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501 INTRODUCTION

The criteria for rainfall design presented in this section shall be used to calculate runoff using the accepted methodologies in Section 600. All detailed hydrologic analysis shall use the rainfall data presented herein for calculating storm runoff.

The National Oceanic and Atmospheric Administration (NOAA) published the *NOAA Atlas 2, Volume 3* (Atlas 2) in 1973 (NOAA, 1973). Atlas 2 was officially superseded by *NOAA Atlas 14* (Atlas 14) (NOAA, 2013) on April 19, 2013, for Colorado. The UDFCD then conducted a detailed evaluation of Atlas 14. While the point rainfall values in Atlas 14 are lower than those in Atlas 2, the Atlas 14 values were determined not to be statistically significantly different from the Atlas 2 values. Furthermore, nearly all infrastructure built in the last 40 years was based on the Atlas 2 values and has performed very well during flood events. The UDFCD ultimately determined continuing using point rainfall depths from Atlas 2 for hydrologic analysis in the Denver metro area was preferred. The UDFCD published a memorandum that details their findings (MacKenzie, 2013), which can be found on their website (*http://udfcd.org/wp-content/uploads/uploads/resources/position%20papers/UDFCD_Position_on_the 2013_NOAA_Precipitation-Frequency_Atlas.pdf*) or via an internet search for "UDFCD Atlas 14."

Boulder County agrees with the assessment by the UDFCD, and Atlas 2 was used to develop 1-hour and 6-hour point rainfall maps for the 5- and 100-year return periods in the county. These point rainfall maps are presented in Figures 500-1 through 500-4, which is located at the end of this section. These maps are more detailed than those in the USDCM (UDFCD, 2016) and shall be used as long as the UDFCD continues to prefer Atlas 2 to Atlas 14. Equations for intensity and depth were taken from the USDCM. If revisions to these equations are included in future versions of the USDCM, those revisions shall apply.

502 INTENSITY-DURATION CURVES FOR RATIONAL METHOD

To develop depth-duration curves or intensity-duration curves for use with the Rational Method, the 1-hour point rainfall depths for the design storm shall be obtained from Figures 500-1 and 500-3, which are located at the end of this Section. Rainfall intensity can be calculated for a given duration using Equation 500.1. Equation 500.2 can be used to calculate total rainfall depths for durations less than one hour.

$$I = \frac{28.5P_1}{\left(10 + T_d\right)^{0.786}} \qquad (500.1)$$

$$D = \frac{28.5P_1\left(T_d / 60\right)}{\left(10 + T_d\right)^{0.786}} \qquad (500.2)$$

where

I = rainfall intensity (inches/hour)

D = rainfall depth (inches)

P_1 = 1-hour point rainfall depth (inches)

T_d = storm duration or time of concentration (minutes).

503 COLORADO URBAN HYDROGRAPH PROCEDURE RAINFALL HYETOGRAPHS

The Colorado Urban Hydrograph Procedure (CUHP) requires 2-hour rainfall hyetographs to calculate stormwater runoff. The program will automatically create the necessary hyetographs using methodology calibrated to the metro Denver area. Hyetographs creation of requires the 1-hour point rainfall depth, which are available in Figures 500-1 through 500-4, located at the end of this section, as well as the return period for the design storm. CUHP will also create area-corrected hyetographs for project areas with a watershed greater than 10 square miles (see Section 504). The 6-hour point rainfall and watershed area in square miles are required to calculate an area-corrected hyetograph. Hyetographs with durations longer than 2 hours are automatically generated as required for area correction. Hyetographs generated by CUHP are recommended for most projects, but a user-defined hyetograph can be entered if required. The reader should refer to the CUHP users' manual for additional information.

504 WATERSHED SIZE RAINFALL DISTRIBUTION ADJUSTMENTS

Rainfall distributions for watersheds larger than 10 square miles need to be adjusted to account for rainfall not typically being evenly distributed over such a large area. The adjustment procedure is performed within CUHP on the Raingages worksheet. Any CUHP subcatchment draining to a design point with a total drainage area larger than 10 square miles must use an area-corrected rainfall distribution. Note that the requirement for area correction is determined at the design point level. CUHP subcatchment hydrographs that were created for a design point that requires area correction cannot be used for the analysis of a design point that either does not require area correction or requires a different amount of area correction. A large project with multiple design points may require multiple hydrologic models to account for the varying amounts of area correction that are required at different design points. Individual area-corrected rainfall distributions should typically be created each time a design point with a total drainage area changes by more than 10 square miles. For example, a unique rainfall distribution should be created for use with design points with a drainage area greater than 10, 20, 30, and 40 square miles, and so on; although, specific projects may require a higher degree of refinement.

505 REFERENCES

MacKenzie, K., 2013. *USFCD Position of the NOAA Atlas 14 Precipitation-Frequency Atlas, Volume 8*, memorandum prepared by K. Mackenzie, Urban Drainage and Flood Control District, Denver, CO.

National Oceanic and Atmospheric Administration, 2013. *Precipitation-Frequency Atlas of the United States, Midwestern States (Colorado, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Oklahoma, South Dakota, Wisconsin),* NOAA Atlas 14, Vol. 8, prepared by the National Oceanic and Atmospheric Administration, Washington, DC.

National Oceanic and Atmospheric Administration, 1973. *Precipitation-Frequency Atlas of the Western United States, Colorado*, NOAA Atlas 2, Vol. III, prepared by the National Oceanic and Atmospheric Administration, Washington, DC.

Urban Drainage and Flood Control District, 2016. *Urban Storm Drainage Criteria Manual: Volume 1 Management, Hydrology, and Hydraulics*, prepared by the Urban Drainage and Flood Control District, Denver, CO.

Figure 500-1 Boulder County 5-Year 1-Hour Point Rainfall Depths

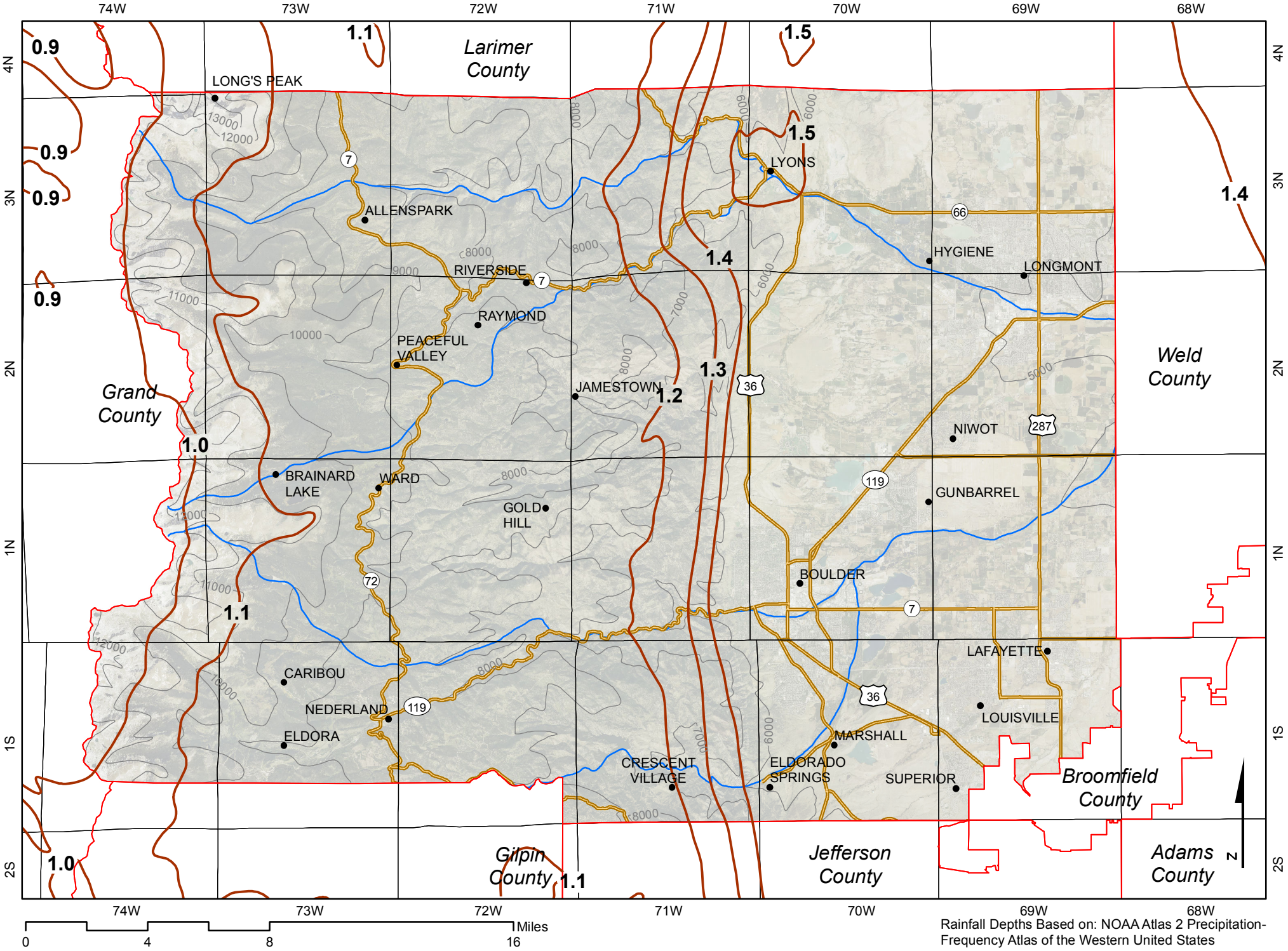

Figure 500-2 Boulder County 5-Year 6-Hour Point Rainfall Depths

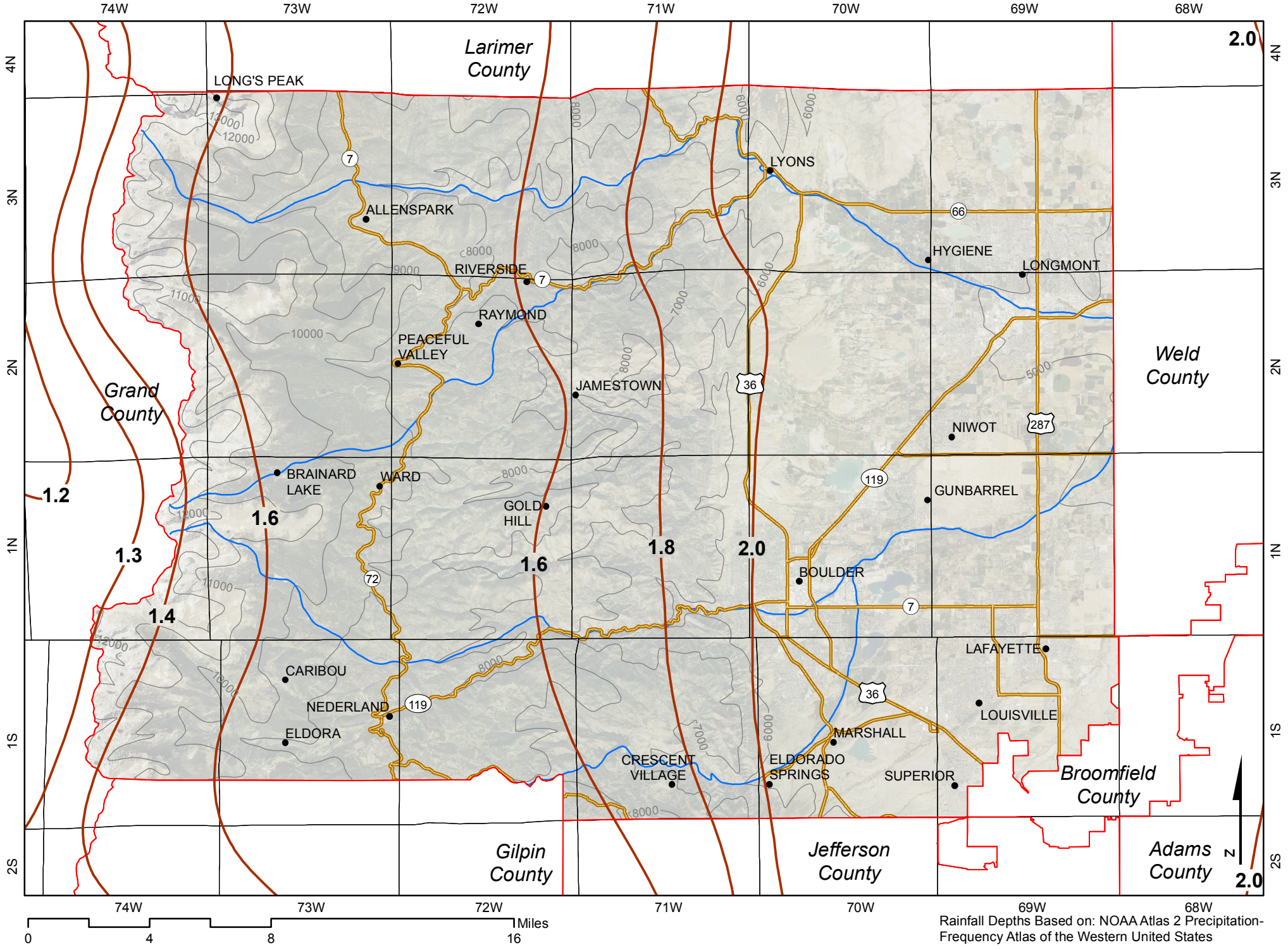

Figure 500-3 Boulder County 100-Year 1-Hour Point Rainfall Depths

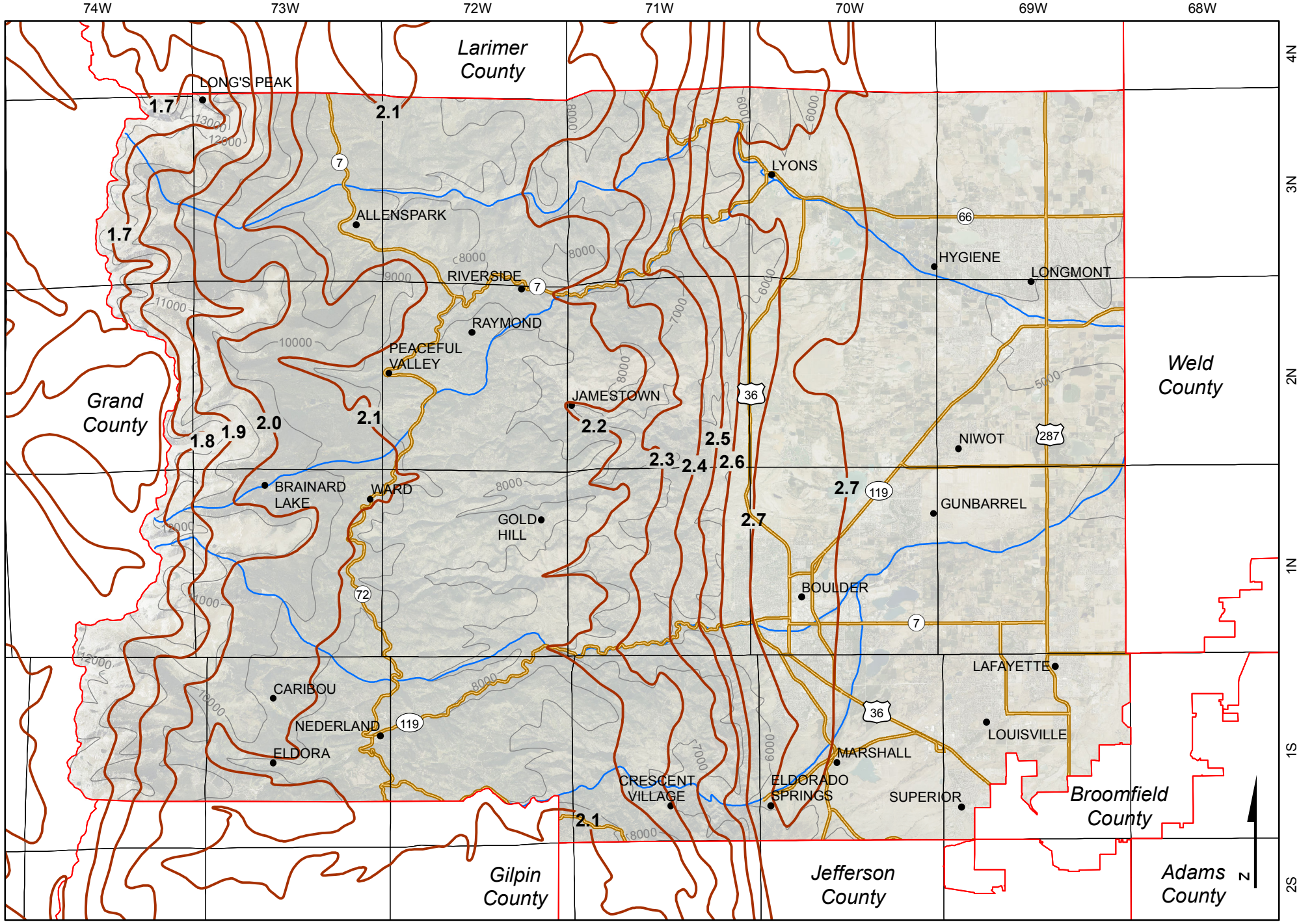

Figure 500-4 Boulder County 100-Year 6-Hour Point Rainfall Depths