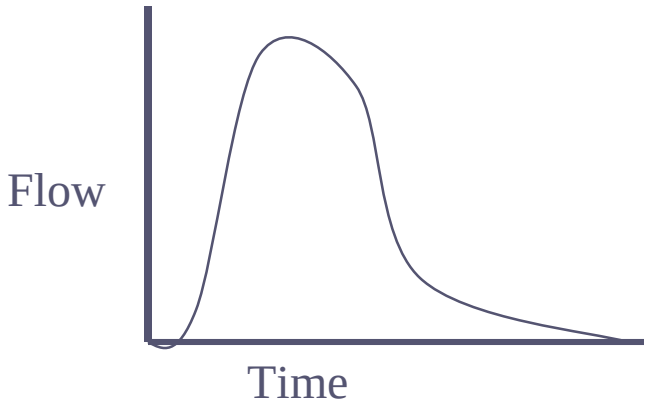
Section 3

SBUH Method

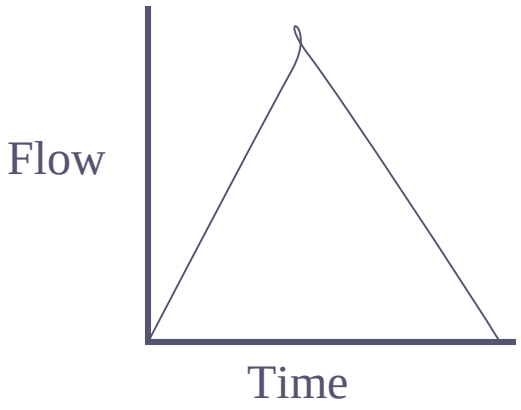
DEFINITIONS

- SBUH-Santa Barbara Urban Hydrograph was developed for small and median urban basins to generate an actual hydrograph. Hydraulic Manual – pg 2-13

- Hydrograph- A graph of runoff rate past a specific point in time.



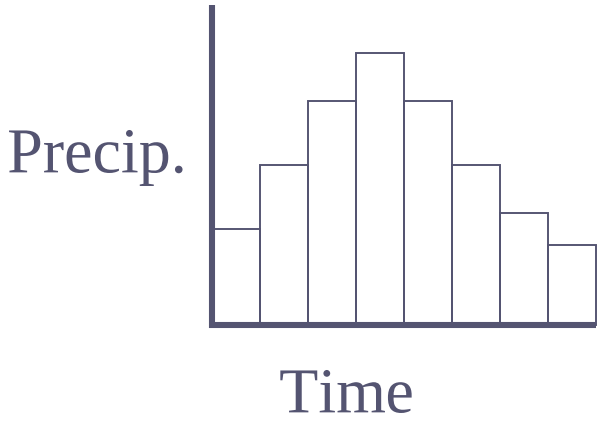
SBUH Method



Rational Method

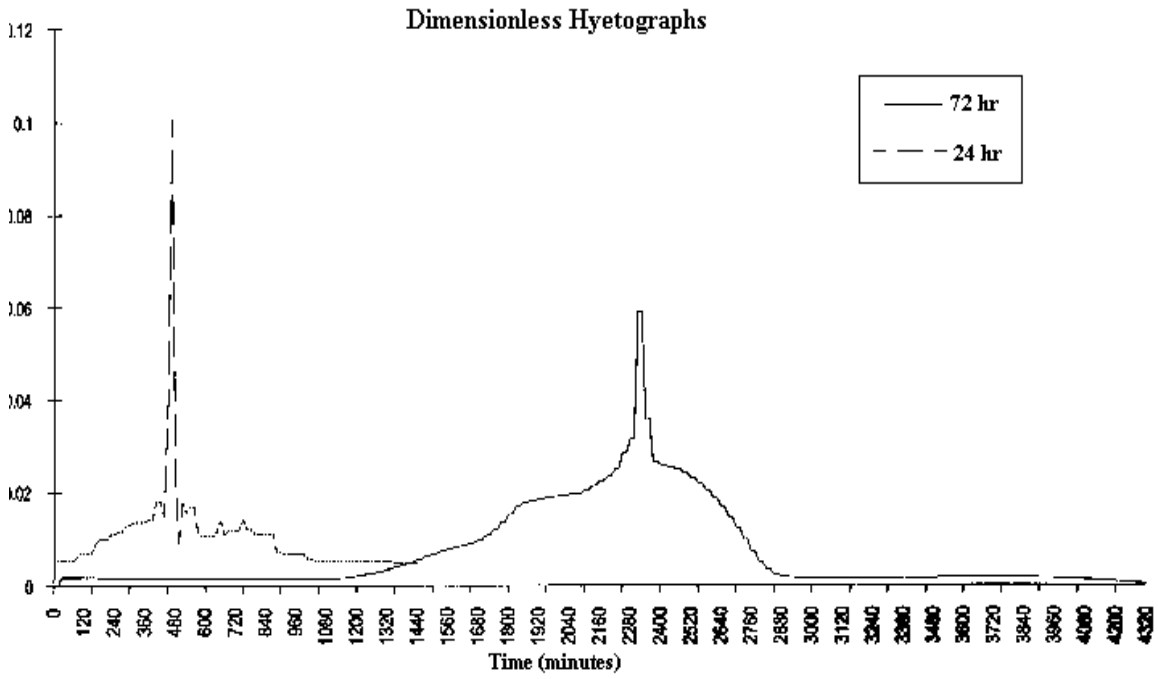
DEFINITIONS

- Hyetograph-A graph of precipitation versus time. Each time is subdivided by 10 minutes blocks as a standard.



A hyetograph closely resemble a rainfall pattern. It captures the precipitation pattern before it's runoff.

Dimensionless Hyetograph



- There are different rainfall patterns in the state as well as different rainfall patterns for seasons that change with time.

United States Rainfall patterns

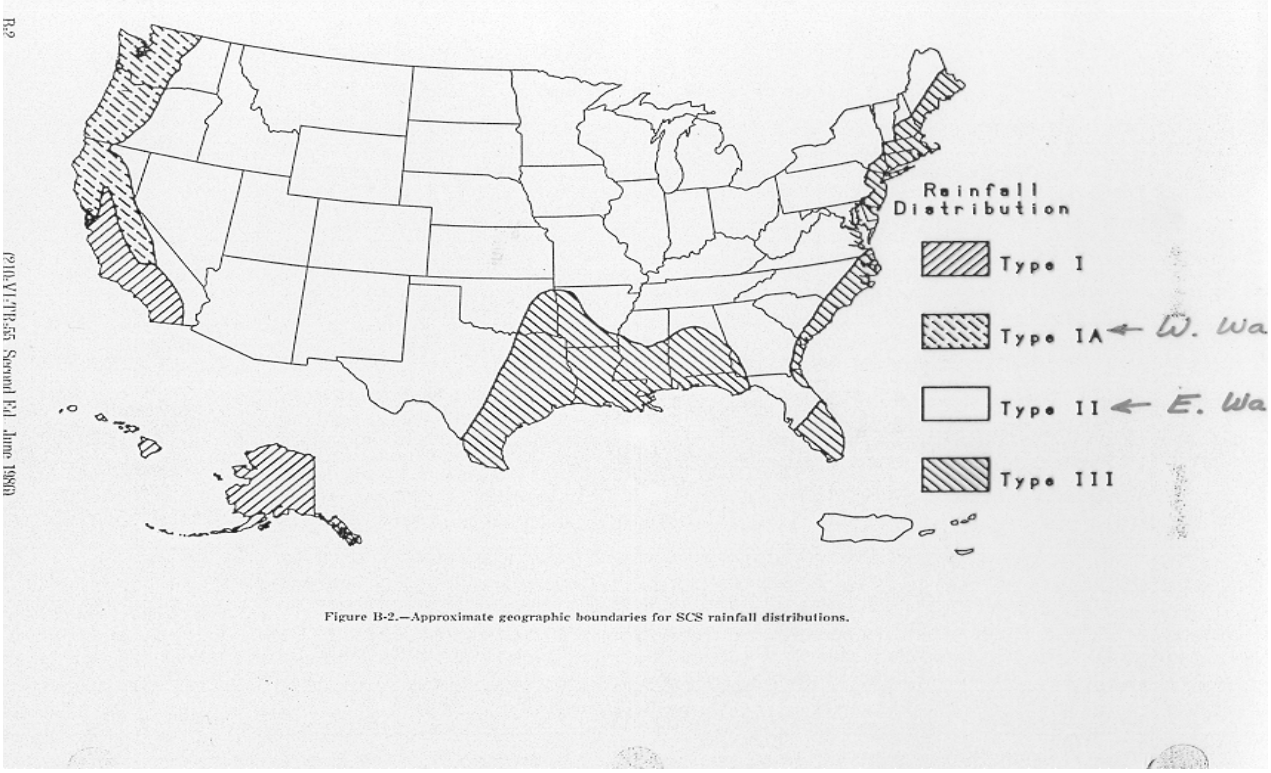


Figure B-2.—Approximate geographic boundaries for SCS rainfall distributions.

- Type 1A rainfall pattern should be applied to everything west of the Cascades.
- Type 2 rainfall pattern should be applied to everything east of the Cascades.

SBUH Computation Requirements

- Precipitation- 24hour duration rainfall in the Highway Runoff Manual page 3-4 or the Isopluvial maps from your Hydraulic Contacts.

- Contributing Areas- Basins sizes for this method are good under 100 acres, anything above 1000 acres will give you bad results

- Soil Characteristics- Determination of soils types and locations for land cover use values. This information is provided in the Soils Conservation Service books by counties.

- Travel Time- There are 3 different types of flow paths when using the SBUH method

Precipitation

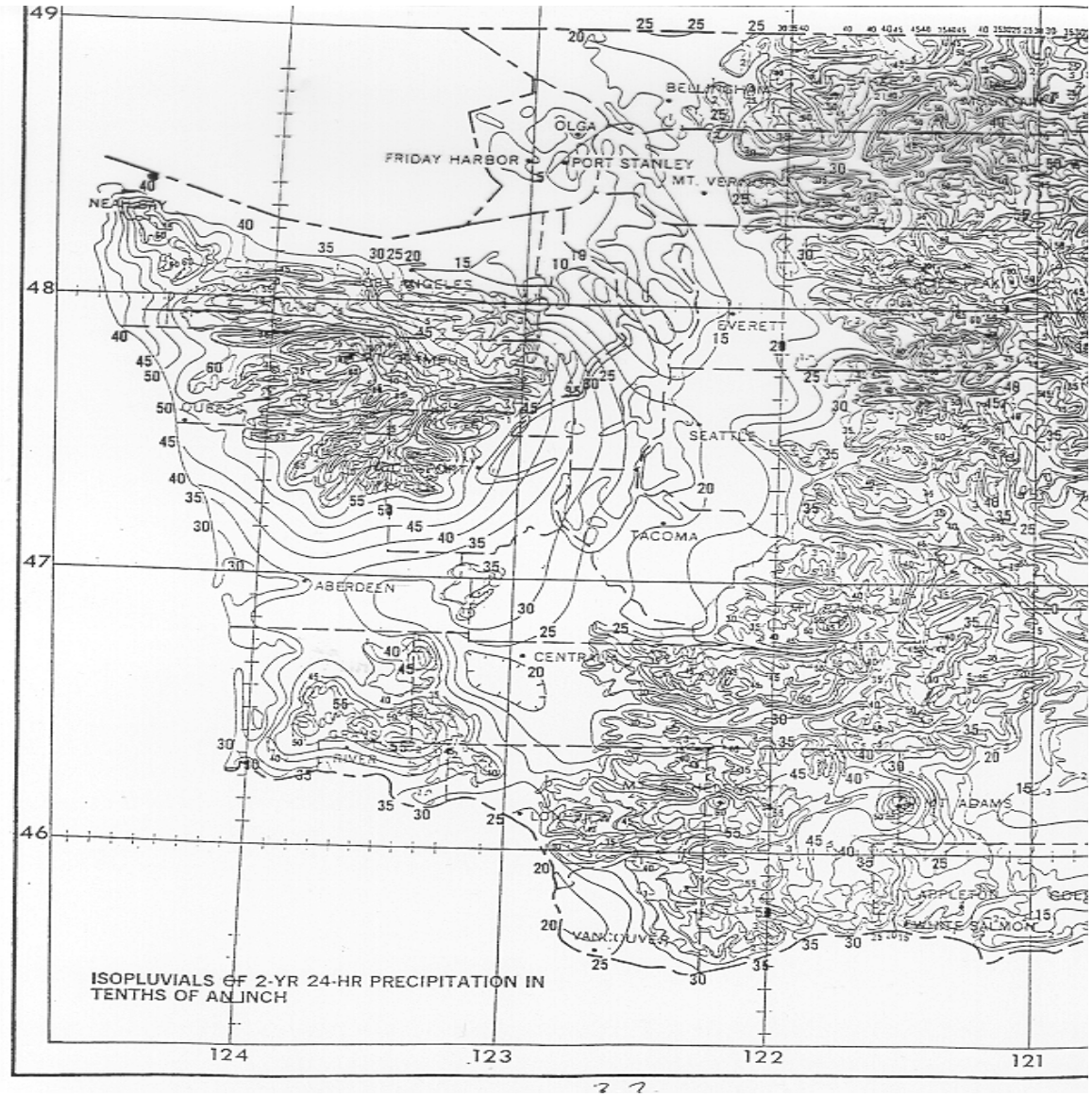
24-Hour Duration Rainfall Depths

Location	2-year	10-year	25-year	100-year
Aberdeen and Hoquiam	2.5	3.2	4.0	5.0
Anacortes	1.2	2.0	2.5	3.1
Bellingham	1.8	2.7	3.1	3.8
Bremerton	2.5	3.5	4.5	5.0
Cathlamet	3.5	5.0	5.7	6.8
Centralia and Chehalis	2.2	3.0	3.5	4.3
Clarston and Colfax	1.4	1.8	2.1	2.6
Colville	1.4	1.9	2.2	2.6
Ellensburg	1.5	2.3	2.7	3.5
Elma	3.0	4.2	4.7	6.0
Everett	1.5	2.3	2.6	3.2
Forks	5.5	7.5	8.5	10.0
Gold Bar	3.0	3.5	4.0	5.0
Goldendale	1.5	2.3	2.8	3.5
Hoffstadt Creek	4.5	6.0	7.5	9.0
Hoodsport	4.8	6.6	7.7	9.5
Humptulips	5.0	6.7	8.0	10.0
Kelso and Longview	2.5	3.5	4.0	5.0
Leavenworth	1.5	2.0	2.5	3.0
Long Beach	3.0	4.0	4.5	5.5
Moses Lake	0.7	1.1	1.3	1.7
Mount Vernon	1.7	2.6	3.0	3.7
Naselle	4.5	6.0	7.0	8.5
North Bend	4.0	5.0	6.0	6.5
Olympia	2.8	4.3	5.1	6.1
Omak	1.0	1.6	1.8	2.2
Pasco and Richland	0.8	1.3	1.6	2.0
Port Angeles	2.1	3.1	3.9	4.6
Port Townsend	1.0	1.7	2.0	2.5
Poulsbo	2.0	2.4	3.5	4.0
Queets	5.2	6.5	7.5	9.3
Raymond	3.5	4.9	5.5	6.5
Seattle	2.0	2.8	3.4	4.0
Sequim	1.5	2.0	2.5	2.8
Shelton	4.0	5.5	6.5	8.5
Snoqualmie Pass	5.5	7.0	8.0	10.0
Spokane	1.4	2.0	2.2	2.6
Stevens Pass	5.0	6.5	7.5	9.0
Sumas	2.5	3.3	3.8	4.5
Sumner	2.0	2.8	3.3	3.9
Tacoma	2.0	3.0	3.5	4.0
Toledo	2.3	3.0	3.5	4.2
Vancouver	2.3	3.0	3.5	4.3
Vantage	1.0	1.6	1.9	2.3
Walla Walla	1.2	1.9	2.0	2.4
Wenatchee	1.5	2.2	2.5	3.1
White Pass	4.5	6.0	7.0	8.0
Yakima	1.0	1.5	1.8	2.2

Figure 3-3.1

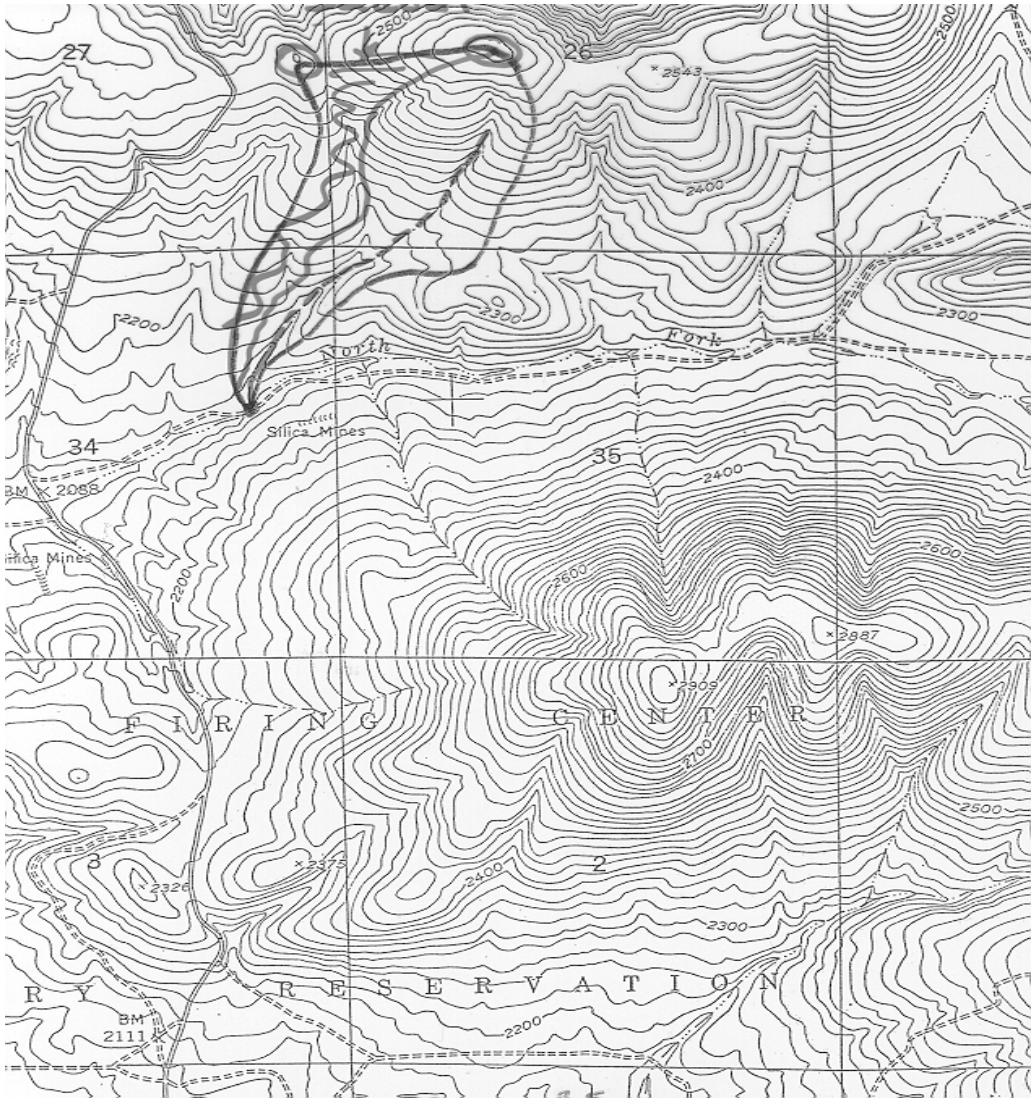
Highway Runoff Manual-pg3-4

Precipitation



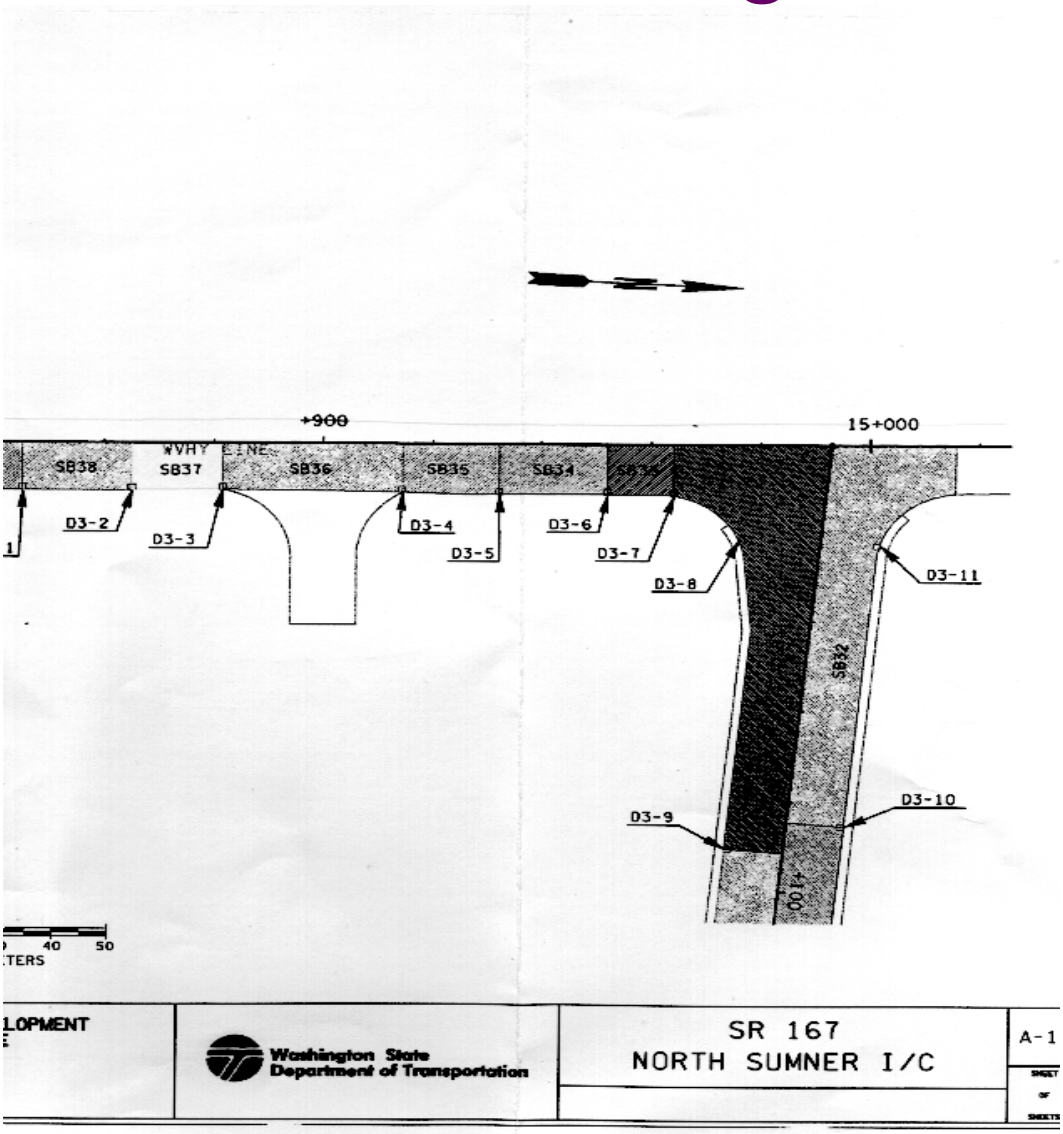
- Isopluvial Map for 2year MRI

Threshold Discharge Areas



- When delineating a basin it's important to be perpendicular to the contours.

Threshold Discharge Areas



- Urban basin delineation should be for the contributing area to each catch basin.

Drainage Basin Example

Soil Characteristics

- Hydrologic Soil Groups

*Type A- Soils having high infiltration rates, even when thoroughly wetted, and consisting of deep well to excessively drained sands or gravels. These soils have a high rate of water transmission.

Examples: Everett Soils
Winthrop Soils
Spanaway Soils

*Type B- Soils having moderate infiltration rates when thoroughly wetted, and consisting of moderately fine to moderately course textures. These soils have a moderate rate of water transmission.

Examples: Walla Walla Soils
Washougal Soils
Spokane Soils

Soil Characteristics

- Hydrologic Soil Groups

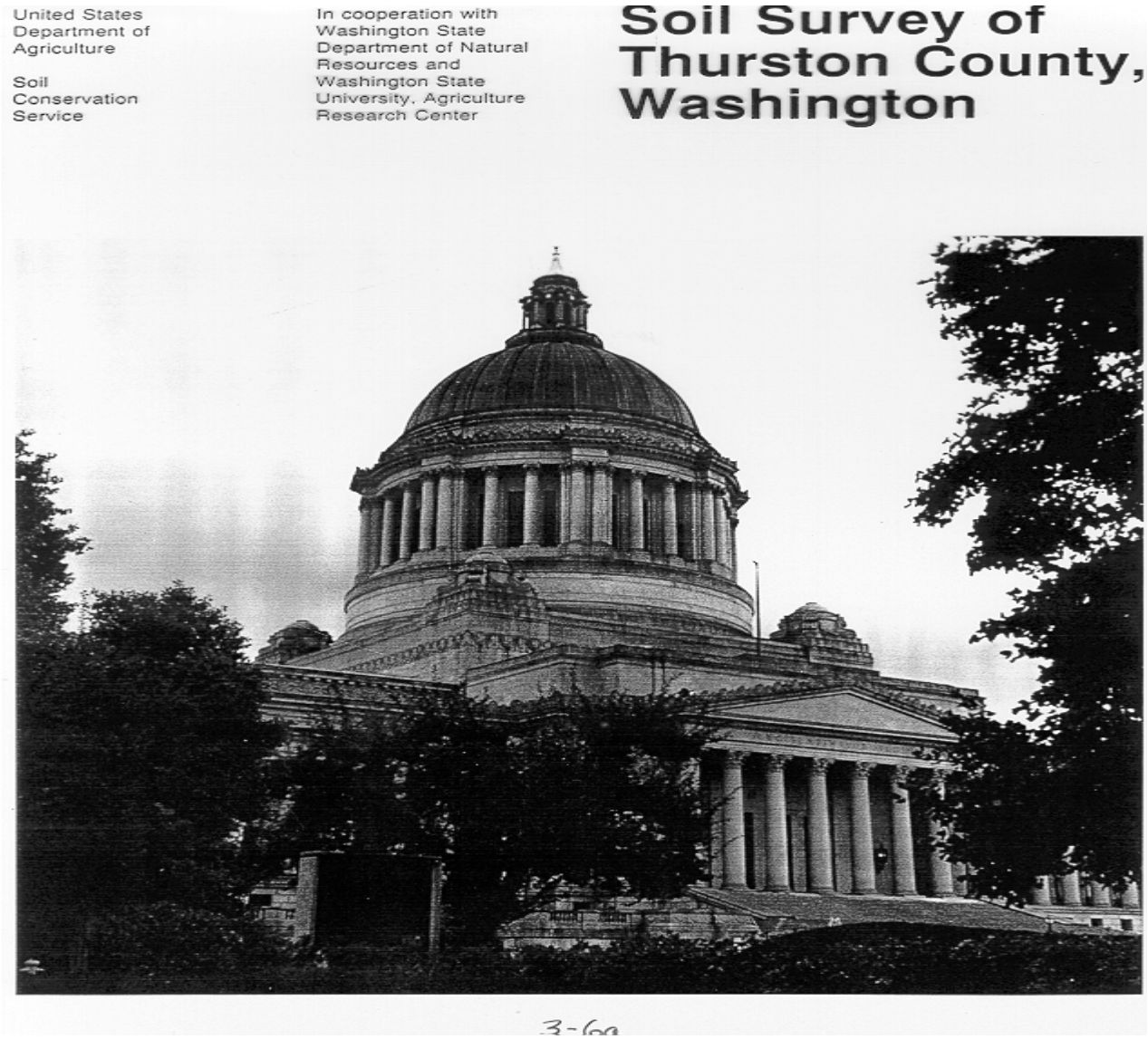
*Type C- Soils having slow infiltration rates when thoroughly wetted and consisting of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine textures. These soils have a slow rate of water transmission

Examples: Montesano Soils
Sumas Soils

*Type D- Soils having very slow infiltration rates when thoroughly wetted and consisting of clay soils with high swelling potentials, soils with a permanent high water table, soils with a hardpan or clay layer at or near the surface and shallow soils over nearly impervious materials. These soils have very slow rate of water transmission.

Examples: Colville Soils
Wapato Soils

Soil Characteristics



Good resource to find out soils characteristics.

Soil Characteristics

Example: Project site in Olympia soils #42

Soil Characteristics

Thurston County, Washington 275

TABLE 16.--WATER FEATURES--Continued

Soil name and map symbol	Hydrologic group	Flooding			High water table		
		Frequency	Duration	Months	Depth	Kind	Months
					Ft.		
32, 33, 34, 35 Everett	A	None	---	---	>6.0	---	---
36 Everson	D	None	---	---	1.0-3.0	Apparent	Nov-Apr
37 Galvin	D	None	---	---	0.5-1.5	Apparent	Nov-Apr
38, 39, 40 Giles	B	None	---	---	>6.0	---	---
41 Godfrey	D	Occasional	Brief	Nov-Mar	1.0-2.0	Apparent	Oct-Mar
42 Grove	A	None	---	---	>6.0	---	---
43, 44 Hoogdal	C	None	---	---	1.5-2.0	Perched	Dec-Mar
45 Hydraquents	D	Frequent	Brief	Jan-Dec	+1-0	Apparent	Jan-Dec
46, 47, 48 Indianola	A	None	---	---	>6.0	---	---
49 Jonas	B	None	---	---	>6.0	---	---
50, 51, 52, 53, 54, 55 Kapowsin	D	None	---	---	1.0-2.0	Perched	Dec-Jun
56, 57 Katula	C	None	---	---	>6.0	---	---
58, 59 Lates	C	None	---	---	>6.0	---	---
60, 61 Mal	C	None	---	---	>6.0	---	---
62, 63 Mashel	B	None	---	---	>6.0	---	---
64 Maytown	C	Occasional	Brief	Nov-Mar	2.5-3.5	Apparent	Nov-Apr
65 McKenna	D	None	---	---	+1-0.5	Perched	Nov-Apr
66, 67, 68 Melbourne	B	None	---	---	>6.0	---	---
69 Mukilteo	D	None	---	---	+1-0	Apparent	Oct-Apr
70 Mukilteo	C	None	---	---	1.5-3.0	Apparent	Oct-May

See footnote at end of table.

#42 soil is called Grove with a hydrological group of A

Soil Characteristics

TABLE 15.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS--Continued

Soil name and map symbol	Depth	Clay	Permeability	Available water capacity	Soil reaction	Shrink-swell potential	Erosion factors K	Erosion factors T	Organic matter
	In	Pct	In/hr	In/in	pH				Pct
20---------- Cagey	0-6	1-5	6.0-20	0.07-0.10	6.1-7.3	Low----------	0.37	4	2-5
	6-28	0-5	6.0-20	0.06-0.08	6.1-7.3	Low----------	0.20		
	28-60	0-2	6.0-20	0.05-0.07	6.1-7.3	Low----------	0.15		
21, 22---------- Cathcart	0-12	---	0.6-2.0	0.15-0.20	4.5-6.0	Low----------	0.20	4	2-8
	12-33	---	0.6-2.0	0.10-0.20	5.1-6.5	Low----------	0.32		
	33-44	---	0.6-2.0	0.10-0.15	5.1-6.5	Low----------	0.32		
	44	---	---	---	---	----------	----		
23, 24, 25------- Centralia	0-10	15-25	0.6-2.0	0.19-0.21	5.1-6.5	Low----------	0.32	5	3-8
	10-42	27-35	0.6-2.0	0.19-0.21	5.1-6.0	Moderate-------	0.28		
	42-60	22-30	0.6-2.0	0.18-0.21	4.5-5.5	Moderate-------	0.32		
26---------- Chehalis	0-7	15-25	0.6-2.0	0.19-0.21	5.6-6.5	Low----------	0.37	5	5-10
	7-44	25-35	0.6-2.0	0.17-0.21	5.6-7.3	Moderate-------	0.28		
	44-60	25-45	0.6-2.0	0.19-0.21	5.6-7.3	Low----------	0.32		
27, 28---------- Delphi	0-8	---	0.6-2.0	0.12-0.15	5.1-6.0	Low----------	0.15	4	5-10
	8-13	15-25	0.6-2.0	0.12-0.15	5.1-6.0	Low----------	0.20		
	13-48	15-27	0.6-2.0	0.09-0.14	5.1-5.5	Low----------	0.10		
29---------- Dupont	0-7	---	0.6-2.0	0.25-0.35	4.5-5.5	Low----------	0.00	5	30-50
	7-17	---	0.2-0.6	0.15-0.20	4.5-5.5	Low----------	0.55		
	17-60	---	0.6-2.0	0.25-0.35	4.5-5.5	Low----------	0.00		
30---------- Dystric Xerochrepts	0-4	5-15	0.6-2.0	0.05-0.08	5.6-6.5	Low----------	0.10	5	2-4
	4-30	5-15	0.6-2.0	0.05-0.09	6.1-7.3	Low----------	0.15		
31---------- Eld	0-7	18-27	0.6-2.0	0.16-0.20	5.6-6.5	Moderate-------	0.37	5	5-10
	7-22	18-27	0.6-2.0	0.18-0.22	5.6-6.5	Moderate-------	0.32		
	22-35	18-27	0.6-2.0	0.16-0.20	5.6-6.5	Moderate-------	0.32		
	35-60	18-30	0.6-2.0	0.15-0.19	5.6-6.5	Moderate-------	0.28		
32, 33, 34, 35--- Everett	0-3	---	0.6-2.0	0.08-0.13	5.6-6.5	Low----------	0.20	1	3-9
	3-20	---	6.0-20	0.08-0.13	5.6-6.5	Low----------	0.10		
	20-60	0-5	>20	0.02-0.05	5.6-6.5	Low----------	0.10		
36---------- Everson	0-6	27-35	0.6-2.0	0.25-0.35	5.1-6.0	Moderate-------	0.28	2	3-9
	6-30	35-45	0.06-0.2	0.20-0.30	5.6-6.0	Moderate-------	0.28		
	30-60	0-5	6.0-20	0.05-0.10	5.6-6.0	Low----------	0.20		
37---------- Galvin	0-12	10-25	0.6-2.0	0.19-0.21	5.6-6.5	Low----------	0.37	5	5-10
	12-35	23-35	0.2-0.6	0.19-0.21	4.5-6.5	Moderate-------	0.32		
	35-60	30-50	0.06-0.2	0.14-0.17	4.5-6.5	Moderate-------	0.24		
38, 39, 40------- Giles	0-10	---	0.6-2.0	0.25-0.35	5.1-6.0	Low----------	0.32	5	2-10
	10-48	---	0.6-2.0	0.20-0.30	5.6-6.5	Low----------	0.32		
	48-60	---	0.6-2.0	0.15-0.20	5.6-6.5	Low----------	0.43		
41---------- Godfrey	0-8	27-40	0.2-0.6	0.18-0.22	4.5-6.0	Moderate-------	0.32	5	.5-2
	8-52	35-50	0.06-0.2	0.14-0.18	5.6-6.5	High----------	0.24		
	52-60	35-50	<0.06	0.13-0.15	6.1-7.3	High----------	0.24		
42---------- Grove	0-6	5-10	2.0-6.0	0.05-0.08	5.1-6.0	Low----------	0.05	2	2-10
	6-21	2-7	6.0-20	0.03-0.05	5.1-6.0	Low----------	0.02		
	21-60	0-6	>20	0.02-0.05	5.1-6.0	Low----------	0.02		

See footnote at end of table.

3-6c

Grove soil has the following characteristics that might be helpful to know for your project.

Soil Characteristics

TYPICAL CN VALUES

LAND USE DESCRIPTION		CURVE NUMBERS BY HYDROLOGIC SOIL GROUP A	B	C	D
Mountain brush - oak brush, aspen, maple:					
Good Condition:	ground cover > 70%	40	40	41	48
Fair Condition:	ground cover 30% to 70%	40	48	57	63
Poor Condition:	ground cover < 30%	46	66	74	79
Woods or forest land:					
Good condition:	Natural conditions	40	55	70	77
Fair condition:	Some forest litter	40	60	73	79
Poor condition:	No small trees or brush	45	66	77	83
Woods/Grass combination (orchard or tree farm):					
Good condition:	ground cover > 75%	40	58	72	79
Fair condition:	ground cover 50% to 75%	43	65	76	82
Poor condition:	ground cover < 50%	57	73	82	86
Brush with weeds and grass:					
Good condition:	ground cover > 75%	40	48	65	73
Fair condition:	ground cover 50% to 75%	40	56	70	77
Poor condition:	ground cover < 50%	48	67	77	83
Meadow - continuous grass:		40	58	71	78
Residential districts:					
1/4 acre lots:		61	75	83	87
1/3 acre lots:		57	72	81	86
1/2 acre lots:		54	70	80	85
1 acre lots:		51	68	79	84
Pasture or range:					
Good condition:	lightly grazed	40	61	74	80
Fair condition:	not heavily grazed	49	69	79	84
Poor condition:	heavily grazed w/ no mulch	68	79	86	89
Newly graded areas (no vegetation established)		77	86	91	94
Open spaces, lawns, parks, golf courses, cemeteries:					
Good condition:	grass cover > 75%	40	61	74	80
Fair condition:	grass cover 50% to 75%	49	69	79	84
Poor condition:	grass cover < 50%	68	79	86	89
Gravel roads & parking lots:		88	92	95	98
Dirt roads & parking lots:		86	90	94	98
Impervious surfaces:	pavement and roofs	98	98	98	98
Open water bodies:	lakes, wetlands and ponds	100	100	100	100

3-7

Now we can determine the Curve Number (CN) value for the project based on its land use.

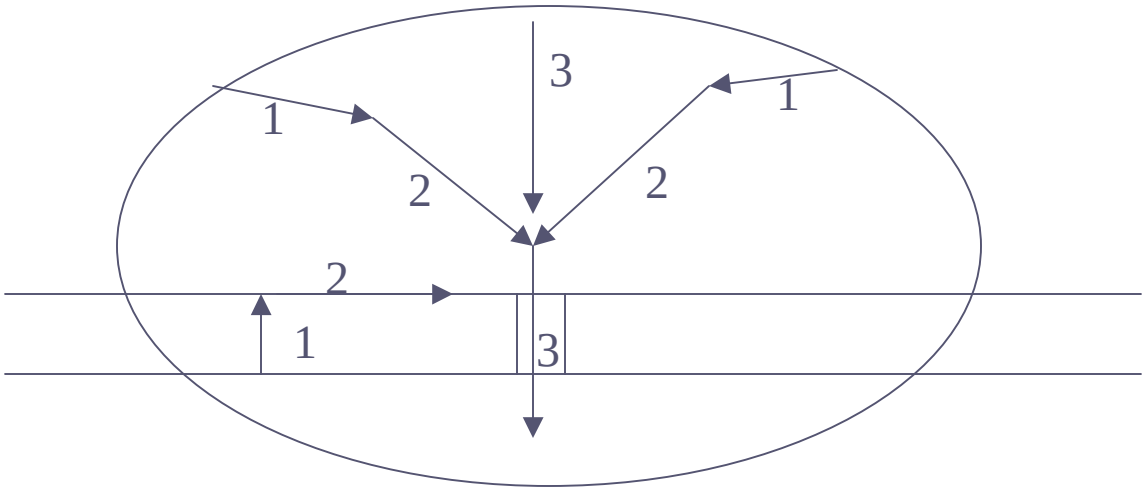
Travel Time

- Travel Time (Tt)-The time it takes water to travel from one location to another in a watershed. There are three types of flows:

  1- Sheet Flow- Overland flow with very little depth with a max distance of 300 feet.

  2. Shallow Flow – Gully or curb like flow with some depth.

  3- Open Channel Flow – Flow with a certain amount of depth majority of the time.



Travel Time Equations

- Sheet Flow

  Tt= 0.42(nsL)^0.8 / (P2)^0.527(so)^0.4

  ns- Manning's sheet flow coefficient
  L- Flow length (ft)
  P2- 2year 24hr Rainfall (in)
  so- Slope of land segment (ft/ft)

- Shallow Flow

  Tt= L / 60(ks)(so)^0.5

  L- Flow length (ft)
  ks- Velocity factor coefficient
  so- Slope of land segment (ft/ft)

- Open Channel Flow

  Tt= L / 60(kc)(so)^0.5

  L- Flow length (ft)
  kc- Velocity factor coefficient
  so- Slope of land segment (ft/ft)

Travel Time
“n” & “k” values

Highway Runoff Manual Page 3-17
January 2001

Sheet Flow Equation Manning’s n	**ns**
Smooth surfaces (concrete, asphalt, gravel)	0.011
Fallow fields or loose soil surface (no residue)	0.05
Cultivated soil with residue cover (s< 0.20 ft/ft)	0.06
Cultivated soil with residue cover (s> 0.20 ft/ft)	0.17
Short prairie grass and lawns	0.15
Dense grasses	0.24
Bermuda grass	0.41
Range (natural)	0.13
Woods or forest with light underbrush	0.40
Woods or forest with dense underbrush	0.80

Shallow Concentrated Flow	**ks**
1. Forest with heavy ground litter and meadows (n = 0.10)	3
2. Brushy ground with some trees (n = 0.060)	5
3. Fallow or minimum tillage cultivation (n = 0.040)	8
4. High grass (n = 0.035)	9
5. Short grass, pasture and lawns (n = 0.030)	11
6. Nearly bare ground (n = 0.25)	13
7. Paved and gravel areas (n = 0.012)	27

Channel Flow (Intermittent)	**kc**
1. Forested swale with heavy ground litter (n = 0.10)	5
2. Forested drainage course with defined channel bed (n = 0.050)	10
3. Rock-lined waterway (n = 0.035)	15
4. Grassed waterway (n = 0.030)	17
5. Earth-lined waterway (n = 0.025)	20
6. CMP pipe (n = 0.024)	21
7. Concrete pipe (0.012)	42

Channel Flow	**kc**
1. Meandering stream with some pools (n = 0.040)	20
2. Rock-lined stream (n = 0.035)	23
3. Grass-lined stream (n = 0.030)	27

“n” AND “k” Values for Travel Time Calculations

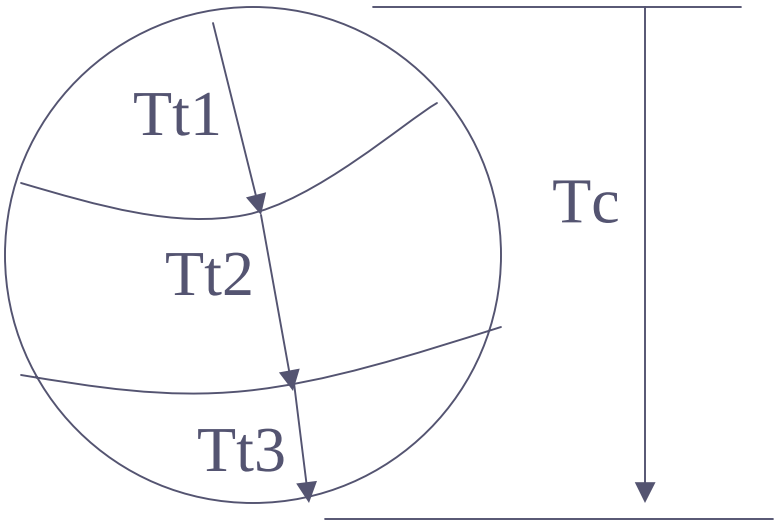
Figure 3-3.4

• A culvert or bridge can act as a reservoir outlet if there is significant storage behind it. A hydrograph should be developed to this point and the level pool routing technique described in Section 3-3.4 should be used to determine the outflow rating curve through the culvert or bridge.

Time of Concentration

- Time of Concentration (Tc)- The time it takes runoff to travel from the most hydraulically distance point of the watershed. It's also the summation of the travel time.

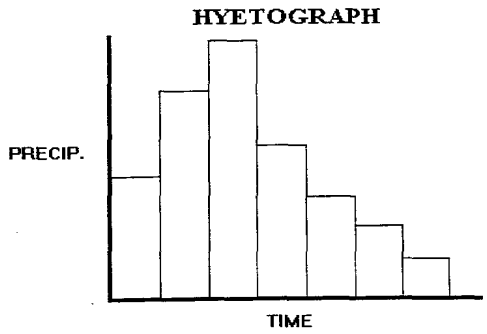
  Tc = Tt1+ Tt2 +Tt3

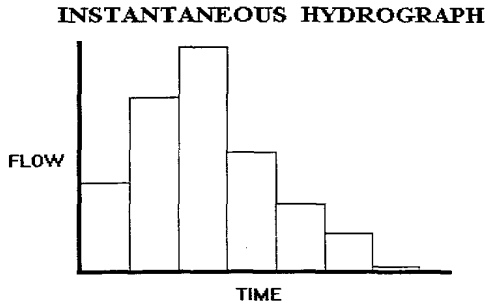


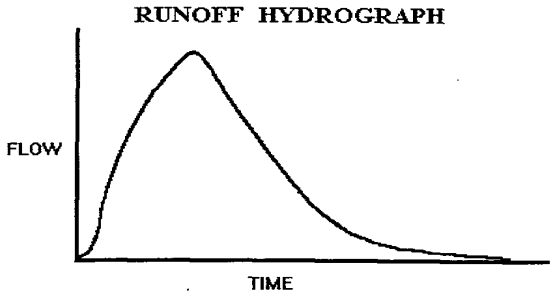
Five Steps for SBUH

- 1- Basins Areas in acres
- 2- Precipitation for 24hr storm events in inches
- 3- Soil Characteristics for Curve Number
- 4- Travel time for basin in minutes
- 5- Solve for runoff when using computer program

Graphs


HYETOGRAPH
PRECIP.
TIME


INSTANTANEOUS HYDROGRAPH
FLOW
TIME


RUNOFF HYDROGRAPH
FLOW
TIME

3-10

SBUH Equations

- Abstract Runoff value
  $S = (1000/CN) - 10$

- Runoff Depth
  $D(t) = (pt - .2(S))^2/(pt + .8(S)$

- Total Runoff
  $R(t) = D(t) - D(t-1)$

- Instantaneous Hydrograph
  $I(t) = 60.5(R(t))A/dt$

- Design Flow Rate
  $Q(t+1) = Q(t) + w(I(t) + I(t+1) - 2Q(t))$

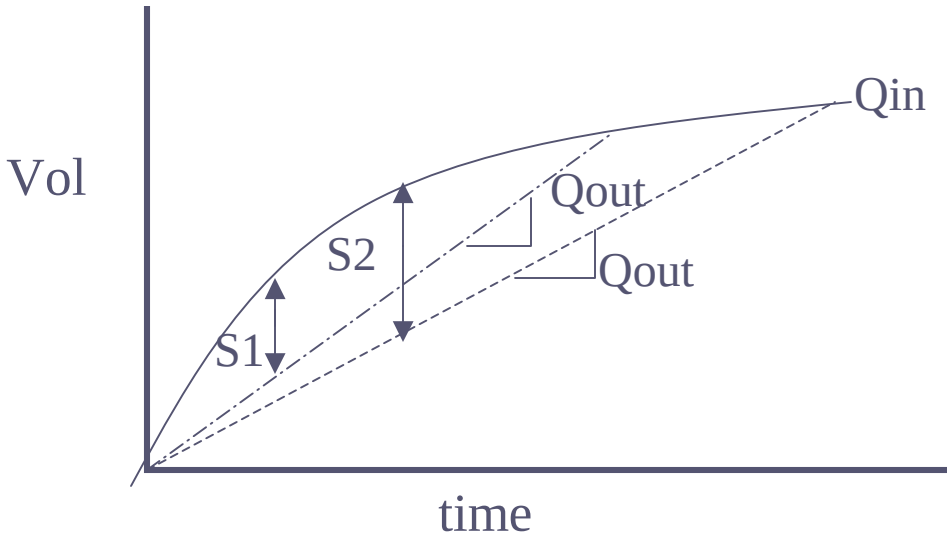
CN = Curve Number
pt = Precipitation for the time increment-24hr MRI
A = Basin Area in acres
dt = Time interval in ten minutes
w = dt/(2Tc+dt)
Tc = Time of concentration for the drainage basin

Level Pool Analysis

Inflow – Outflow = Change in Storage

$[(I1+I2)/2] – [(O1+O2)/2] = S2-S1$

Where: I = Inflow at time 1 and time 2
O = Outflow at time 1 and time 2
S = Storage at time 1 and time2



Increase volume (S) due to increase time