Long Duration (Regional) Storms – Criteria For Use

Long-duration design storms are appropriate for designing stormwater detention and runoff treatment facilities where runoff volume is primarily of concern. The criteria for sizing both runoff treatment and flow control facilities is summarized in Table 4-8 and 4-9, section 4-4 of the Highway Runoff Manual. For the detention and infiltration pond examples in this tutorial we will need Table 4-9, which specifies the Regional or Type IA Storm depending on the climatic Region.

Table 4-8. Criteria for sizing runoff treatment facilities in eastern Washington.

Facility Type	Criteria	Model
Volume-based	Size facility using the runoff volume predicted for the 6-month, 24-hour event under post-developed conditions for each drainage basin area.	Single event model (SCS or SBUH) Regional Storm (Climatic Regions 1 – 4) or Type 1A Storm (Regions 2 and 3)
Flow-based: facility located upstream of detention/retention facility	Size facility using the peak flow rate predicted for the 6-month, short duration storm under post-developed conditions for each drainage basin area.	Single event model (SCS or SBUH) Short duration storm
Flow-based: facility is located downstream of detention facility	Size facility using the full 2-year release rate from the detention facility, under post-developed conditions for each drainage basin area.	Single event model (SCS or SBUH) Short duration storm or Regional Storm (Climatic Regions 1 – 4) or Type 1A Storm (Regions 2 and 3), which ever produces the greatest flow.

Table 4-9. Criteria for sizing flow control facilities in eastern Washington.

Facility Type	Criteria	Model
Detention/combination treatment and detention facilities	Provide storage volume required to match ½ of the 2-year pre-developed peak flow rate and match the pre-developed 25-year peak flow rate, and check the 100-year peak flow for flood control and property damage.	Single Event Model (SCS or SBUH) Regional Storm (Climatic Regions 1 – 4) or Type 1A Storm (Regions 2 and 3)
Infiltration facilities	Size facility to infiltrate the entire volume of the 25-year storm with an overflow or infiltrate 100% of the storm runoff volume.	Single Event Model (SCS or SBUH) Regional Storm (Climatic Regions 1 – 4) or Type 1A Storm (Regions 2 and 3)

Regional Storms

Climatic Regions

As stated in the Beginning Storm Shed class, there are 4 climatic regions within eastern Washington. Climatic Regions 2 and 3 can use the Type IA Storm, however Climatic Regions 1 and 4 are required to use the Long Duration Storm. Description of the regions can be found in section 4D-2 of the HRM and shown below. Additionally, the Mean Annual Precipitation Map, Figure 4-3.1, on HQ Hydraulics web page or Appendix 4A of the HRM visually shows the location of the regions and is included on the next page of this tutorial.

Climatic Region Descriptions

Region 1 – East Slopes of Cascade Mountains

This region is comprised of mountain areas on the east slopes of the Cascade Mountains. It is bounded on the west by the Cascade crest and generally bounded to the east by the contour line of 16-inches mean annual precipitation.

Region 2 – Central Basin

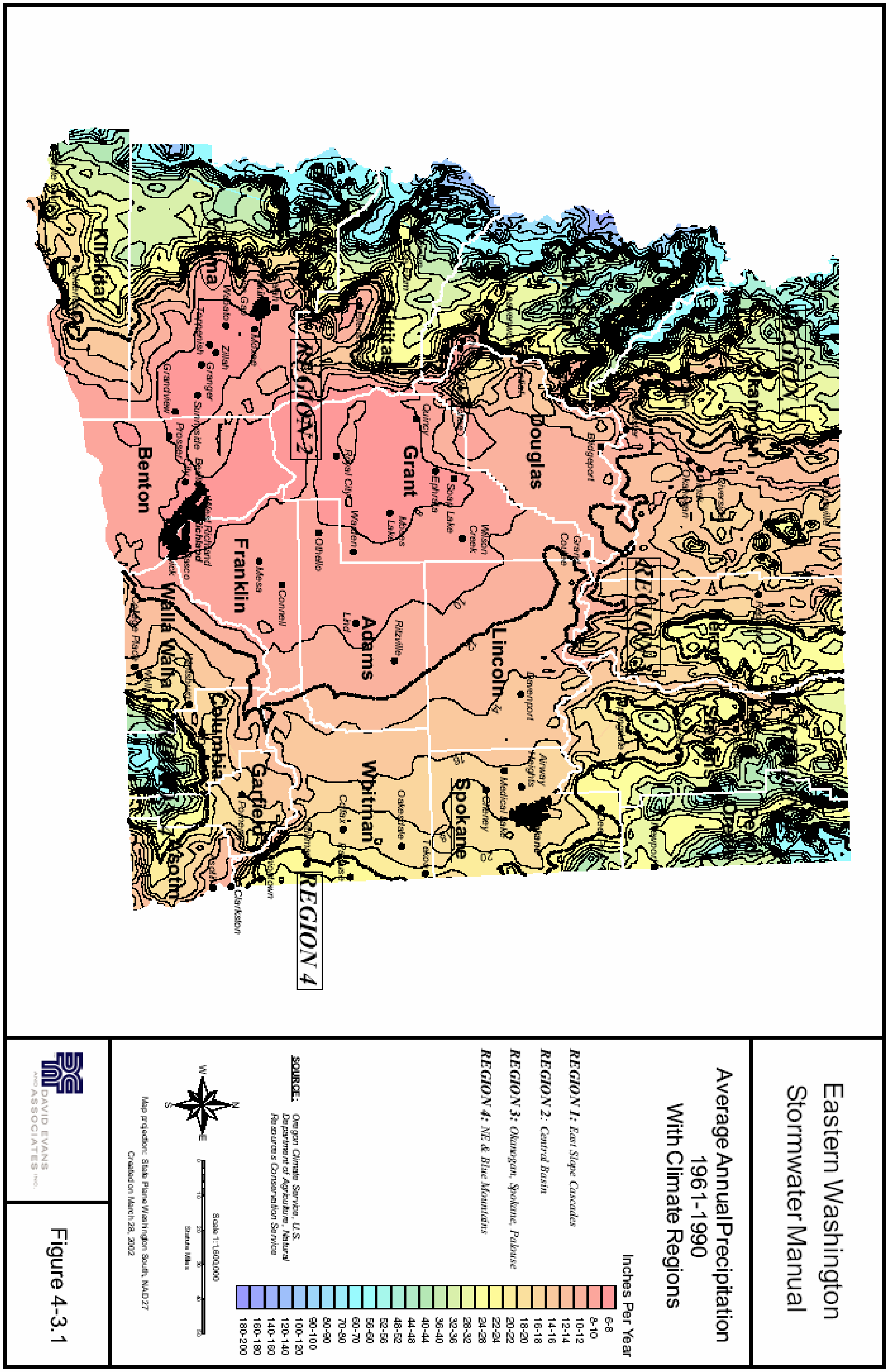
The Central Basin region is comprised of the Columbia Basin and adjacent low elevation areas in central Washington. It is generally bounded on the west by the contour line of 16-inches mean annual precipitation at the base of the east slopes of the Cascade Mountains. The region is bounded on the north and east by the contour line of 12-inches mean annual precipitation. Most of this region receives about eight inches of mean annual precipitation. Many of the larger cities in eastern Washington are in this region, including: Ellensburg, Kennewick, Moses Lake, Pasco, Richland, Wenatchee, and Yakima.

Region 3 – Okanogan, Spokane, Palouse

This region is comprised of inter-mountain areas and includes areas near Okanogan, Spokane, and the Palouse. It is bounded on the northwest by the contour line of 16-inches mean annual precipitation at the base of the east slopes of the Cascade Mountains. It is bounded on the south and west by the contour line of 12-inches mean annual precipitation at the eastern edge of the Central Basin. It is bounded on the northeast by the Kettle River Range and Selkirk Mountains at approximately the contour line of 22-inches mean annual precipitation. It is bounded on the southeast by the Blue Mountains, also at the contour line of 22-inches mean annual precipitation.

Region 4 – Northeastern Mountains and Blue Mountains

This region is comprised of mountain areas in the easternmost part of Washington State. It includes portions of the Kettle River Range and Selkirk Mountains in the northeast, and the Blue Mountains in the southeast corner of eastern Washington. Mean annual precipitation ranges from a minimum of 22-inches to over 60-inches. The western boundary of this region is the contour line of 22-inches mean annual precipitation.



Eastern Washington
Stormwater Manual
Average Annual Precipitation
1961-1990
With Climate Regions
Inches Per Year
REGION 1: East Slope Cascades
REGION 2: Central Basin
REGION 3: Okanogan, Spokane, Palouse
REGION 4: NE & Blue Mountains
SOURCE: Oregon Climate Service, U.S. Department of Agriculture, Natural Resources Conservation Service
Scale 1:1,600,000
Statute Miles
Map projection: State Plane Washington South, NAD 27
Created on March 28, 2002
DAVID EVANS AND ASSOCIATES INC.
Figure 4-3.1
REGION 1
REGION 2
REGION 3
REGION 4
Klickitat
Yakima
Kittitas
Douglas
Grant
Benton
Franklin
Adams
Lincoln
Walla Walla
Columbia
Garfield
Whitman
Spokane

Regional Storms

Long Duration (Regional) Storms – Description

When rainfall patterns during storms were analyzed in eastern Washington, it was concluded that the SCS Type II rainfall distribution does not match the historical records for the two storm types of interest for stormwater analyses in eastern Washington: the short duration thunderstorm and the long-duration winter storm. Short duration storms are further discussed in the Beginning Storm Shed Tutorial; the focus of this tutorial will be long-duration storms.

Long-duration general storms can occur at any time of the year, but are most common in late fall through winter, and in late spring and early summer. General storms in eastern Washington vary by region and are characterized by sequences of storms and intervening dry periods, occurring over 72 hours, see Figure 4D-4 below. Low to moderate storm intensity precipitation is typical during the periods of storm activity. These types of events can produce floods with moderate peak discharge and large runoff volumes. The runoff volume can be augmented by snowmelt when precipitation falls on snow during winter and early spring storms. These types of storms are important where runoff volume and peak discharge are design considerations.

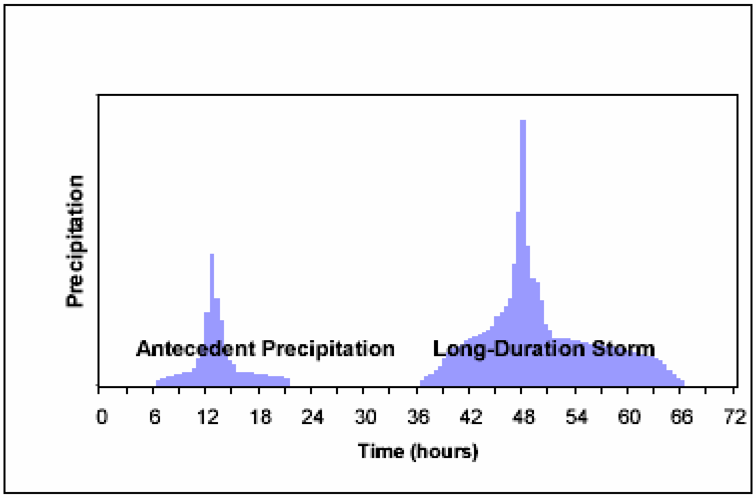


Figure 4D-4. Sample long-duration storm hyetograph.

The smaller event (Antecedent Precipitation from 6 to 21 hours, above) is insufficient to generate runoff that is present when the larger precipitation commences. For that reason, it is not necessary to directly model the smaller precipitation event. Only the larger portion (commencing at 36 hours as shown above) is necessary to directly model.

The larger portion is similar to the 24-hour SCS Type 1A storm. For climate regions 2 and 3, the SCS Type IA storm is sufficiently similar to the four regional long-duration storm hyetographs to use directly.

Tabular values of the regional long-duration storm hyetographs are listed in Table 4D-8 to 4D-11.

Long Duration (Regional) Storms – Precipitation Adjustment

If the 24-hour SCS Type 1A storm is used for the long-duration storm, the precipitation totals are the 24-hour amounts without adjustment. If the regional long-duration hyetographs are used, the precipitation totals need to be adjusted as indicated for Regions 1 and 4.

Table 4D-11 provides the multipliers, by region, for the conversion of the 24-hour precipitation to the regional long-duration storm precipitation. Using the precipitation values from the Isopluvial Maps and the conversion factor below, the precipitation can be adjusted for the long-duration hyetograph.

Table 4D-11. Conversion factor for 24-hour to regional long-duration storm precipitation.

Region #	Region Name	Conversion Factor
1	East Slope Cascades	1.16
2	Central Basin	1.00
3	Okanogan, Spokane, Palouse	1.06
4	NE & Blue Mountains	1.07

$$P_{sds} = C_{sds} (P_{N\text{-}yr\ 24\text{-}hr})$$

Where:

P_{sds} - the precipitation adjusted for the long duration hyetograph.
C_{sds} - a conversion factor Table 4D-11
$P_{N\text{-}yr\ 24\text{-}hr}$ - The precipitation from the Isopluvial maps for N years and 24 hours.

Long Duration (Regional) Storms – Antecedent Moisture Content

Regardless whether the 24-hour SCS Type 1A or regional hyetographs are used for long-duration storm modeling, the prior soil wetting produced by the smaller storm event (antecedent precipitation from 6 hours to 21 hours) that is not modeled needs to be accounted for. The Antecedent Moisture Content (AMC), can have a significant effect on both the volume and the rate of runoff. Recognizing this, the SCS developed three antecedent soil moisture conditions, labeled conditions I, II, and III.

AMC I: Soils are dry but not to the wilting point

AMC II: Average Conditions

AMC III: Heavy rainfall, or light rainfall and low temperatures, has occurred within the last 5 days; bear saturated or saturated soil.

The amount of antecedent precipitation can be expressed as a percentage of the total precipitation modeled, as shown in Table 4D-1. Using the Table, the precipitation should be multiplied by the percentage in the Table for an applicable Region.

Regional Storms

Table 4D-1. Antecedent precipitation prior to long-duration storm.

Region #	Region Name	Antecedent Precipitation as Percentage of 24-Hour SCS Type 1A Storm Precipitation
1	East Slope Cascades	33%
2	Central Basin	19%
3	Okanogan, Spokane, Palouse	27%
4	NE & Blue Mountains	36%

Region #	Region Name	Antecedent Precipitation as Percentage of Regional Long-Duration Storm Hyetograph Precipitation
1	East Slope Cascades	28%
2	Central Basin	19%
3	Okanogan, Spokane, Palouse	25%
4	NE & Blue Mountains	34%

Next, the P_{sds} value is compared to Table 4D-2 to determine the AMC for the soil. Since the long duration storm occurs mostly in late fall through winter and late spring through early summer, most all long duration storms occur during the dormant season and designers should use the dormant column. The chart below was developed for other states and is more applicable in the Midwest where the long duration storm occurs during the growing season.

Table 4D-2. Total 5-day antecedent rainfall (inches).

AMC	Dormant Season	Growing Season
I	Less than 0.5	Less than 1.4
II	0.5 to 1.1	1.4 to 2.1
III	Over 1.1	Over 2.1

Long Duration (Regional) Storms – CN Adjustments from AMC Values

Curve number in Appendix 4B of the HRM are based on AMC values of II. If the AMC is determined to be other than II, designers should consult Table 4B-4 to adjust the CN value as specified.

Table 4B-4. Curve number conversions for different antecedent moisture conditions (case Ia = 0.2 S).

CN for AMC II	CN for AMC I	CN for AMC III
100	100	100
99	97	100
98	94	99
97	91	99
96	89	99
95	87	98
94	85	98
93	83	98
92	81	97
91	80	97
90	78	96
89	76	96
88	75	95
87	73	95
86	72	94
85	70	94
84	68	93
83	67	93
82	66	92
81	64	92
80	63	91
79	62	91
78	60	90
77	59	89
76	58	89
75	57	88
74	55	88
73	54	87
72	53	86
71	52	86
70	51	85
69	50	84
68	48	84
67	47	83
66	46	82
65	45	82
64	44	81
63	43	80
62	42	79
61	41	78
60	40	78
59	39	78
58	38	76
57	37	75
56	36	75
55	35	74
54	34	73
50	31	70

Source: SCS-NEH4. Table 10.1.

Long Duration (Regional) Storms – Example Problem

A section of highway near the city of Spokane is to be improved and the Regional Storm will be used for flow control. The soil in the project vicinity has been identified as type B, meadow.

1. Using the descriptions on page 27 and Figure 4-3.1, the climatic region for Spokane is region 3. From Table 4-9, climatic region 3 can either used the Type IA storm or the regional long duration storm. For this example we will use the regional storm.

2. Using the Isopluvial Maps, the 24 hour precipitation values for the following storms were found and noted below. A section of the maps is shown below, remember the values are listed in tenths of an inch.

   $P_{2\text{-yr 24-hr}}$ = 1.4 in
   $P_{25\text{-yr 24-hr}}$ = 2.2 in
   $P_{100\text{-yr 24-hr}}$ = 2.6 in

25 year 24 hour **100 year 24 hour**

3. Using Table 4D-11, adjust the precipitation for the long duration storm. These values should be input into StormShed and used to size the ponds. *(Remember if the Type IA storm were used, this step would be skipped.)*

   $P_{2\ yr\ lds}$ = 1.06 (1.4 in) = 1.48 in

   $P_{25\ yr\ lds}$ = 1.06 (2.2 in) = 2.33 in

   $P_{100\ yr\ lds}$ = 1.06 (2.6 in) = 2.76 in

4. Determine the affects of the AMC using the lower table of Table 4D-1. Remember this is the moisture content from the first hump of the storm. For Region 3, use 25%:

   2.33 (0.25) = 0.58

5. Now we will determine what the AMC values mean by referencing Table 4D-2. Since our values are between 0.5 and 1.1, we will not be making any adjustment to the CN value. If the precipitation values were determined to be greater than the limits listed in the table, the CN of 58 could be adjusted to 76 as shown in Table 4B-4.