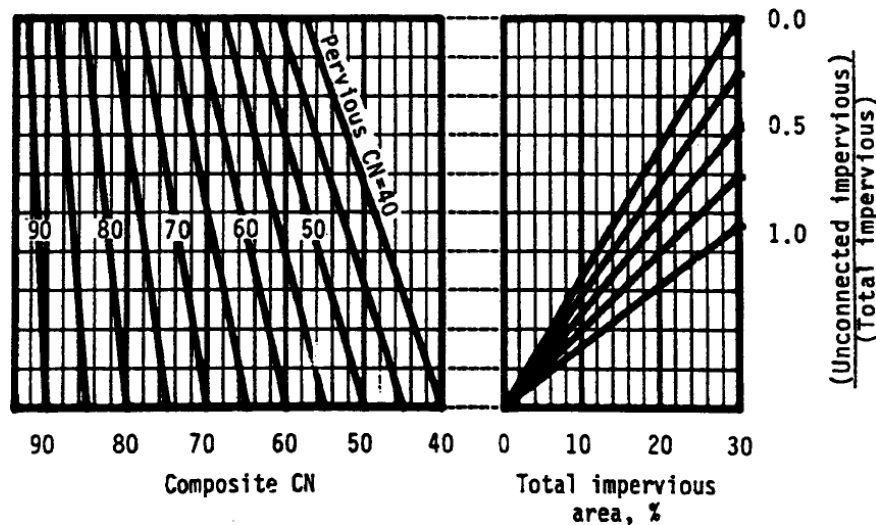


Figure C3-S5-4: Composite CN with unconnected impervious areas (total impervious area less than 30%)

### E. WinTR-55 for analysis

The previous versions of the NRCS CN Method and hydrology analysis used a series of graphs and tabular information to enable the user to determine runoff volume and peak flow. In addition, a tabular method was developed for creating runoff hydrographs from the 24-hour rainfall distributions and the associated unit hydrographs. The DOS versions of the program, created in 1971 and updated in 1986, has now been updated to the Windows operating system to take full advantage of the graphical interface.

A WinTR-55 work group was formed in the spring of 1998 to modernize and revise TR-55 and the computer software. The current changes include: upgrading the source code to Visual Basic, changing the philosophy of data input, developing a Windows interface and output post-processor, and enhancing the hydrograph-generation capability of the software and flood routing hydrographs through stream reaches and reservoirs. The availability and technical capabilities of the personal computer have significantly changed the philosophy of problem solving for the engineer. Computer availability eliminated the need for TR-55 manual methods, thus the manual portions (graphs and tables) of the user document have been eliminated as official guidance. The WinTR-55 user manual (NRCS 2002a) covers the procedures used and the operation of the WinTR-55 computer program. Part 630 of the NRCS National Engineering Handbook provides detailed information on NRCS hydrology, and is the technical reference for WinTR-55. The graphs and tables related to the CN method and the associated  $T_c$  computations were included here to assist in explaining the NRCS design procedures shown in this and the previous sections. All of these computations are now handled within the computer version of the method. All the site specific data required to be entered by the designer is now entered through an interactive graphical user interface. The program comes preloaded with the TP40 rainfall data for all Iowa counties and the user can enter custom rainfall data and distributions as well

The user can obtain a full working copy of the WinTR-55 program and user manual at the NRCS Water and Climate Center at <http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/water/?cid=stelprdb1042901>. The windows version of TR- 20 (WinTR-20) can also be obtained at this same site.

1. **Program description.** WinTR-55 is a single-event rainfall-runoff small watershed hydrologic model. The model generates hydrographs from both urban and agricultural areas and at selected points along the stream system. Hydrographs are routed downstream through channels and/or reservoirs. Multiple sub-areas can be modeled within the watershed.
2. **WinTR-55 model overview.** A watershed is composed of sub-areas (land areas) and reaches (major flow paths in the watershed). Each sub-area has a hydrograph generated from the land area based on the land and climate characteristics provided. Reaches can be designated as either channel reaches, where hydrographs are routed based on physical reach characteristics, or as storage reaches, where hydrographs are routed through a reservoir, based on temporary storage and outlet characteristics. Hydrographs from sub-areas and reaches are

combined, as needed, to accumulate flow as water moves from the upland areas down through the watershed reach network. The accumulation of all runoff from the watershed is represented at the watershed outlet. Up to ten sub-areas and ten reaches may be included in the watershed. WinTR-55 uses the TR-20 (NRCS 2002b) model for all of the hydrograph procedures: generation, channel routing, storage routing, and hydrograph summation. Figure C3-S5-5 is a diagram showing the WinTR-55 model, its relationship to TR-20, and the files associated with the model.

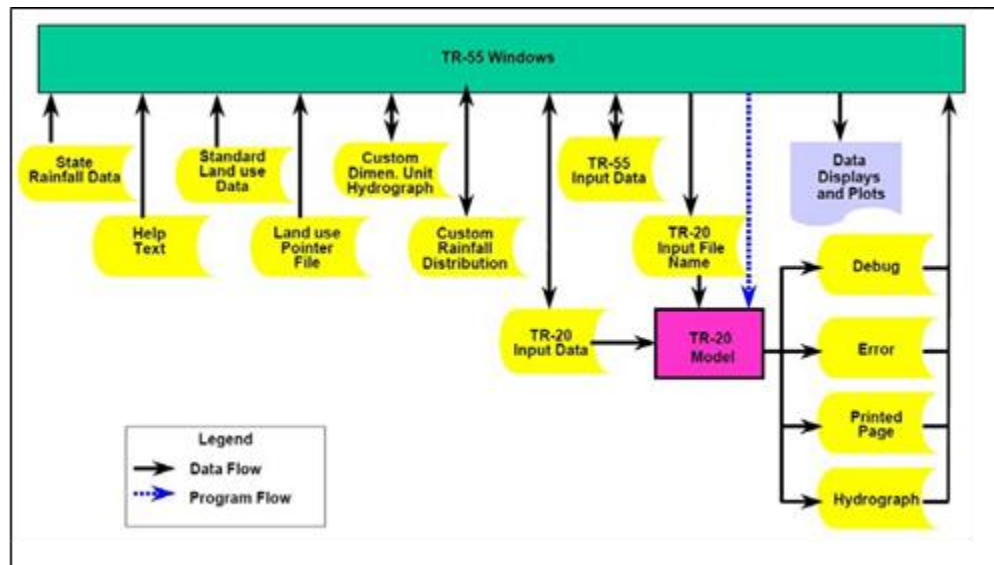


Figure C3-S5-5: WinTR-55 model

3. **Capabilities and limitations.** WinTR-55 hydrology has the capability to analyze watersheds that meet the criteria listed in Table C3-S5-5. The various data used in the WinTR-55 procedures are user entered via a series of input windows in the model. A description of each of the input windows follows the figure. Data entry is needed only on the windows that are applicable to the watershed being evaluated.

Table C3-S5-5: WinTR-55 capabilities and limitations

Variable	Limits
Minimum drainage area	No absolute minimum is included in the software. However, carefully examine results from sub-areas less than 1 acre.
Maximum area	25 square miles (6500 hectares)
Time of concentration for any sub-area	$0.1 \text{ hour} \leq T_c \leq 10\text{-hours}$
Number of reaches	0-10
Types of reaches	Channel or structure
Reach routing	Muskingum-Cunge
Structure routing	Storage-indication (modified puls)
Structure types	Pipe or weir
Structure trial sizes	3-3
Rainfall depth*	Default or user defined; 0-50 inches
Rainfall distributions	NRCS Type I, Ia, II, III, MN60, NM65, NM70, NM75, or user-defined
Rainfall duration	24-hour
Dimensionless unit hydrograph	Standard peak rate factor 484, or user-defined
Antecedent moisture condition	2 (average)

\*The current version of WinTR-55 (Version 1.0.08, 2004) uses the TP40 (1961) rainfall data as the default Iowa county rainfall depth files. Users may manually enter the design storm depths (24-hr duration) for Iowa from **Error! Reference source not found.**, or create custom rainfall files for use at a specific location. Although no minimum rain depth is listed by the NRCS in the above table, it must be recognized that the original NRCS curve number methods, incorporated in this newer version, are not accurate for small

storms. In most cases, larger storms used for drainage design are reasonably well-suited to this method. Pitt (1987) and Pitt, et al. (2002) showed that rain depths less than 2 or 3 inches (typical 2-yr storm) can have significant errors when using the CN approach. A method for determining a modified CN for determination of peak discharge rate for the WQv design storm (1.25 inches) is presented in Chapter 3 - Section 6 Small Storm Hydrology. This method allows the use of WinTR-55 for analysis of the WQv storm.

Source: NRCS, 2003

4. **Minimum data requirements.** While WinTR-55 can be used for watersheds with up to ten sub- areas and up to ten reaches, the simplest run involves only a single sub-area. Data required for a single sub-area run can be entered on the TR-55 main window. These data include:
  - Identification data: user, state, county, project, and Subtitle
  - Dimensionless unit hydrograph, storm data, rainfall distribution, and sub-area data. The sub- area data can be entered directly into the subarea entry and summary table.
  - Sub-area name, sub-area description, sub-area flows to reach/outlet, area, runoff curve number (CN), and time of concentration ( $T_c$ ). Detailed information for the subarea CN and  $T_c$  can be entered here or on other windows; if detailed information is entered elsewhere, the computational results are displayed in this window.
5. **Watershed subareas and reaches.** To properly route stream flow to the watershed outlet, the user must understand how WinTR-55 relates watershed subareas and stream reaches. Figure C3-S5-6 and Table C3-S5-6 show a typical watershed with multiple sub-areas and reaches. Reaches define flow paths through the watershed to its outlet. Each sub-area and reach contributes flow to the upstream end of a receiving reach or to the outlet. Accumulated runoff from all sub-areas routed through the watershed reach system, by definition, is flow at the watershed outlet.

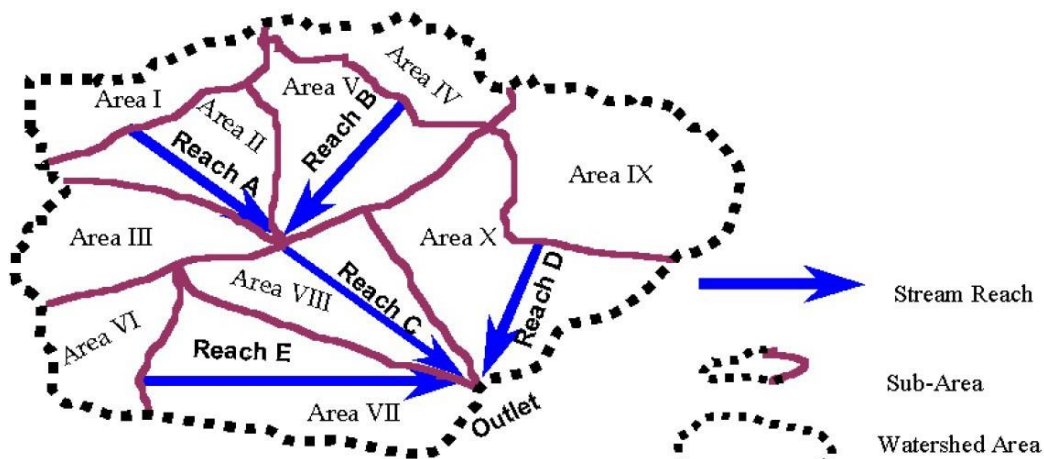


Figure C3-S5-6: Sample watershed schematic for WinTR-55

Source: NRCS 2002a

Table C3-S5-6: Sample watershed flows

Sub-area	Flows into upstream end	Reach	Flows into
Area I	Reach A	Reach A	Reach C
Area II	Reach C	Reach B	Reach C
Area III	Reach C	Reach C	OUTLET
Area IV	Reach B	Reach D	OUTLET
Area V	Reach C	Reach E	OUTLET
Area VI	Reach E		
Area VII	OUTLET		
Area VIII	OUTLET		
Area IX	Reach D		
Area X	OUTLET		

6. **Processes.** WinTR-55 relies on the TR-20 model for all hydrograph processes. These include: hydrograph generation, combining hydrographs, channel routing, and structure routing. The program now uses a Muskingum- Cunge method of channel routing (Chow, et al. 1988; Maidment 1993; Ponce 1989). The storage-indication method (NRCS NEH Part 630, Chapter 17) is used to route structure hydrographs.

A number of example design scenarios with data input and output data files are included with the program to assist the new user get started.