United States
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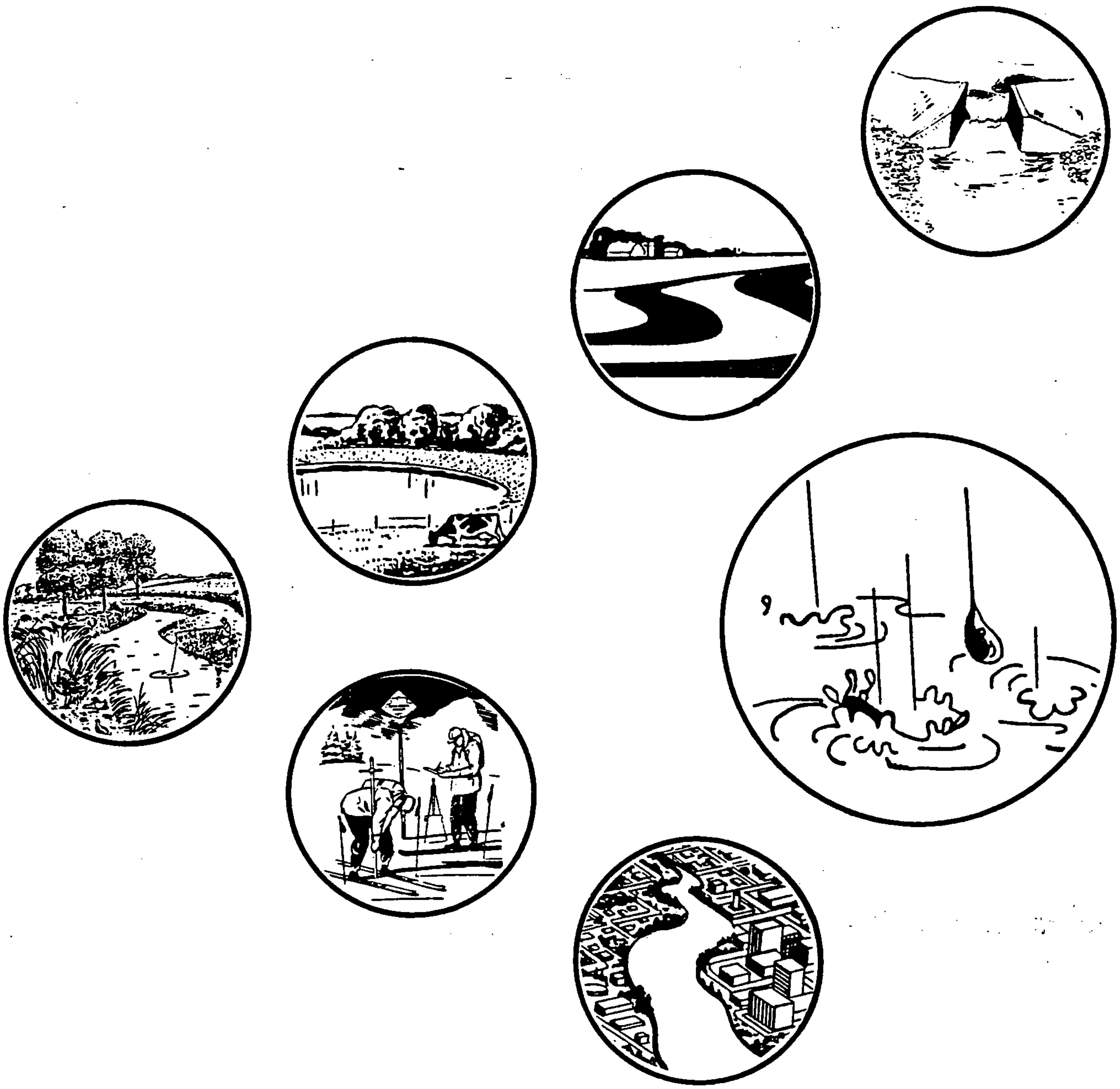
Agriculture

**Soil
Conservation
Service**

Portland,
Oregon

Oregon Engineering Handbook

Hydrology Guide



O R E G O N   H Y D R O L O G Y   G U I D E

FOREWORD

The Engineering Field Manual, Chapter 2, Estimating Runoff, presents a simplified method for determining storm runoff volume and peak rate of discharge. However, the method presented in this EFM chapter applies to watersheds with less than 2,000 acres. A simplified method for hydrology determination for watersheds over 2,000 acres did not exist until the June 1986 revision of Technical Release No. 55, Urban Hydrology for Small Watersheds, was issued. Although the title of TR-55 implies that it is primarily for urban hydrology, in actuality it applies to any watershed (urban and non-urban) within the limitations stated in the TR.

The purpose of the Oregon Hydrology Guide is to assist in applying the simplified hydrology procedures of TR-55 for developing peak flow and hydrograph estimates in Oregon. The guide accomplishes this by:

1. Providing instructions beyond those given in TR-55. This is done with detailed explanation, step-by-step procedures, and example solution. As mentioned in TR-55, the time of concentration (Tc) is a critical parameter. For this reason, the guide gives considerable emphasis to the determination of Tc. Chapters in the guide correspond to the chapters of TR-55.

2. Enclosing additional maps and tables specific to Oregon. Also included is information specific to Oregon needed to use the TR-55 computer programs.

The Oregon Hydrology Guide is to be used in conjunction with TR-55. No attempt was made to duplicate data already available in TR-55. For this reason, the guide should be filed with TR-55.

The procedure for estimating runoff, in Chapter 2 of the EFM, may continue to be used for watersheds less than 2,000 acres. Chapter 2 of the EFM, TR-55, TR-20, and streamgage analyses are accepted procedures for obtaining peak flows in Oregon.

TABLE OF CONTENTS

CHAPTER 1

INTRODUCTION

Watershed and Sub-Area Drainage Areas

Delineation

The drainage area of the watershed to be studied is outlined using a USGS topographic map, aerial photographs, county drainage or road maps, or other available map. A field observation of the terrain may be helpful in this delineation.

Sub-Areas

One drainage outline is normally adequate for a watershed. Larger, or unique, watersheds may need to be divided into sub-areas. Watersheds which might need sub-division are: larger watersheds (over 2500 acres); watersheds with two or more major branches which are very different in watershed slope or shape; or watersheds which have a significant pond or swamp within the watershed.

The advantages of developing sub-areas are as follows: (1) results are more precise, (2) basic data is more easily developed, and (3) areas contributing most to the peak flow can be identified. Disadvantages of using sub-areas are as follows: (1) more data is required, (2) some required data may be difficult to obtain, (3) a hydrograph must be developed in addition to the peak flow, and (4) hydrographs may need to be routed to obtain a composite hydrograph.

Measurement

The watershed or sub-area(s) is measured to determine its acreage. A planimeter, a dot grid, computation by average dimensions, or an electronic measuring device may be used to measure area.

The method used to measure the sub-area, and when to use sub-areas, is dependent on the precision necessary for the study. Generally, the more precise the data collection, the more accurate the answers. Structures in urban areas may require more intensive data collection procedures than those in rural areas.

CHAPTER 2

ESTIMATING RUNOFF

Runoff Curve Number Procedure

The steps to determine the Runoff Curve Number (RCN) are (see Worksheet 2):

1. Identify the soil series found in the watershed area. Use published soil survey maps when available. If a soil map is not available, a soil scientist will need to determine the soil series.

2. Determine the Hydrologic Soil Group (HSG) from the list of soils in Appendix A of this guide, or from SCS Soils 5. Slope does not affect the HSG of a soil series. All soils of one HSG, regardless of slope, can be combined into one unit.

3. Determine the cover type, treatment, and hydrologic condition. Several combinations are listed on Table 2-2 of TR-55. Pick the combination which most closely fits the conditions in the watershed.

4. Read the applicable curve number for the cover description and HSG from Table 2-2 in TR-55.

5. If more than one soil or cover condition occurs in the watershed, determine the area in each combination of soil and cover. Area can be measured in either acres, square miles, or percent of the watershed.

6. Multiply the applicable curve number times the area.

7. Repeat Steps 1 through 6 for each soil-cover combination in the watershed.

8. Sum the areas and the products.

9. Compute the weighted curve number by the equation:

$$CN = \frac{\text{Total Product}}{\text{Total Area}}$$

10. Round off the curve number to the nearest whole number.

Examples

Example 2-1 - Runoff Curve Number

Develop RCN and Runoff for Watershed near Pendleton and 10-, 25-, 50-year frequency storms.

Sub-Area 1 Data:

Soil	Cover, Treatment	Acres
Walla Walla, B slope-	Fallow Bare soil	650
Walla Walla, C slope-	Fallow Bare soil	40
Walla Walla, B slope-	Fallow w/crop residue, poor	120
Anderly, C slope-	Fallow Bare soil	45
Walla Walla, B slope-	Wheat straight row, poor	650
Walla Walla, C slope-	Wheat straight row, poor	40
Walla Walla, B slope-	Wheat contour w/residue, poor	120
Anderly, C slope-	Wheat straight row, poor	45

Example 2-2 - Runoff Curve Number (RCN)

Develop RCN and Runoff for Sub-Area 2 of watershed near Pendleton for the 10-, 25-, and 50-year frequency storms.

Sub-Area 2 Data:

Soil	Cover, Treatment	Acres
Walla Walla	Road, gravel	7
Anderly	Road, gravel	1
Walla Walla	Fallow, bare soil	345
Anderly	Fallow, bare soil	30
Walla Walla	Fallow, crop residence, good	275
Walla Walla	Wheat, straight row, poor	344
Anderly	Wheat, straight row, poor	31
Walla Walla	Wheat, contour & terraced, good	275
Walla Walla	Range, sagebrush, fair	50
Hermiston	Range, sagebrush, fair	40

Worksheet 2: Runoff curve number and runoff

Project Example 2-1 By RSW Date 8-87

Location Uma. - Pendleton Checked IMU Date 8-87

Circle one: (Present) Developed

1. Runoff curve number (CN)

Soil name and hydrologic group (HG APP-A)	Cover description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio) (TR-55 Table 2-2)	CN [1/] Table 2-2	CN [1/] Fig. 2-3	CN [1/] Fig. 2-4	Area ☒ acres ☐ mi^2 ☐ %	Product of CN x area
B-HSG Walla Walla	Fallow, bare soil	86			690	59340
B-HSG	Fallow, crop residue cover cover, poor condition	85			120	10200
B-	Wheat, straight row, poor condition	76			690	52440
B-	Wheat, contour, crop residue, poor condition	73			120	8760
C- Anderly	Fallow, bare soil	91			45	4095
C-	Wheat, straight row, poor condition	84			45	3780
				Totals =	1710	138615

1/ Use only one CN source per line. (TR-55)

CN (weighted) = $\frac{\text{total product}}{\text{total area}} = \frac{138,600}{1710} =$ 81.05; Use CN = 81

2. Runoff

		Storm #1	Storm #2	Storm #3
Frequency	yr	10	25	50
Rainfall, P (24-hour) (HG APP-B)	in	1.3	1.5	1.6
Runoff, Q (Use P and CN with table 2-1, fig. 2-1, or eqs. 2-3 and 2-4.) (TR-55)	in	.23	.32	.38

Worksheet 2: Runoff curve number and runoff

Project Example 2-2 By RSW Date 8-87

Location Uma.-Pendleton Checked CUM Date 8-87

Circle one: (Present) Developed Sub-area 2

1. Runoff curve number (CN)

Soil name and hydrologic group (HG APP-A)	Cover description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio) (TR-55 Table 2-2)	CN [1/] Table 2-2	CN [1/] Fig. 2-3	CN [1/] Fig. 2-4	Area ☒ acres ☐ mi^2 ☐ %	Product of CN x area
Walla Walla-B	Road - gravel Fallow - bare soil	85 86			7 345	
Walla Walla-B	Fallow - crop residue, good	83			275	
Walla Walla-B	Wheat, straight row, poor	76			344	
Walla Walla-B	Wheat, contour & terrace, good	70			275	
Anderly-C	Fallow, bare soil Wheat, str. row, good	91 84			30 31	
Anderly-C	Road - gravel	89			1	
Walla Walla-B Hermiston-B	Range, sagebrush, fair	51			90	
				Totals =	1398	108497

1/ Use only one CN source per line. (TR-55)

CN (weighted) = $\frac{\text{total product}}{\text{total area}} = \frac{108500}{1398} = 77.61$; Use CN = 78

2. Runoff

		Storm #1	Storm #2	Storm #3
Frequency	yr	10	25	50
Rainfall, P (24-hour) (HG APP-B)	in	1.3	1.5	1.6
Runoff, Q (Use P and CN with table 2-1, fig. 2-1, or eqs. 2-3 and 2-4.) (TR-55)	in	.16	.24	.29

CHAPTER 3

TIME OF CONCENTRATION AND TRAVEL TIME

Intensity of Investigation Considerations

The intended use of the computed peak flows will determine the amount of effort that should be put into securing data for estimating time of concentration (Tc). A more detailed investigation is needed where it will be used for (a) detailed design, (b) complex/high hazard structures, (c) important planning decisions, or (d) economic justification. Less detail may be appropriate if it is to be used only for preliminary conclusions or where benefit-cost is not critical. A "minimum" detail would include measuring the travel distance from maps or aerial photographs and estimating average velocity from a general knowledge of the conditions in the area. The procedures in this chapter describe the steps needed to do a "high" detail investigation.

Variability of Tc and Effect Upon the Hydrograph

The time of concentration influences the shape and peak of the runoff hydrograph. Changes in the Tc, due to changes in either the conditions of the water course or the land use, can cause changes in the hydrograph shape and its peak. The Tc will vary with the time of year and the conditions in the watershed. A channel with a lush growth will have a slower velocity than the same channel with dried grasses or as a bare channel. The flow across a frozen or a saturated field would be faster than under dry conditions. Variations in conditions can result in actual changes in Tc of 15% or more and a similar difference in peak flow.

Time of concentration is normally developed considering average flow conditions for the time of year when a problem is likely to occur. Where most of the damaging storms happen in the winter, such as in Western Oregon, the Tc should be developed for dormant conditions. If the damaging storms are resulting from thunderstorms, then summer conditions should be considered. Occasionally, it may be best to develop two "times of concentration" values, one for the dormant season and one for the growing season. Developed peak flows would be compared to determine the desired value to use. This would also require developing two runoff curve number values.

Step Procedure

Step procedure for developing time of concentration is as follows. Worksheet 3 in TR-55 has been prepared to aid in developing the Time of Concentration.

1. Flow Path

   The first step in developing the Tc is to determine the flow path. This would normally be determined using a topographic map or an aerial photograph. Flow path is the path water would take as it flows from the headwaters of the watershed to the point of interest. For Tc, path needed is the one that takes the longest travel time--usually the longest travel distance. Occasionally, it is not obvious whether a longer, moderately sloped path or a shorter, flat one would be the proper Tc path. When this is the case, both paths may need to be evaluated.

2. Reaches or Segments

Using the topographic map or aerial photograph, divide the flow path into reaches or segments, each with approximately a constant slope. Usually, reach breaks are also made where a channel starts and where intermittent flow becomes perennial. Reach breaks may be needed where there are major changes in channel roughness (n-value). A field examination will determine if changes in n-value are significant.

The number of reaches picked would also be related to the considerations for the detail discussed above. Three to five reaches normally would be adequate to define a small watershed. If more are needed, dividing the watershed into two areas should be considered.

Each segment is identified as a sheet flow, shallow concentrated flow, or open channel flow segment. The three groups are described in Chapter 3 of TR-55.

3. Segment Slope

When the reaches have been identified, the length (L) of the flow path in each reach is measured. Scaling distance off the topographic maps or photographs is usually adequate. The change in elevation (Δh) from one end of the reach to the other is also determined from maps or by field observation. Average slope of the reach is computed using the change in elevation divided by the length through the reach.

$$s = \frac{\Delta h}{L}$$

4. Sheet Flow Segment

Sheet flow segment is described on page 3-3 of TR-55. Develop Travel time (Tt) for this segment using equation 3-3. Data needed are: land surface description, flow length, land slope, and 2-year, 24-hour rainfall. Rainfall is available from a map in Appendix B. The other data is known from previous steps.

5. Shallow Concentrated Flow Segments

The segment(s) between sheet flow and a defined channel are computed using shallow concentrated flow as described on page 3-3. The curve for unpaved surface (figure 3-1) would normally be the condition encountered.

6. Open Channel Segments

The travel time (Tt) for the remaining reaches would be developed using channel hydraulics, normally Manning's formula. This is discussed on pages 3-3 and 3-4 of TR-55.

Channel hydraulics are determined as follows:

a. Check measurement of channel length (L) for the reach. Natural streams may have several curves and meanders, as well as overfalls and eddies. Tendencies are, therefore, to underestimate the length of channels and overestimate average slope through reaches.

b. Verify the vertical fall (h) through the reach. This can be taken from a topo map if one is available; otherwise, an approximate measure in the field is needed. Any overfalls should be subtracted from the total vertical drop since they would indicate a greater slope and, therefore, a greater velocity than actually occurs.

c. Recalculate the slope, as in step 3 above, if length or vertical fall have been revised.

$$s = \frac{\Delta h}{L}$$

d. Estimate the average n-value for the channel in the segment considering the vegetative conditions at the time a flood might occur. In the western portions of Oregon, most of the storms occur in November or December. Other locations may be affected by winter frozen soil conditions or by summer thunderstorms. The n-value to use may be picked from Table 3-2 following. The "Guide for Selecting Roughness coefficient 'n' Values for Channels," by Guy B. Faskin, SCS, and "Roughness Characteristics of Natural Channels," USGS WSP-1849, are additional good references. If the actual conditions are not similar to any on the table or more precision is desired, NEH-5 Hydraulics Supplement B has a procedure to develop a computed n-value.

e. Determine approximate trapezoidal channel dimensions for the reach. This is an average typical of the reach being computed. Measure or estimate the average bottom width (bw), depth (d), and top width (tw) of the channel for the reach being considered.

f. Calculate the flow area of the channel.

$$A = (d)\ \frac{(bw+tw)}{2}$$

g. Calculate the wetted perimeter (wp) and hydraulic radius (r).

$$wp = 2\left[\left(\frac{tw-bw}{2}\right)^2+d^2\right]^{\frac{1}{2}} + bw$$

$$r = \frac{A}{wp}$$

h. Determine the travel velocity (v) using Manning's formula.

$$v = \left(\frac{1.49}{n}\right)(r)^{0.67}(s)^{0.5} \qquad \text{[Eq 3-4]}$$

Table 3-2 Values of Roughness Coefficient "n"
Open Channels

Type of Channel and Description	Minimum	Maximum
Lined Channels		
Concrete	0.011	0.020
Riprap	0.020	0.035
Vegetative	0.030	0.040
Excavated		
Earth, straight to winding	0.020	0.040
Earth bottom and rubble sides	0.028	0.035
Stony bottom and weeds on banks	0.025	0.040
Stony, smooth to jagged	0.025	0.045
Unmaintained	0.050	0.140
Natural Channels (minor streams, top width <100 ft.)		
Clean, straight banks, few pools, weeds or stones	0.025	0.040
Winding, some pools, weeds and stones	0.033	0.055
Winding, stony sections, some weeds	0.045	0.060
Sluggish reaches, weedy, deep pools	0.050	0.150
Flood Plains		
Pasture	0.025	0.050
Cultivated	0.020	0.045
Brush		
Scattered brush, thick weed growth	0.035	0.070
Light brush and small trees	0.035	0.080
Medium to dense brush	0.045	0.160
Trees		
Dense willows, full vegetation	0.110	0.200
Cleared land, tree stumps, sprouts	0.030	0.080
Heavy growth of timber, few down, little undergrowth	0.080	0.120

Adapted from "Modern Sewer Design," 1980, American Iron and Steel Institute
Brater & King "Handbook of Hydraulics" 6th Edition, 1970
SCS NEH-5 Hydraulics

i. Determine travel time for segment in hours.

$$Tt = \frac{L}{(3600v)} \qquad \text{[Eq 3-1]}$$

7. Summation of Segments:

Determine time of concentration for entire sub-area by adding travel times of the segments including sheet flow and shallow concentrated flow and channel flow portions.

Field Observations

Much of the data needed to determine the time of concentration may require collection of information in the field. General observations are made in the field of conditions such as the soil-types, land cover and slopes, materials and vegetation in the channel, and the apparent degree of stability of the channel. Indications of debris flows as evidenced by deposition next to the channel and the size of deposited materials, may also be significant.

Other information obtained in the field includes: the shape and size of the channel (tw,bw,d), the average Manning's roughness coefficient (n-value), and a check of the channel slope using a hand level or a transit. These field data will be needed for all segments in each sub-area.

Office Data Collection and Computations

Many of the steps in determining Tc can be done in the office. Higher efficiency can be obtained by doing the map measurement and analysis in the office before going to the field. Computation and tabulation of travel times to develop time of concentration are office operations which normally will follow field data collection. Use worksheet 3 to tabulate and document time of concentration data. Tc sub-routine in the TR-55 computer program can aid in developing the data. A HP-41C program is also available which does the mathematics involved in worksheet 3. Cards and program description are available from the State Office.

Examples

Example 3-1   Time of Concentration

Compute Tc for sub-area 1 of watershed near Pendleton.

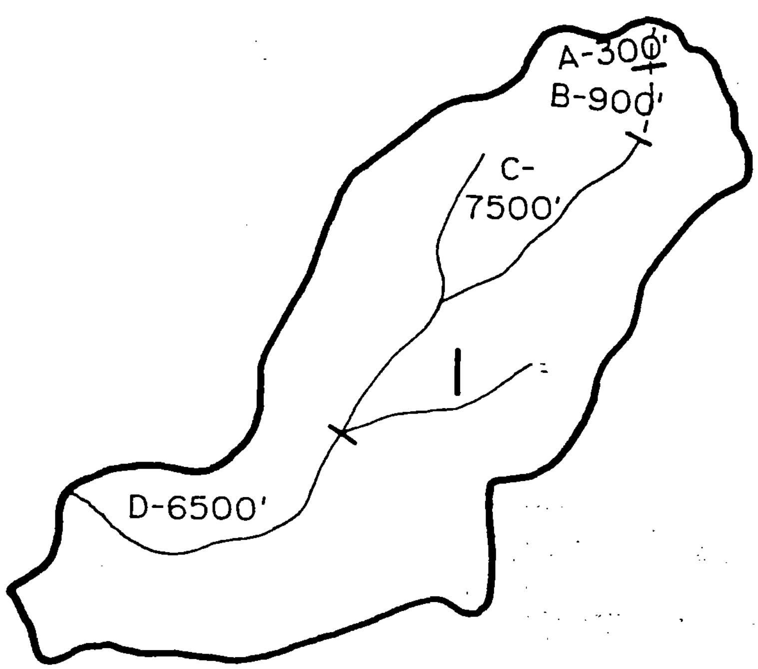
Sub-area 1 Data:

Segment A - Sheet flow on cultivated soil with residue cover >20%. Length is 300 feet with 10-foot difference in elevation.

Segment B - Shallow concentrated flow in cultivated field. Length is 900 feet, elevation change is 35 feet.

Segment C - Channel flow in vegetative draw (tall grasses) with average dimensions: d=1.0, bw=2.0, and tw=10.0.

Segment D - Channel flow in winding natural channel with some weeds and stones. Average channel dimensions are: d=4.0, bw=4.0, tw=10.0.



Project Example 3-1 By RSW Date 8-87

Location Uma. - Pendleton Checked IMU Date 8-87

Circle one: (Present) Developed — Sub-area 1

Circle one: (T_c) T_t through subarea

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)

		Unit	Segment ID A		
1.	Surface description (table 3-1) (TR-55)		cult. >20%		
2.	Manning's roughness coeff., n (table 3-1)		0.17		
3.	Flow length, L (total L ≤ 300 ft)	ft	300		
4.	Two-yr 24-hr rainfall, P_2	in	1.0		
5.	Land slope, s (10/300)	ft/ft	.033		
6.	$T_t = \frac{0.007\,(nL)^{0.8}}{P_2^{0.5}\, s^{0.4}}$ Compute T_t	hr	0.64	+	= 0.64

Shallow concentrated flow

		Unit	Segment ID B		
7.	Surface description (paved or (unpaved))		unp.		
8.	Flow length, L	ft	900		
9.	Watercourse slope, s (35/900)	ft/ft	.039		
10.	Average velocity, V (figure 3-1) (TR-55)	ft/s	3.18		
11.	$T_t = \frac{L}{3600\,V}$ Compute T_t	hr	0.08	+	= 0.08

Channel flow

		Unit	Segment ID C	D	
12.	Cross sectional flow area, a	ft^2	6.0	28.0	
13.	Wetted perimeter, p_w	ft	10.2	14.0	
14.	Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft	.59	2.0	
15.	Channel slope, s	ft/ft	.010	.006	
16.	Manning's roughness coeff., n (HG Table 3-2)		.040	.045	
17.	$V = \frac{1.49\, r^{2/3}\, s^{1/2}}{n}$ Compute V	ft/s	2.62	4.07	
18.	Flow length, L	ft	7500	6500	
19.	$T_t = \frac{L}{3600\,V}$ Compute T_t	hr	0.80	+ 0.44	= 1.24
20.	Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19)	hr			1.96

Example 3-2, Travel Time and Time of Concentration

Compute Tc and Tt for watershed near Pendleton, Sub-area 2

Sub-area 2 data:

Travel time -

Sub-area is downstream of sub-area 1 (see sketch). Main channel flows through the sub-area with average dimensions: d=4 feet, bw=5.0 feet, tw=12 feet. Channel is winding with stony sections and some weeds, generally in good condition. Flow distance is 9000 (7000 + 2000) feet with a 60-foot change in elevation.

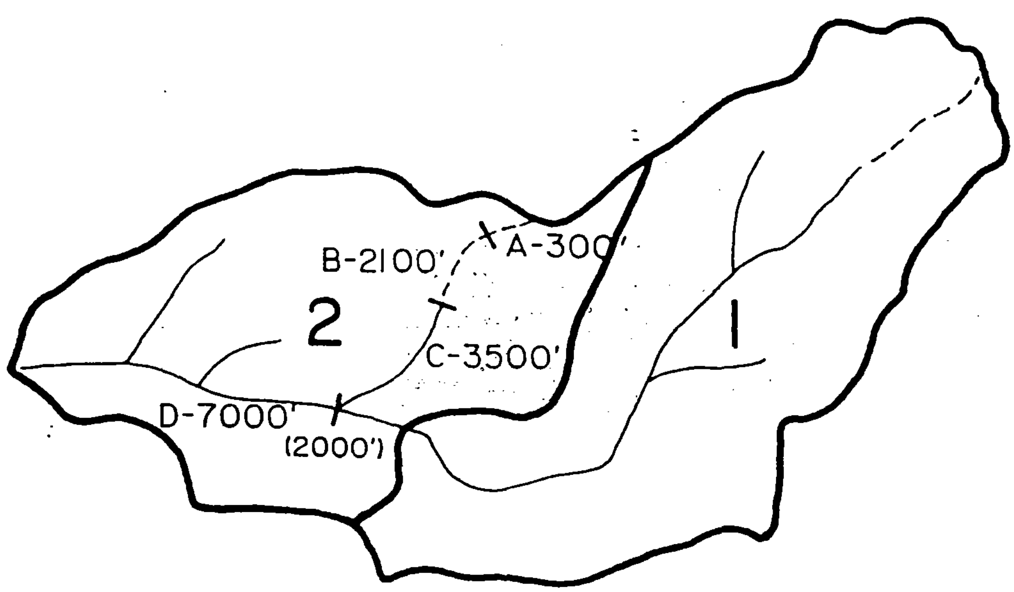
Time of Concentration -

Segment A - Flow over cultivated field with high residue. Length = 300 feet, Elevation Change = 44 feet.

Segment B - Shallow concentrated flow in crop field. Length = 2100 feet, Elevation Change = 44 feet.

Segment C - Channel flow through draw in scattered brush, heavy weeds. Average dimensions are: d=0.6 feet, bw=2.0 feet, tw=6.8 feet. Segment length=3500 feet and Elevation Change=70 feet.

Segment D - Flow in main channel described above with average dimensions: d=4 feet, bw=5.0 feet, tw=12 feet. Length=7000 feet.



Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project Example 3-2 By RSW Date 8-87

Location Uma.-Pendleton Checked IMU Date 8-87

Circle one: Present Developed — Sub-area 2

Circle one: T_c (T_t circled) through subarea — For travel time

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)

		Segment ID			
1. Surface description (table 3-1) (TR-55)					
2. Manning's roughness coeff., n (table 3-1)					
3. Flow length, L (total L ≤ 300 ft)	ft				
4. Two-yr 24-hr rainfall, P_2	in				
5. Land slope, s	ft/ft				
6. $T_t = \frac{0.007\ (nL)^{0.8}}{P_2^{0.5}\ s^{0.4}}$ Compute T_t	hr		+		=

Shallow concentrated flow

		Segment ID --			
7. Surface description (paved or unpaved)					
8. Flow length, L	ft				
9. Watercourse slope, s	ft/ft				
10. Average velocity, V (figure 3-1) (TR-55)	ft/s				
11. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+		=

Channel flow

		Segment ID --			
12. Cross sectional flow area, a	ft^2	34.0			
13. Wetted perimeter, p_w	ft	15.6			
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft	2.18			
15. Channel slope, s	ft/ft	.007			
16. Manning's roughness coeff., n (HG Table 3-2)		.045			
17. $V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n}$ Compute V	ft/s	4.66			
18. Flow length, L	ft	9000			
19. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr	0.54	+	--	= .54

20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) .... hr .54

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project: Example 3-2 By: RSW Date: 8-87

Location: Uma.-Pendleton Checked: ICU Date: 8-87

Circle one: (Present) Developed — Sub-area 2

Circle one: (T_c) T_t through subarea — for time of concentration

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)

	Unit	Segment ID A		Total
1. Surface description (table 3-1) (TR-55)		cult.-high res.		
2. Manning's roughness coeff., n (table 3-1)		0.17		
3. Flow length, L (total L ≤ 300 ft)	ft	300		
4. Two-yr 24-hr rainfall, P_2	in	1.0		
5. Land slope, s (6/300)	ft/ft	.020		
6. $T_t = \frac{0.007\,(nL)^{0.8}}{P_2^{0.5}\,s^{0.4}}$ Compute T_t	hr	0.78	+	= .78

Shallow concentrated flow

	Unit	Segment ID B		Total
7. Surface description (paved or unpaved)		unpave		
8. Flow length, L	ft	2100		
9. Watercourse slope, s (44/2100)	ft/ft	.021		
10. Average velocity, V (figure 3-1) (TR-55)	ft/s	2.3		
11. $T_t = \frac{L}{3600\,V}$ Compute T_t	hr	0.25	+	= .25

Channel flow

	Unit	Segment ID C	D	Total
12. Cross sectional flow area, a	ft^2	2.64		see travel time comp's
13. Wetted perimeter, p_w	ft	6.95		
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft	.38		
15. Channel slope, s (70/3500)	ft/ft	.020		
16. Manning's roughness coeff., n (HG Table 3-2)		.045		
17. $V = \frac{1.49\,r^{2/3}\,s^{1/2}}{n}$ Compute V	ft/s	2.46	4.66	
18. Flow length, L	ft	3500	7000	
19. $T_t = \frac{L}{3600\,V}$ Compute T_t	hr	0.40	+ 0.42	= .82

20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) .... hr **1.85**

CHAPTER 4

GRAPHICAL PEAK DISCHARGE METHOD

The Graphical Peak Discharge procedure is described in TR-55 Chapter 4. Follow the steps in worksheet 4 to obtain peak.

Examples

Example 4-1 Graphical Peak Discharge

Compute peak discharge for sub-area 1 of watershed near Pendleton for the 10-, 25-, and 50-year storms using Graphical procedure. Use data from Examples 2-1 and 3-1.

Worksheet 4: Graphical Peak Discharge method

Project: Example 4-1 By: RSW Date: 8-87

Location: Uma.-Pendleton Checked: ICU Date: 8-87

Circle one: (Present) Developed Sub-area 1

1. Data:

   Drainage area .... A_m = 2.67 mi^2 (acres/640)

   Runoff curve number .... CN = 81 (From worksheet 2)

   Time of concentration .. T_c = 1.96 hr (From worksheet 3)

   Rainfall distribution type = II (I, IA, II, III) (HG APP-B)

   Pond and swamp areas spread throughout watershed ...... = --- percent of A_m (____ acres or mi^2 covered)

		Storm #1	Storm #2	Storm #3
2. Frequency	yr	10	25	50
3. Rainfall, P (24-hour)	in	1.3	1.5	1.6
4. Initial abstraction, I_a .... (Use CN with table 4-1.) (TR-55)	in	0.469	.469	.469
5. Compute I_a/P		0.36	0.31	0.29
6. Unit peak discharge, q_u .... (Use T_c and I_a/P with exhibit 4-____) (TR-55)	csm/in	167	184	190
7. Runoff, Q .... (From worksheet 2).	in	.23	.32	.38
8. Pond and swamp adjustment factor, F_p .... (Use percent pond and swamp area with table 4-2. Factor is 1.0 for zero percent pond and swamp area.) (TR-55)		1.0	1.0	1.0
9. Peak discharge, q_p .... (Where $q_p = q_u A_m Q F_p$)	cfs	103	157	193

CHAPTER 5

TABULAR HYDROGRAPH METHOD

The Tabular Peak Hydrograph procedure is described in Chapter 5 of TR-55. Follow the Steps on Worksheet 5a and 5b to develop peak hydrographs.

Examples

Example 5-1 Tabular Peak Hydrograph

Compute the 25-year peak discharge at the downstream end of sub-area 2 of the watershed near Pendleton. Sub-area 2 data: DA = 1400 acres, RCN = 78. Use also data developed in Examples 2-1, 2-2, 3-1, and 3-2.

Solution:

Enter on worksheet 5a the drainage area (sq. mi.) time of concentration (Tc) and travel time (Tt). Times are obtained from worksheet 3. List the names of downstream subareas for each sub-area. For this example, the flow from sub-area 1 flows through sub-area 2; therefore, travel time summation to outlet is 0.54 hr. The rainfall, curve number, and runoff area read from worksheet 2. Multiply the area by the runoff to get AmQ. Initial abstraction is read directly from table 5-1 using the curve number, and Ia/P is calculated.

Next, determine for worksheet 5b the rounded values of Tc, Tt, and Ia/P to use in the hydrograph tables. In this example, a Tc of 2.0, an Ia/p of .30, and a Tt of .50 are the closest tabulated values to the computed figures. Identify the rainfall distribution for the area from the state map in appendix B. Pendleton is in a type II storm distribution area; therefore, exhibit 5-II, Tabular Hydrograph, will be applicable. Select the hydrograph times which need to be tabulated to cover the peak of each hydrograph. Using the proper combination of Tc, Ia/P, and Tt, identify the peak time for each sub-area. Sub-area 1 has a peak time of 14.0 hours, and sub-area 2 peaks at 13.6 hours. Hydrograph times of 13.0 through 14.6 were selected in this example to determine the shape of the hydrograph peak. For each time, read the unit discharge and multiply it by AmQ. For example, Sub-area 1, 13.0 hour, 37 times 0.83 equals 31 cfs; and for Sub-area 2, 13.6 hour, 185 times 0.50 equals 92 cfs.

Once all hydrographs are tabulated, sum the values for each time to get a composite hydrograph; i.e., at time 14.0, 142 plus 80 equals 222 cfs.

Worksheet 5a: Basic watershed data

Project Example 5-1 Location Uma.-Pendleton By RSW Date 8-87

Circle one: (Present) Developed Sub-Areas 1&2 Frequency (yr) 25 Checked ____ Date ____

Subarea name	Drainage area A_m (mi^2)	Time of concentration T_c (hr)	Travel time through subarea T_t (hr)	Downstream subarea names	Travel time summation to outlet ΣT_t (hr)	24-hr Rainfall P (in)	Runoff curve number CN	Runoff Q (in)	$A_m Q$ (mi^2-in)	Initial abstraction I_a (in)	I_a/P
1	2.67	1.96	--	2	0.54	1.5	81	.32	0.83	.469	.31
2	2.19	1.85	0.54	--	--	1.5	78	.23	0.50	.564	.38

↑ From worksheet 3 (Time of concentration, Travel time through subarea)

↑ From worksheet 2 (Runoff curve number, Runoff)

↑ From table 5-1 (TR-55) (Initial abstraction)

Worksheet 5b: Tabular hydrograph discharge summary

Project **Example 5-1** Location **Uma.-Pendleton** By **RSW** Date **8-87**

Circle one: (Present) Developed **Sub-Areas 1&2** Frequency (yr) **25** Checked ____ Date ____

Subarea name	Basic watershed data used 1/: Sub-area T_c (hr)	ΣT_t to outlet (hr)	I_a/P	A_mQ (mi^2-in)	Select and enter hydrograph times in hours from exhibit 5-II 2/	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6			
					Discharges at selected hydrograph times 3/ (cfs)											
1	2.0	0.50	.30	0.83		31	56	86	113	133	142	137	120			
2	2.0	--	.30	0.50		58	74	84	92	85	80	66	55			
Composite hydrograph at outlet						89	130	170	205	218	222	203	175			

1/ Worksheet 5a. Rounded as needed for use with exhibit 5. (TR-55)
2/ Enter rainfall distribution type used. (HG APP-B)
3/ Hydrograph discharge for selected times is A_mQ multiplied by tabular discharge from appropriate exhibit 5. (TR-55)

Appendix A

Hydrologic Soil Groups of the soil series used in Oregon. Use in place of Exhibit A-1 in TR-55.

HYDROLOGIC GROUPS OF THE SOIL SERIES USED IN OREGON

Soil Series	Group
ABEGG	B
ABERT	B
ABIQUA	B
ABIQUA, FLOODED	C
ACANOD	C
ACKER	B
ADKINS	B
ADKINS, ALKALI	C
ADKINS, WET	C
AGATE	D
AGENCY	C
AHTANUM	D
A'BEE	C
ALCOT	A
ALDING	D
ALGOMA	B/D
ALICEL	B
ALOHA	C
ALPHA	B
ALS	A
ALSEA	B
ALSPAUGH	C
ALSTONY	B
ALTHOUSE	B
ALVODEST	D
AMITY	D
AMMON	B
ANATONE	D
ANAWALT	D
ANDERLY	C
ANDERS	C
ANGELPEAK	B
ANUNDE	B
APPLEGATE	C
APT	B
ARDNAS	B
ARRITOLA	D
ARRON	D
ASCAR	C
ASCHOFF	B
ASTORIA	B
ATERON	D
ATHENA	B
ATRING	B
AUSMUS	D
AVERLANDE	D
AWBRIG	D
AYRES	D
BACONA	B
BAKEOVEN	D
BAKER	C
BALD	C
BALDER	D
BALDOCK	D
BALDRIDGE	B
BALM	D
BANDON	C
BANNING	C
BARCAVE	B
BARHISKEY	A
BARKLEY	C
BARLOW	B
BARNARD	C
BARRON	B
BASHAW	D
BATEMAN	B
BAYSIDE	D
BEDEN	D
BEDNER	C
BEEKMAN	C
BEIRMAN	D
BELLPINE	C
BENHAM	C
BENSLEY	B
BENTILLA	C
BERGSVIK	D
BISBER	D
BIGELOW	B
BILGER	D
BINGLE	B
BINS	B
BLACHLY	B
BLACKLOCK	D
BLALOCK	D
BLAYDEN	D
BLUEJOINT	B
BLY	B
BOARDTREE	C
BOCKER	D
BODELL	D
BOGUS	C
BOHANNON	C
BOILER	C
BONDRANCH	D
BONNICK	A
BOOMER	B
BOOTH	C
BORAVALL	D
BORGES	D
BORNSTEDT	C
BOROBEY	C
BOSLAND	C
BOULDER LAKE	D
BOULDROCK	B
BOWLUS	B
BOYCE	D
BOZE	B
BRACE	C
BRADER	D
BRALLIER	D
BRAND	D
BRANNAN	B
BRAUN	C
BRENNER	D
BRICKEL	C
BRIDGECREEK	C
BRIEDWELL	B
BRIGHTWOOD	B
BROCK	D
BROCKMAN	C
BROGAN	B
BROWNLEE	B
BROWNSCOMBE	C
BRUNCAN	D
BUCKCREEK	C
BUCKEYE	C
BUCKSHOT	B
BULL RUN	B
BULL RUN, HARDPAN SUBSTRATUM	C
BULLARDS	B
BULLY	B
BURBANK	A
BURKE	C
BURLINGTON	A
BURNTRIVER	B
BUTTON	D
BYBEE	D
CALABAR	D
CALDER	D
CALDERWOOD	D
CALIMUS	B
CALOUSE	B
CALZACORTA	D
CAMAS	A
CAMPCREEK	C
CANDERLY	B
CANEST	D
CANTALA	B
CAPONA	C
CARIS	C
CARLTON	C
CARNEY	D
CARRYBACK	C
CASCADE	C
CASSIDAY	C
CATERL	B
CATHERINE	C
CATLOW	B
CAZADERO	C
CENCOVE	B
CENTRAL POINT	B
CHAMATE	B
CHAMBEAM	B
CHAPMAN	B
CHEHALEM	C
CHEHALIS	B
CHEHULPUM	D
CHENOWETH	B
CHERRYHILL	B
CHESNIMNUS	B
CHETCO	D
CHEVAL	C
CHILCOTT	D
CHILCOTT, BEDROCK SUBSTRATUM	C
CHILOQUIN	D
CHINCHALLO	D
CHISMORE	D
CHITWOOD	D
CHOCK	D
CHOPTIE	D
CIRCLEBAR	C
CLACKAMAS	D
CLAMP	D
CLATSOP	D
CLAWSON	C
CLIMAX	D
CLOQUATO	B
COBURG	C
COKER	D
COLEMAN	C
COLESTINE	C
COLLIER	A
CONCORD	D
CONDON	C
CONLEY	C
CONSER	D
COPSEY	D
COQUILLE	D
CORNELIUS	C
CORNUTT	C
COTTRELL	C
COUGHANOUR	C
COURT	B
COURTNEY	D
COURTROCK	B
COUSE	C
COVE	D
COWSLY	C
COYATA	C
CRABTREE	C
CRACKERCREEK	B
CRACKLER	B
CRANNLER	B
CRATER LAKE	B
CRIMS	D
CROFLAND	D
CROOKED	D
CROQUIB	D
CROWCAMP	D
CRUISER	B
CRUME	B
CRUMP	D
CRUMP, DRAINED	C
CRUTCH	C
CULBERTSON	B
CULTUS	B
CUMLEY	C
CUPOLA	B
CUPPER	B
CURANT	B
CURTIN	D
CURTIS CREEK	D
DABNEY	A
DAMEWOOD	C
DAMON	D
DARBY	C
DARKCANYON	C
DAROW	C
DAVEY	B
DAVEY, SANDY SUBSTRATUM	A
DAXTY	C
DAY	D
DAYTON	D
DAYVILLE	C
DEATMAN	C
DEBENGER	C
DECANTEL	D
DEE	C
DEFENBAUGH	B
DEGARMO	D
DEGNER	B
DEHLINGER	B
DELENA	D
DEMENT	B
DEPOE	D
DEPPY	D
DERALLO	B
DERR	C
DERRINGER	C
DESCHUTES	C
DESKAMP	C
DESOLATION	B
DESTER	C
DETER	C
DICKERSON	D
DIGGER	C
DILANSON	D
DILMAN	C
DINZER	B
DISABEL	C
DIVERS	B
DIXON	B
DIXONVILLE	C
DOBBINS	C
DODES	B
DOGTOWN	B
DONICA	A
DONICA, LOAMY SURFACE	B
DONNING	D
DONNYBROOK	D
DOWDE	B
DOYN	D
DREWS	B
DROVAL	C
DUART	C
DUBAKELLA	C
DUFF	B
DUFUR	B
DULANDY	C
DUMONT	B
DUPEE	C
DURKEE	C
EAD	C
EAGLECAP	B
EASTWELL	D
ECOLA	C
EDENBOWER	D
EDSON	C
EIGHTLAR	D
EILERTSEN	B
ELLISFORDE	B
ELLUM	C
ELMORE	B
ELSIE	B
EMBAL	B
EMILY	B
ENCINA	B
ENDERSBY	B
ENDICOTT	C
ENKO	C
ENOLA	B
EPHRATA	B
ERA	B
ESPIL	D
ESQUATZEL	B
ETELKA	C
EVANS	B
FALOMA	D
FANTZ	C
FARMELL	B
FARMELL, CLAYEY SUBSTRATUM	D
FARVA	C
FELCHER	B
FELTHAM	B
FENDALL	C
FERNHAVEN	B
FERNWOOD	B
FERRELO	B
FERTALINE	D
FISHFIN	D
FIVEBIT	D
FIVES	B
FLAGSTAFF	D
FLANE	C
FLOKE	D
FOEHLIN	B
FOPIANO	D
FORDICE	B
FORDNEY	A
FORDNEY, WET	C
FORESTER	C
FORMADER	C
FORSEER	C
FORT ROCK	C
FRAILEY	B
FREEWATER	B
FREEZENER	B
FREN	B
FRITSLAND	B
FROHMAN	C
FUEGO	C
FURY	D
FURY, DRAINED	C
GACEY	D
GAPCOT	D
GARBUTT	B
GARDINER	A
GARDONE	A
GAULDY	B
GEARHART	A
GEISEL	B
GEM	C
GEM, STONY	D
GEPPERT	C
GILISPIE	D
GINGER	D
GINSER	C
GLASGOW	C
GLENEDEN	D
GLOHM	C

NOTES: TWO HYDROLOGIC SOIL GROUPS SUCH AS B/C INDICATES THE DRAINED/UNDRAINED SITUATION.
MODIFIERS SHOWN, E.G., BEDROCK SUBSTRATUM, REFER TO A SPECIFIC SOIL SERIES PHASE FOUND IN SOIL MAP LEGEND.

GOBLE	C	HORES	C	KUHL	D	MCCANN	B	NETARTS	B
GOODLOW	B	HORES, GRAVELLY	B	KWEO	A	MCCOIN	D	NEVADOR	B
GOODRICH	B	SUBSTRATUM		LA GRANDE	C	MCCONNEL	B	NEVTAH	C
GOODWIN	B	HORNING	B	LABISH	D	MCCONNEL, FLOODED	A	NEWANNA	C
GOOLAWAY	C	HOSLEY	D	LABUCK	B	MCCULLY	C	NEWBERG	B
GOOSE LAKE	D	HOT LAKE	C	LADD	B	MCCURDY	C	NEWLANDS	B
GOSNEY	D	HOUSTAKE	C	LADERLY	C	MCDADE	C	NINEMILE	D
GRADON	C	HUBERLY	D	LADYCOMB	D	MCDUFF	C	NONPAREIL	D
GRANDE RONDE	D	HUDSPETH	C	LAIDLAW	C	MCEWEN	B	NORAD	B
GRASSVAL	D	HUFFLING	D	LAKEVIEW	C	MCGARR	C	NORTH POWDER	C
GRAVDEN	D	HUKILL	B	LAKI	B	MCGINNIS	C	NORTHRUP	C
GREENLEAF	B	HULLT	B	LAMBRING	B	MCKAY	C	NOTI	D
GREENSCOMBE	B	HUMMINGTON	C	LAMONTA	D	MCLOUGHLIN	B	NOTUS	C
GREGORY	D	HUNTROCK	B	LANGELLAIN	D	MCMEEN	C	NOUQUE	D
GPZLL	D	HURWAL	B	LANGLOIS	D	MCMILLE	B	NUSS	D
GRIBBLE	D	HUTCHINSON	C	LANGRELL	B	MCMULLIN	D	NYSSA	C
GRINDBROOK	C	HUTSON	B	LAPHAM	A	MCMURDIE	C	OAK GROVE	B
GUERIN	D	HYALL	C	LAPINE	A	MCNULL	C	OAKLAND	C
GURDANE	C	ICENE	D	LARMINE	D	MCNULTY	B	OATMAN	B
GUSTIN	D	ILLAHEE	B	LASTANCE	B	MEDA	B	OBRAY	D
GWIN	D	IMBLER	B	LATES	C	MEDCO	D	OCHOCO	C
GWIN, GRAVELLY	C	IMMIG	C	LATHER	D	MEDFORD	B	ODIN	C
GWINLY	D	INKLER	B	LATOURELL	B	MEHLHORN	C	OFFENBACHER	C
HACK	B	IRONDYKE	B	LAURELWOOD	B	MELBOURNE	B	OLAC	D
HACKWOOD	B	IRRIGON	C	LAWEN	B	MELBY	B	OLD CAMP	D
HAFLINGER	A	IZEE	C	LAYCOCK	B	MELD	C	OLEX	B
HAGER	D	JASON	D	LEGLER	B	MELLOWMOON	B	OLIPHANT	B
HALFWAY	D	JAYAR	C	LEMONEX	C	MEMALOOSE	C	OLOT	C
HALL RANCH	C	JEROME	D	LEMPIRA	B	MENBO	C	OLSON	D
HANKINS	C	JESSE CAMP	B	LERROW	C	MERLIN	D	OLYIC	B
HAPGOOD	B	JETT	B	LETHA	C	MERSHON	C	ONEONTA	B
HARANA	B	JIMBO	B	LETTIA	B	METOLIUS	B	ONTKO	D
HARDSCRABBLE	D	JOENEY	D	LICKSKILLET	D	MIKKALO	C	ONYX	B
HARLOW	D	JORY	B	LICKSKILLET,	C	MILBURY	C	OREANNA	B
HARRIMAN	B	JORY, STONY	C	GRAVELLY		MILCAN	C	ORENEVA	C
HARRIMAN, WET	C	JOSEPHINE	B	LINSLAW	D	MILLICOMA	C	ORFORD	B
HARRINGTON	C	JOSSET	C	LINT	B	MINAM	B	OTOOLE	C
HARSLOW	C	JUMPOFF	C	LITHGOW	C	MINNIECE	D	OTWIN	C
HART	D	JUNTURA	D	LITTLE POLE	D	MOAG	D	OUTERKIRK	B
HARTIG	B	KAHLER	B	LOBERT	B	MODKIN	C	OWYHEE	B
HATCHERY	C	KAMELA	C	LOCEY	C	MODOC	C	OXBOW	C
HAZELAIR	D	KANID	B	LOCODA	D	MOE	B	OXLEY	C
HEADLEY	B	KANUTCHAN	D	LOFFTUS	C	MOLALLA	B	OXWALL	D
HEBO	D	KAUPPI	B	LOGDELL	B	MONDOVI	B	OZAMIS	D
HEBO, LOAMY	C	KEATING	C	LOLAK	D	MONTLID	C	PACKARD	B
SUBSTRATUM		KEEL	C	LONELY	C	MOOLACK	A	PAIT	B
HECETA	D	KENNEWICK	B	LONERIDGE	C	MOREHOUSE	D	PALANUSH	C
HELMICK	D	KENUSKY	D	LOOKINGGLASS	C	MORFITT	B	PALOUSE	B
HELTER	B	KERBY	B	LOOKOUT	C	MORNINGSTAR	B	PANTHER	D
HELVETIA	C	KERRFIELD	D	LORELLA	D	MORROW	C	PARKDALE	B
HEMBRE	B	KETCHLY	B	LOSTBASIN	C	MOSIDA	B	PARMELE	C
HEMCROSS	B	KIESEL	C	LOSTINE	B	MOSIDA, CALCAREOUS	A	PATIO	C
HENLEY	C	KILCHIS	D	LOVLINE	C	MOUND	C	PAULINA	D
HENLINE	C	KILMERQUE	C	LOZA	D	MOYINA	D	PEARSOLL	D
HEPPSIE	D	KILOWAN	C	LUCE	C	MT. HOOD	B	PEAVINE	C
HERMISTON	B	KIMBERLY	B	LUCKIAMUTE	D	MUES	C	PEDIGO	C
HERSHAL	D	KINNEY	B	LURNICK	C	MULKEY	C	PEEL	C
HESSLAN	C	KINTON	C	MACKLYN	C	MULTNOMAH	B	PENGRA	C
HEZEL	B	KINZEL	B	MADELINE	D	MULTORPOR	A	PERDIN	C
HIBBARD	C	KIRK	D	MADRAS	C	MURNEN	B	PERNTY	D
HIGHCAMP	B	KIRKENDALL	C	MAKLAK	A	MURTIP	B	PERVINA	B
HIGHHORN	B	KLAMATH	D	MALABON	C	MUSTY	C	PHILOMATH	D
HILLSBORO	B	KLAWHOP	B	MALHEUR	C	NAGLE	B	PHOENIX	D
HISKEY	B	KLICKER	C	MALIN	C	NANSENE	B	PHYS	B
HOBIT	C	KLICKITAT	B	MANITA	C	NATAL	D	PIERSONTE	A
HOLCOMB	D	KLISTAN	B	MARACK	C	NATROY	D	PILCHUCK	C
HOLDERMAN	C	KLOOQUEH	B	MARCOLA	C	NECANICUM	B	PILCHUCK,	A
HOLLAND	B	KLOOTCHIE	B	MARSDEN	B	NEHALEM	B	PROTECTED	
HOLTLE	B	KNAPKE	B	MARTY	B	NEHALEM, FLOODED	C	PILOT ROCK	C
HOMESTAKE	C	KNAPPA	B	MASCAMP	D	NEKIA	C	PINEHURST	B
HONEYGROVE	B	KOEHLER	C	MASET	B	NEKOMA	B	PIT	D
HOOD	B	KOTZMAN	B	MAUPIN	C	NELSCOTT	C	PLUSH	B
HOODVIEW	B	KRACKLE	B	MAYGER	C	NEPALTO	A	POALL	C
HOOLY	C	KREBS	B	MCALPIN	C	NESKOWIN	C	PODEN	B
HOOPAL	D	KUBLI	D	MCBEE	C	NESTUCCA	D	POE	C

NOTES: TWO HYDROLOGIC SOIL GROUPS SUCH AS B/C INDICATES THE DRAINED/UNDRAINED SITUATION.
MODIFIERS SHOWN, E.G., BEDROCK SUBSTRATUM, REFER TO A SPECIFIC SOIL SERIES PHASE FOUND IN SOIL MAP LEGEND.

POKEGEMA	B	SAHALIE	B	SPRINGWATER	C	VENA	C	WOODCOCK	B
POLLARD	C	SALANDER	B	STAMPEDE	D	VENATOR	C	WOODSEYE	D
POLLY	B	SALEM	B	STANFIELD	C	VENETA	D	WRENTHAM	C
PONINA	D	SALISBURY	C	STARBUCK	D	VERBOORT	D	WRIGHTMAN	C
POTAMUS	B	SALISBURY, HIGH	D	STARKEY	C	VERGAS	C	WUKSI	A
POUJADE	D	ELEVATION		STATZ	D	VERMISA	D	WYEAST	D
POWDER	B	SALKUM	B	STAYTON	D	VERNONIA	B	WYETH	B
POWELL	C	SANTIAM	C	STEARNS	D	VIL	D	XANADU	B
POWLEY	D	SATURN	B	STEIGER	A	VILOT	C	YAINAX	B
POWWATKA	C	SAUM	B	STEIWER	C	VINING	C	YAKIMA	B
PRAG	C	SAUVIE	D	STICES	B	VIRTUE	C	YALLANI	B
PREACHER	B	SAUVIE, PROTECTED	B	STOCKEL	D	VOATS	B	YAMHILL	C
PRICE	B	SAWTELL	C	STOOKMOOR	C	VOLTAGE	B	YAMSAY	D
PRINEVILLE	C	SCAPONIA	B	STOVEPIPE	D	VONDERGREEN	C	YANCY	D
PRITCHARD	C	SCAREDMAN	B	STRAIGHT	C	VOORHIES	C	YAPOAH	B
PRONG	C	SCHAMP	C	STUKEL	D	WAGONTIRE	D	YAQUINA	D
PROSSER	C	SCHERRARD	D	STURGILL	D	WAHA	C	YAQUINA, DRAINED	C
PROVIG	C	SCHRIER	B	SUMPLEY	C	WAHKEENA	B	YARCO	D
PULS	D	SEARLES	C	SUTHERLIN	C	WANSTAL	D	YAWHEE	B
PYBURN	D	SEBASTIAN	D	SUVER	D	WAHTIGUP	B	YAWKEY	B
QUAFENO	C	SECRET CREEK	B	SVENSEN	B	WALDO	D	YELLOWSTONE	D
QUARTZVILLE	B	SEGUNDO	B	SWALER	D	WALDPORT	A	YONNA	D
QUARZ	C	SELMAC	D	SWALESILVER	D	WALLA WALLA	B	YOUTLKUE	D
QUATAMA	C	SEMIAHMOO	D	SWARTZ	D	WALLOWA	C	ZANGO	D
QUILLAMOOK	B	SERPENTANO	B	SYCAN	A	WALLUSKI	C	ZING	C
QUILLAYUTE	B	SEVENOAKS	A	TAHKENITCH	B	WALVAN	B	ZUMAN	D
QUINCY	A	SHANAHAN	B	TAKILMA	B	WAMIC	B	ZUMAN, PROTECTED	C/D
QUINTON	C	SHANO	B	TALAPUS	B	WANOGA	B	ZUMWALT	C
QUOSATANA	D	SHEFFLEIN	B	TALLOWBOX	C	WANSER	D	ZWAGG	C
RAFTON	D	SHERAR	C	TANDY	D	WAPATO	D	ZYGORE	B
RAIL	D	SHEVLIN	C	TATERPA	B	WAPINITIA	B	ZYZZUG	D
RAMO	C	SHIPPA	D	TATOUCHE	B	WARDBORO	A		
RANDCORE	D	SHIVIGNY	B	TAUNTON	C	WARDEN	B		
RASTUS	C	SHOAT	D	TEETERS	C	WARRENTON	D		
RATTO	C	SHUKASH	A	TELEMON	D	WATAMA	C		
RATTO, STONY	D	SIBANNAC	D	TEMPLETON	B	WATERBURY	D		
RAZ	D	SIFTON	B	TERRABELLA	D	WATO	B		
REALLIS	B	SILAS	B	TETHRICK	B	WAULD	C		
REAVIS	B	SILAS, GRAVELLY	C	THADER	C	WAUNA	D		
REDBELL	B	SUBSTRATUM		THATUNA	C	WAUNA, PROTECTED	C		
REDCLIFF	C	SILAS, WET	C	THISTLEBURN	B	WEBFOOT	C		
REDMOND	C	SILCOX	B	TIMBERLY	B	WEDDERBURN	B		
REDMOUNT	B	SILETZ	B	TISHAR	B	WELCH	D		
REEDSPORT	C	SILVERTON	C	TOLANY	B	WESTBUTTE	C		
REINECKE	B	SILVIES	D	TOLKE	B	WHETSTONE	C		
REMOTE	B	SIMAS	C	TOLO	B	WHITEHORSE	B		
RESTON	D	SINAMOX	B	TONOR	C	WHITESON	D		
RHEA	B	SINKER	C	TOP	C	WHITING	B		
RICCO	D	SISKIYOU	B	TOPPER	B	WHOBREY	C		
RICKREALL	D	SISLEY	B	TOURNQUIST	B	WICKIUP	C		
RIDLEY	C	SISTERS	A	TRASK	C	WILHOIT	B		
RINEARSON	B	SKEDADDLE	D	TREHARNE	C	WILKINS	D		
RITNER	C	SKELLOCK	B	TRUESDALE	C	WILLAKENZIE	C		
RITTER	B	SKINNER	B	TUB	C	WILLAMETTE	B		
RITZVILLE	B	SKIPANON	B	TULANA, DRAINED	B	WILLAMETTE, WET	C		
ROBINETTE	B	SKOOKUM	C	TULANA, NONFLOODED	C	WILLANCH	D		
ROBSON	D	SKOOKUMHOUSE	B	TUMALO	C	WILLIS	C		
ROCKFORD	B	SKULLGULCH	C	TUMTUM	D	WILLOWDALE	B		
ROCKLY	D	SKYLINE	D	TURBYFILL	B	WINBERRY	C		
ROGUE	B	SKYMOR	D	TUTNI	B	WINCHESTER	A		
ROLOFF	C	SLAYTON	D	TUTUILLA	C	WINCHUCK	C		
RONDOWA	B	SLICKROCK	B	TYGH	C	WIND RIVER	B		
ROSEBURG	B	SNAG	B	UKIAH	D	WINEMA	C		
ROSEHAVEN	B	SNAKER	D	UMAPINE	D	WINGVILLE	D		
ROUEN	C	SNELL	C	UMAPINE, DRAINED	C	WINLO	D		
ROYAL	B	SNELLBY	C	UMATILLA	B	WINOM	D		
ROYST	C	SNOW	B	UMIL	D	WINOPEE	B		
RUCH	B	SNOWLIN	B	UMPCOOS	D	WINTLEY	B		
RUCKLES	D	SOOSAP	C	UTLEY	B	WITHAM	D		
RUCLICK	C	SORF	C	VALBY	C	WITZEL	D		
RUDDLEY	D	SPANGENBURG	C	VALSETZ	C	WOLFER	B		
RUGG	B	SPANGENBURG,	D	VAN HORN	B	WOLLENT	D		
RUTAB	B	PONDED		VANNOY	C	WOLOT	B		
SAG	B	SPEAKER	C	VARCO	D	WOLVERINE	A		
SAGEHILL	B	SPOFFORD	D	VEAZIE	B	WOODBURN	C		

NOTES: TWO HYDROLOGIC SOIL GROUPS SUCH AS B/C INDICATES THE DRAINED/UNDRAINED SITUATION.
MODIFIERS SHOWN, E.G., BEDROCK SUBSTRATUM, REFER TO A SPECIFIC SOIL SERIES PHASE FOUND IN SOIL MAP LEGEND.

Appendix B - Synthetic Rainfall Distributions and Rainfall Data Sources

Synthetic Rainfall Distributions

Storm distribution types I, IA, and II are to be used in Oregon. The following map shows the areas where each distribution type applies. Generally, the area from the east slopes of the Cascade Mountains to the Pacific Ocean would use type IA distribution. Type I is used for most of the area east of the Cascades with Type II being used in specific areas of extreme eastern and northeastern Oregon.

Rainfall Data Sources

Precipitation records are collected and maintained by NOAA. Data is published monthly in Climatalogical Data (daily records) and Hourly Precipitation Data. These records are kept at the SCS State Office, at the WNTC-WSF, with the State Climatologist in Corvallis, and at many local libraries.

NOAA Atlas 2, Precipitation-Frequency Atlas of the Western United States, Volume X-Oregon, contains maps of the state with various storm durations and frequencies. The 24-hour storm duration maps have been reprinted and are included in this appendix.

NOAA Technical Report NWS 36, Water Available for Runoff ... for Selected Agricultural Regions in the Northwest United States, gives combined frequency of precipitation with water available from snowmelt for all or part of 11 counties in Northeast Oregon. Maps present Water Available for Runoff (WAR) for 1-, 5-, and 10-day durations and 2-, 10-, and 100-year frequencies. These may be used to supplement the precipitation maps. Copies of the NWS 36 report are available from the SCS Oregon State Conservation Engineer.

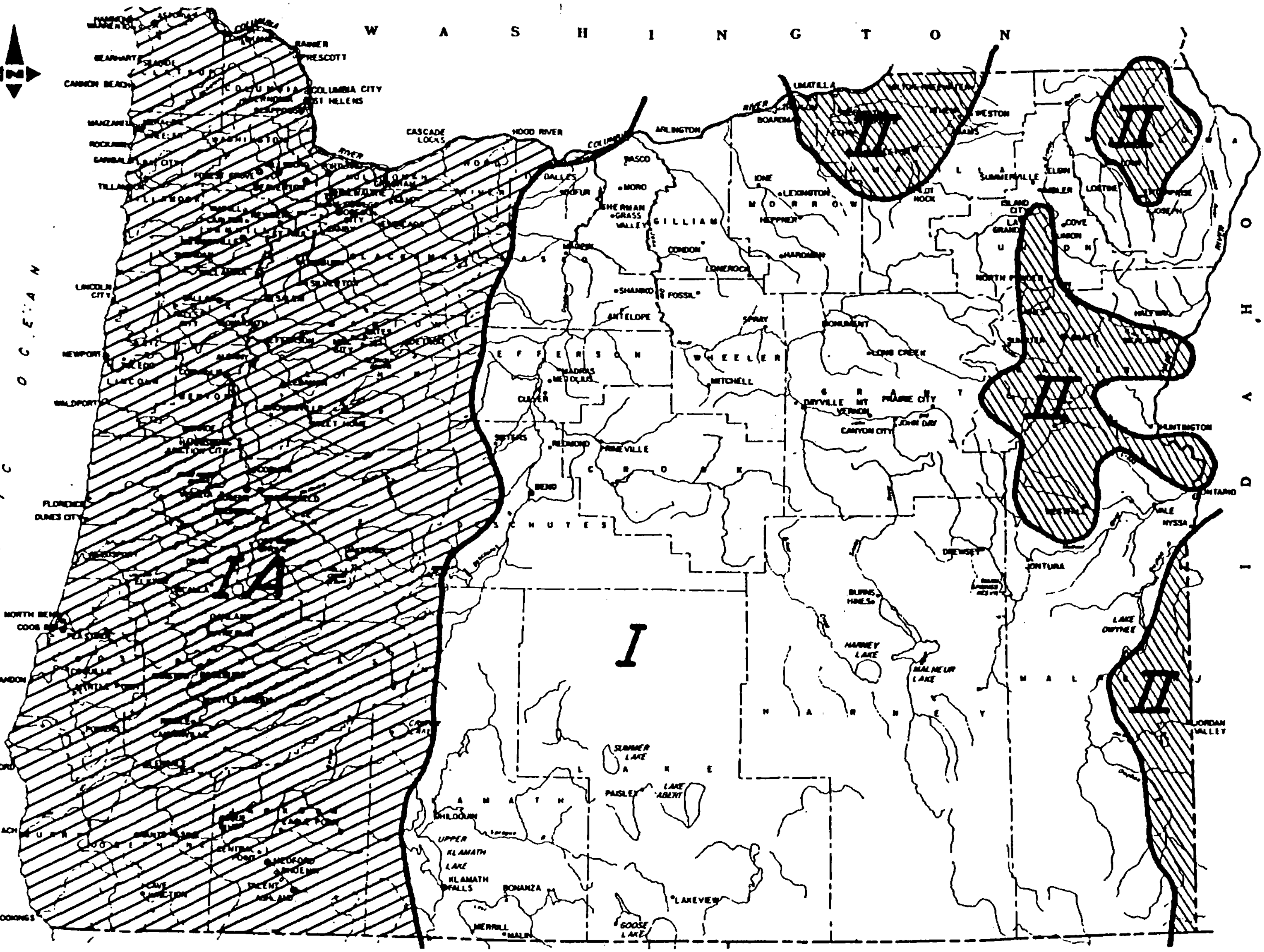
OR-B-2

(210-VI-ORHG,Sept. 1987)

U. S. DEPARTMENT OF AGRICULTURE

OREGON

SOIL CONSERVATION SERVICE



GEOGRAPHIC BOUNDARIES FOR SCS RAINFALL DISTRIBUTIONS

OREGON

DECEMBER 1971

Appendix C - Computer Program

The TR-55 computer program is set up to help guide through the input of data and will solve the equations for computing RCN, Tc, and peak flow. Samples of the computer output of each routine are attached. These use the input data of the examples in this guide.

The program requests a county name as early input data. If the name entered agrees with one on the county rainfall table in the program, the rainfall-frequency data will be read by the program. A county rainfall table for Oregon is in the program; however, the large counties and varied rainfall patterns required that multiple locations in a county be identified. The following Table C-1 lists county-city combinations which are in the program.

The locations are generally in the agricultural areas of the counties. This assumes that usually peak flows will be wanted in these areas. If the location under study is not similar to one of the cities listed, rainfall data from the maps in Appendix B should be entered where needed.

The county-city entry must be entered just as it is listed for the program to recognize the location (i.e., Clackamas-Oregon Cy). The spacing and abbreviations need to be as listed. Upper or lower case letters are acceptable.

TABLE C-1 - TR-55 COMPUTER PROGRAM COUNTY RAINFALL DATA SITES

AREA	COUNTY-CITY	AREA	COUNTY-CITY
1	BENTON-CORVALLIS	1	LINN-LEBANON
1	CLACKAMAS-OREGON CY	1	LINN-HALSEY
1	CLACKAMAS-SANDY	1	LINN-SWEET HOME
1	CLACKAMAS-MOLLALA	1	MARION-SALEM
1	CLATSOP-ASTORIA	1	MARION-MILL CITY
1	CLATSOP-CANNON BCH	1	MULTNOMAH-PORTLAND
1	COLUMBIA-CLATSKANIE	1	POLK-DALLAS
1	COLUMBIA-VERNONIA	1	POLK-FALLS CITY
1	COLUMBIA-SCAPPOOSE	1	TILLAMOOK-NEHALEM
1	LANE-FLORENCE	1	TILLAMOOK-TILLAMOOK
1	LANE-EUGENE	1	WASHINGTON-HILLSBORO
1	LANE-JUNCTION CITY	1	WASHINGTON-BANKS
1	LANE-OAKRIDGE	1	YAMHILL-MCMINNVILLE
1	LINCOLN-NEWPORT	1	YAMHILL-NEWBERG
1	LINCOLN-LINCOLN CY		

AREA	COUNTY-CITY	AREA	COUNTY-CITY
2	COOS-COOS BAY	2	JACKSON-MEDFORD
2	COOS-MYRTLE POINT	2	JACKSON-BUTTE FALLS
2	COOS-POWERS	2	JEFFERSON-MADRAS
2	CROOK-PRINEVILLE	2	JOS.-GRANTS PASS
2	CROOK-CAMP CR JCT	2	JOS.-CAVE JUNCTION
2	CURRY-GOLD BEACH	2	KLAM.-KLAMATH FALLS
2	DESCHUTES-BEND	2	KLAM.-BONANZA
2	DESCHUTES-REDMOND	2	LAKE-LAKEVIEW
2	DOUGLAS-REEDSPORT	2	LAKE-PAISLEY
2	DOUGLAS-ELKTON	2	SHERMAN-MORO
2	DOUGLAS-ROSEBURG	2	WASCO-THE DALLES
2	HOOD R.-CASCADE LOC.	2	WASCO-MAUPIN
2	HOOD R.-HOOD RIVER	2	WASCO-ANTELOPE

AREA	COUNTY-CITY	AREA	COUNTY-CITY
3	BAKER-BAKER	3	MORROW-BOARDMAN
3	BAKER-SUMPTER	3	MORROW-HEPPNER
3	BAKER-RICHLAND	3	UMA.-HERMISTON
3	GILLIAM-ARLINGTON	3	UMA.-PENDLETON
3	GILLIAM-CONDON	3	UMA.-MILTON-FREE.
3	GRANT-MONUMENT	3	UNION-ELGIN
3	GRANT-JOHN DAY	3	UNION-LAGRANDE
3	HARNEY-DREWSEY	3	UNION-NORTH POWDER
3	HARNEY-BURNS	3	WALLOWA-ENTERPRISE
3	MAL.-ONTARIO	3	WALLOWA-WALLOWA
3	MAL.-JORDAN VALLEY	3	WHEELER-FOSSIL

Example 2-1

TR-55 CURVE NUMBER COMPUTATION VERSION 1.11

Project : Pendleton watershed User: rsw Date: 08-19-87
County : UMA.-PENDLETON State: OR Checked: ____ Date: ________
Subtitle: Examples- sub-area 1

COVER DESCRIPTION			A	B	C	D
			Hydrologic Soil Group Acres (CN)			
CULTIVATED AGRICULTURAL LANDS						
Fallow	Bare soil	----	-	690(86)	45(91)	-
	Crop residue (CR)	poor	-	120(85)	-	-
Small grain	Straight row (SR)	poor	-	690(76)	45(84)	-
	C + Crop residue	poor	-	120(73)	-	-
Total Area (by Hydrologic Soil Group)				1620	90	

TOTAL DRAINAGE AREA: 1710 Acres WEIGHTED CURVE NUMBER:81*

* - Generated for use by GRAPHIC method

Example 3-1

TR-55 Tc and Tt THRU SUBAREA COMPUTATION VERSION 1.11

Project : Pendleton watershed User: rsw Date: 08-19-87
County : UMA.-PENDLETON State: OR Checked: ____ Date: ________
Subtitle: Examples- sub-area 1

Flow Type	2 year rain	Length (ft)	Slope (ft/ft)	Surface code	n	Area (sq/ft)	Wp (ft)	Velocity (ft/sec)	Time (hr)
Sheet	1.0	300	.033	d					0.636
Shallow Concent'd		900	.039	u					0.078
Open Channel		7500	.010		.040	6.0	10.2		0.797
Open Channel		6500	.006		.045	28.0	14.0		0.443
							Time of Concentration =		1.96*

--- Sheet Flow Surface Codes ---
A Smooth Surface
B Fallow (No Res.)
C Cultivated < 20 % Res.
D Cultivated > 20 % Res.
E Grass-Range, Short
F Grass, Dense
G Grass, Burmuda
H Woods, Light
I Woods, Dense

--- Shallow Concentrated ---
--- Surface Codes ---
P Paved
U Unpaved

* - Generated for use by GRAPHIC method

Example 2-2

TR-55 CURVE NUMBER COMPUTATION VERSION 1.11

Project : Pendleton Watershed User: rsw Date: 08-19-87
County : UMA.-PENDLETON State: OR Checked: ____ Date: ________
Subtitle: EXAMPLES sub-areas 1 & 2
Subarea : 2

COVER DESCRIPTION			Hydrologic Soil Group A	B	C	D
				Acres (CN)		
FULLY DEVELOPED URBAN AREAS (Veg Estab.)						
Streets and roads						
Gravel (w/ right-of-way)			-	7(85)	1(89)	-
CULTIVATED AGRICULTURAL LANDS						
Fallow	Bare soil	----	-	345(86)	30(91)	-
	Crop residue (CR)	good	-	275(83)	-	-
Small grain	Straight row (SR)	poor	-	344(76)	31(84)	-
	Cont & terraces(C&T)	good	-	275(70)	-	-
ARID AND SEMIARID RANGELANDS						
Sagebrush (w/ grass understory)		fair	-	90(51)	-	-
Total Area (by Hydrologic Soil Group)				1336 ====	62 ====	

SUBAREA: 2 TOTAL DRAINAGE AREA: 1398 Acres WEIGHTED CURVE NUMBER:78

Example 3-2

TR-55 Tc and Tt THRU SUBAREA COMPUTATION VERSION 1.11

Project : Pendleton Watershed User: rsw Date: 08-19-87
County : UMA.-PENDLETON State: OR Checked: ____ Date: ________
Subtitle: EXAMPLES sub-areas 1 & 2

Subarea #2 - 2

Flow Type	2 year rain	Length (ft)	Slope (ft/ft)	Surface code	n	Area (sq/ft)	Wp (ft)	Velocity (ft/sec)	Time (hr)
Sheet	1.0	300	.020	d					0.778
Shallow Concent'd		2100	.021	u					0.249
Open Channel		3500	.020		.045	2.64	6.95		0.396
Open Channel		7000						4.66	0.417
							Time of Concentration =		1.84* =====
Open Channel		9000	.007		.045	34.0	15.6		0.537
							Travel Time =		0.54* =====

--- Sheet Flow Surface Codes ---
A Smooth Surface
B Fallow (No Res.)
C Cultivated < 20 % Res.
D Cultivated > 20 % Res.
E Grass-Range, Short
F Grass, Dense
G Grass, Burmuda
H Woods, Light
I Woods, Dense

--- Shallow Concentrated ---
--- Surface Codes ---
P Paved
U Unpaved

* - Generated for use by TABULAR method

Example 4-1

TR-55 GRAPHICAL DISCHARGE METHOD VERSION 1.11

Project : Pendleton watershed User: rsw Date: 08-19-87
County : UMA.-PENDLETON State: OR Checked: ____ Date: ________
Subtitle: Examples- sub-area 1

Data: Drainage Area : 1710 * Acres
Runoff Curve Number : 81 *
Time of Concentration: 1.96 * Hours
Rainfall Type : II
Pond and Swamp Area : NONE

Storm Number	1	2	3	4	5	6	7
Frequency (yrs)	2	5	10	25	50	100	0
24-Hr Rainfall (in)	1	1.2	1.3	1.5	1.6	1.8	0
Ia/P Ratio	0.47	0.39	0.36	0.31	0.29	0.26	0.00
Runoff (in)	0.10	0.17	0.22	0.31	0.37	0.48	0.00
Unit Peak Discharge (cfs/acre/in)	0.196	0.244	0.260	0.286	0.295	0.306	0.000
Pond and Swamp Factor 0.0% Ponds Used	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Peak Discharge (cfs)	33	72	97	154	186	252	0

* - Value(s) provided from TR-55 system routines

Example 5-1 (with Ia/P rounded)

TR-55 TABULAR DISCHARGE METHOD VERSION 1.11

Project : Pendleton Watershed User: rsw Date: 08-19-87
County : UMA.-PENDLETON State: OR Checked: ____ Date: ________
Subtitle: EXAMPLES sub-areas 1 & 2

Total watershed area: 4.854 sq mi Rainfall type: II Frequency: 25 years

	Subareas 1	Subareas 2
Area(sq mi)	2.67	2.18*
Rainfall(in)	1.5	1.5
Curve number	81	78*
Runoff(in)	0.31	0.23
Tc (hrs)	1.96	1.84*
(Used)	2.00	2.00
TimeToOutlet	0.54*	0.00
(Used)	0.50	0.00
Ia/P	0.31	0.38
(Used)	0.30	0.30

Time (hr)	Total Flow	Subarea Contribution to Total Flow (cfs) 1	2
11.0	0	0	0
11.3	0	0	0
11.6	0	0	0
11.9	0	0	0
12.0	0	0	0
12.1	1	0	1
12.2	2	0	2
12.3	4	0	4
12.4	9	1	8
12.5	15	2	13
12.6	22	3	19
12.7	36	8	28
12.8	51	13	38
13.0	90	31	59
13.2	132	57	75
13.4	173	87	86
13.6	208	114	94P
13.8	221	134	87
14.0	225P	144P	81
14.3	206	139	67
14.6	177	121	56
15.0	141	96	45
15.5	109	73	36
16.0	87	58	29
16.5	72	47	25
17.0	61	40	21
17.5	54	35	19
18.0	48	31	17
19.0	41	26	15
20.0	36	23	13
22.0	28	18	10
26.0	11	8	3

P - Peak Flow * - value(s) provided from TR-55 system routines

Example 5-1 (with Ia/P as computed)

TR-55 TABULAR DISCHARGE METHOD VERSION 1.11

Project : Pendleton Watershed User: rsw Date: 08-19-87
County : UMA.-PENDLETON State: OR Checked: ____ Date: ________
Subtitle: EXAMPLES sub-areas 1 & 2

Total watershed area: 4.854 sq mi Rainfall type: II Frequency: 25 years

	Subareas 1	Subareas 2
Area(sq mi)	2.67	2.18*
Rainfall(in)	1.5	1.5
Curve number	81	78*
Runoff(in)	0.31	0.23
Tc (hrs)	1.96	1.84*
(Used)	2.00	2.00
TimeToOutlet	0.54*	0.00
(Used)	0.50	0.00
Ia/P	0.31	0.38

Time (hr)	Total Flow	Subarea Contribution to Total Flow (cfs) 1	2
11.0	0	0	0
11.3	0	0	0
11.6	0	0	0
11.9	0	0	0
12.0	0	0	0
12.1	1	0	1
12.2	1	0	1
12.3	3	0	3
12.4	7	1	6
12.5	12	2	10
12.6	17	3	14
12.7	29	8	21
12.8	42	13	29
13.0	75	29	46
13.2	116	55	61
13.4	155	84	71
13.6	189	111	78P
13.8	205	130	75
14.0	211P	139P	72
14.3	197	135	62
14.6	172	119	53
15.0	140	95	45
15.5	110	73	37
16.0	89	58	31
16.5	75	48	27
17.0	65	41	24
17.5	57	36	21
18.0	52	32	20
19.0	44	27	17
20.0	39	24	15
22.0	30	18	12
26.0	11	8	3

P - Peak Flow * - value(s) provided from TR-55 system routines

Appendix D - Worksheets

Worksheets are included which can be reproduced for use with Chapters 2 through 5. Notes have been added to the worksheets referencing the data sources.

Worksheet 2: Runoff curve number and runoff

Project ______________________ By ______ Date ______

Location ______________________ Checked ______ Date ______

Circle one: Present Developed ______________________

1. Runoff curve number (CN)

Soil name and hydrologic group (HG APP-A)	Cover description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio) (TR-55 Table 2-2)	CN 1/ Table 2-2	Fig. 2-3	Fig. 2-4	Area ☐ acres ☐ mi² ☐ %	Product of CN x area
				Totals =		

1/ Use only one CN source per line. (TR-55)

CN (weighted) = $\frac{\text{total product}}{\text{total area}}$ = ______ = ______; Use CN = ☐

2. Runoff

		Storm #1	Storm #2	Storm #3
Frequency	yr			
Rainfall, P (24-hour) ....(HG APP-B).....	in			
Runoff, Q .... (Use P and CN with table 2-1, fig. 2-1, or eqs. 2-3 and 2-4.) (TR-55)	in			

OR-D-2

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project ______________________ By _____ Date _______

Location ______________________ Checked _____ Date _______

Circle one: Present Developed ______________________

Circle one: T_c T_t through subarea ______________________

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)	Segment ID				
1. Surface description (table 3-1) (TR-55)					
2. Manning's roughness coeff., n (table 3-1) ..					
3. Flow length, L (total L ≤ 300 ft)	ft				
4. Two-yr 24-hr rainfall, P_2	in				
5. Land slope, s	ft/ft				
6. $T_t = \frac{0.007\ (nL)^{0.8}}{P_2^{0.5}\ s^{0.4}}$ Compute T_t	hr		+		=
Shallow concentrated flow	Segment ID				
7. Surface description (paved or unpaved)					
8. Flow length, L	ft				
9. Watercourse slope, s	ft/ft				
10. Average velocity, V (figure 3-1) (TR-55)	ft/s				
11. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+		=
Channel flow	Segment ID				
12. Cross sectional flow area, a	ft^2				
13. Wetted perimeter, p_w	ft				
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft				
15. Channel slope, s	ft/ft				
16. Manning's roughness coeff., n (HG Table 3-2)					
17. $V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n}$ Compute V	ft/s				
18. Flow length, L	ft				
19. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+		=

20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) .... hr ______

OR-D-3

Worksheet 4: Graphical Peak Discharge method

Project ______________________ By _____ Date _______

Location ______________________ Checked _____ Date _______

Circle one: Present Developed ______________________

1. Data:

   Drainage area .... A_m = ________ mi^2 (acres/640)

   Runoff curve number .... CN = ________ (From worksheet 2)

   Time of concentration .. T_c = ________ hr (From worksheet 3)

   Rainfall distribution type = ________ (I, IA, II, III) (HG APP-B)

   Pond and swamp areas spread throughout watershed ...... = ________ percent of A_m (____ acres or mi^2 covered)

Item	Units	Storm #1	Storm #2	Storm #3
2. Frequency	yr			
3. Rainfall, P (24-hour)	in			
4. Initial abstraction, I_a .... (Use CN with table 4-1.) (TR-55)	in			
5. Compute I_a/P				
6. Unit peak discharge, q_u .... (Use T_c and I_a/P with exhibit 4-____) (TR-55)	csm/in			
7. Runoff, Q .... (From worksheet 2).	in			
8. Pond and swamp adjustment factor, F_p .... (Use percent pond and swamp area with table 4-2. Factor is 1.0 for zero percent pond and swamp area.) (TR-55)				
9. Peak discharge, q_p .... (Where $q_p = q_u A_m Q F_p$)	cfs			

OR-D-4

Worksheet 5a: Basic watershed data

Project ______________________ Location ______________________ By ______ Date ________

Circle one: Present Developed ______________________ Frequency (yr) ______ Checked ______ Date ________

Subarea name	Drainage area A_m (mi^2)	Time of concentration T_c (hr)	Travel time through subarea T_t (hr)	Downstream subarea names	Travel time summation to outlet ΣT_t (hr)	24-hr Rainfall P (in)	Runoff curve number CN	Run-off Q (in)	$A_m Q$ (mi^2-in)	Initial abstraction I_a (in)	I_a/P

↑ ↑ From worksheet 3 (Time of concentration, Travel time through subarea)

↑ ↑ From worksheet 2 (Runoff curve number, Run-off)

↑ From table 5-1 (TR-55) (Initial abstraction)

Worksheet 5b: Tabular hydrograph discharge summary

Project ______________________ Location ______________________ By ________ Date ________

Circle one: Present Developed ______________________ Frequency (yr) ________ Checked ________ Date ________

Subarea name	Basic watershed data used 1/				Select and enter hydrograph times in hours from exhibit 5- 2/											
	Sub-area T_c (hr)	ΣT_t to outlet (hr)	I_a/P	A_mQ (mi^2-in)												
					Discharges at selected hydrograph times 3/ (cfs)											
Composite hydrograph at outlet																

1/ Worksheet 5a. Rounded as needed for use with exhibit 5. (TR-55)
2/ Enter rainfall distribution type used. (HG APP-B)
3/ Hydrograph discharge for selected times is A_mQ multiplied by tabular discharge from appropriate exhibit 5. (TR-55)