Real-Time Rainfall Measurement in the City of Charlotte and Mecklenburg County, North Carolina

A Partnership between the U.S. Geological Survey and Local Governments

Prepared by: W.F. Hazell and Jerad D. Bales

Fact Sheet FS-052-97

The U.S. Geological Survey (USGS) has measured rainfall at various locations in Mecklenburg County, North Carolina, since 1963. Between 1992 and 1997, the USGS, in cooperation with Charlotte Stormwater Services, installed 43 raingages throughout Mecklenburg County and adjoining counties (fig. 1). These 43 raingages, combined with three previously installed gages, compose a data-collection network that provides detailed, accurate information on rainfall throughout the county.

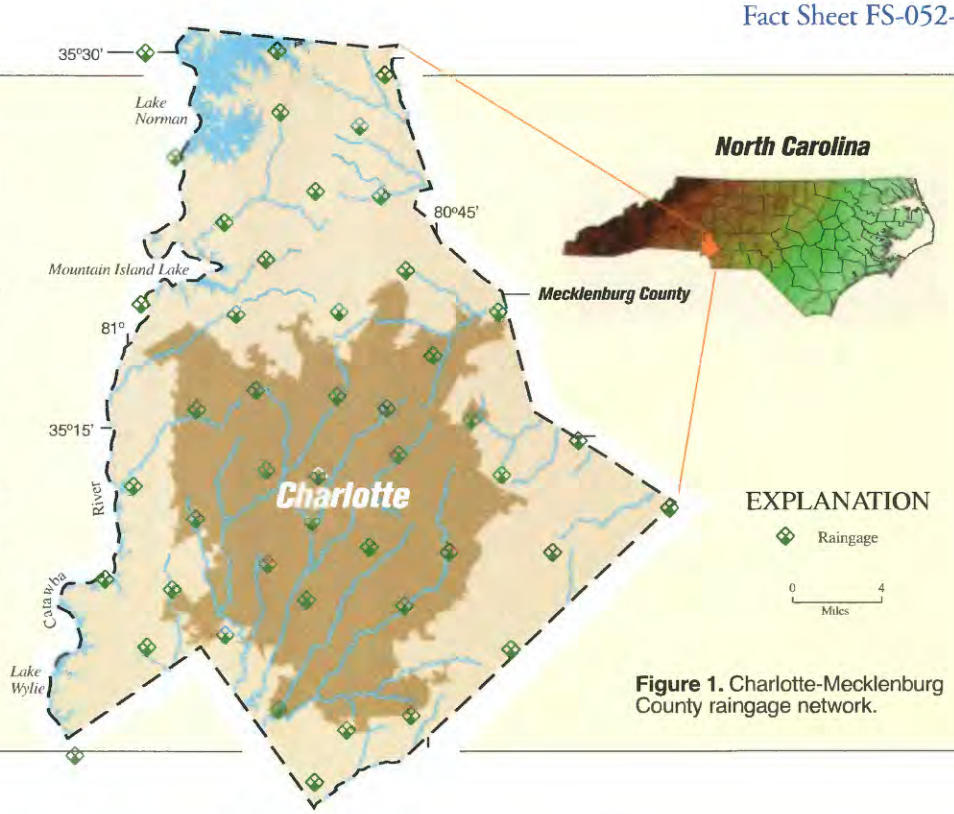

Figure 1. Charlotte-Mecklenburg County raingage network.

The Rainfall Network

The rainfall network consists of 46 raingages. Forty-one of the gages are located within Mecklenburg County, and five gages are located just outside the county line. These raingages are located in 37 named stream basins in the county, including all of the major stream basins in Charlotte and Mecklenburg County. Rainfall is measured to the nearest 0.01 inch at 5-minute intervals.

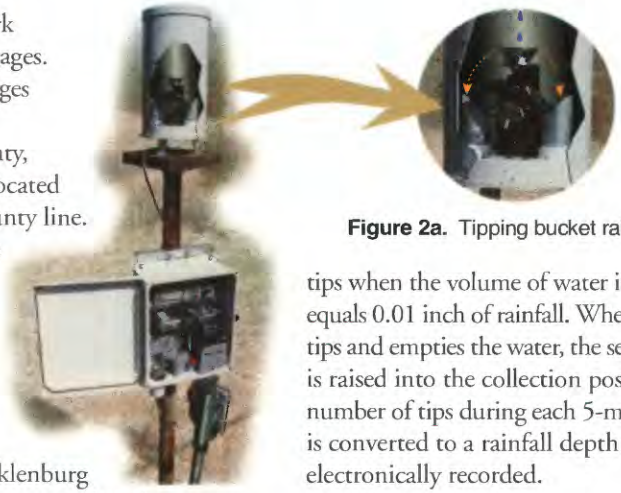

Figure 2a. Tipping bucket raingage.

Most of the gages in the network are tipping-bucket raingages (fig. 2a). A tipping-bucket raingage collects rainfall in an 8-inch diameter funnel resting above the tipping assembly, which consists of a center-pivot arm with small buckets on each end of the arm. Rainfall is directed into a bucket, which tips when the volume of water in the bucket equals 0.01 inch of rainfall. When the bucket tips and empties the water, the second bucket is raised into the collection position. The number of tips during each 5-minute period is converted to a rainfall depth that is electronically recorded.

Collection-well raingages (fig. 2b) are used at a few sites in the network, because this type of raingage is less susceptible to vandalism than are tipping-bucket gages. Collection-well gages consist of a 10-inch by 5-inch catchment which funnels rainfall to a 3-inch diameter collection well. A float in the pipe is attached to an electronic encoder that records the water level in the collection well, and water level is then converted to a rainfall amount. Each raingage is connected by land-line telemetry to the USGS data base. Data from each raingage are automatically retrieved daily, then processed and stored in the data base using computer software developed by the USGS. The raingages also can be manually interrogated at any time by using a computer and modem. In this way, rainfall amounts during a storm can be remotely monitored in real time. The gages also are programmed to dial a digital pager whenever preset rainfall amounts or rates are exceeded. More information and selected data can be found in Robinson and others (1996).

Figure 2b. Collection well raingage.

Rainfall in the City of Charlotte and Mecklenburg County

Rainfall amounts for individual storms often are quite variable over the county. For example, during June 19-20, 1996, rainfall amounts ranged from 0.31 to 3.02 inches at sites in Mecklenburg County (fig. 3). Because the small streams in the county generally respond very quickly to rainfall, emergency and post-event response to flooding can be complicated by such widely varying rainfall amounts.

Total annual rainfall also is quite variable spatially. During 1995, rainfall amounts recorded in the City of Charlotte ranged from about 42 to about 58 inches (fig. 4). The entire 46-gage network was not complete during this period, so the isohyetals (lines of equal rainfall amount) cannot be reliably extended to all parts of Mecklenburg County. The 46-gage network makes it possible for rainfall to be reliably estimated for the entire county.

In addition to rainfall amounts, storm recurrence intervals are of interest to city and county stormwater managers. Most drainage structures (for example, culverts and detention ponds) are designed to accommodate rainfall amounts from an event having a specific duration and recurrence interval. The recurrence interval, in years, (also called the return period) of a rainfall event having a specific duration and amount is an indication of the probability that the amount will be equalled or exceeded during any given year. For example, a recurrence interval of 10 years indicates that there is a 1 in 10 (or 10-percent) chance that 2.4 inches of rainfall will fall in 1 hour in Mecklenburg County in any year (figure 5). Likewise, there is a 1 in 2 (or 50-percent) chance that 3.5 inches of rainfall will fall during a single 24-hour period in the county during any given year. The information in figure 5 is based on rainfall frequency-duration relations for the United States developed by Hershfield in 1961 using available historic data.

The USGS developed software to search rainfall records from each site to determine the greatest rainfall amount occurring during any consecutive 0.5-, 1-, 2-, 3-, 6-, 12-, and 24-hour period for a specific rainfall event. These amounts are then converted to recurrence intervals by using the information in figure 5, and are displayed on a map. As an example, the recurrence intervals in Mecklenburg County for the storm of

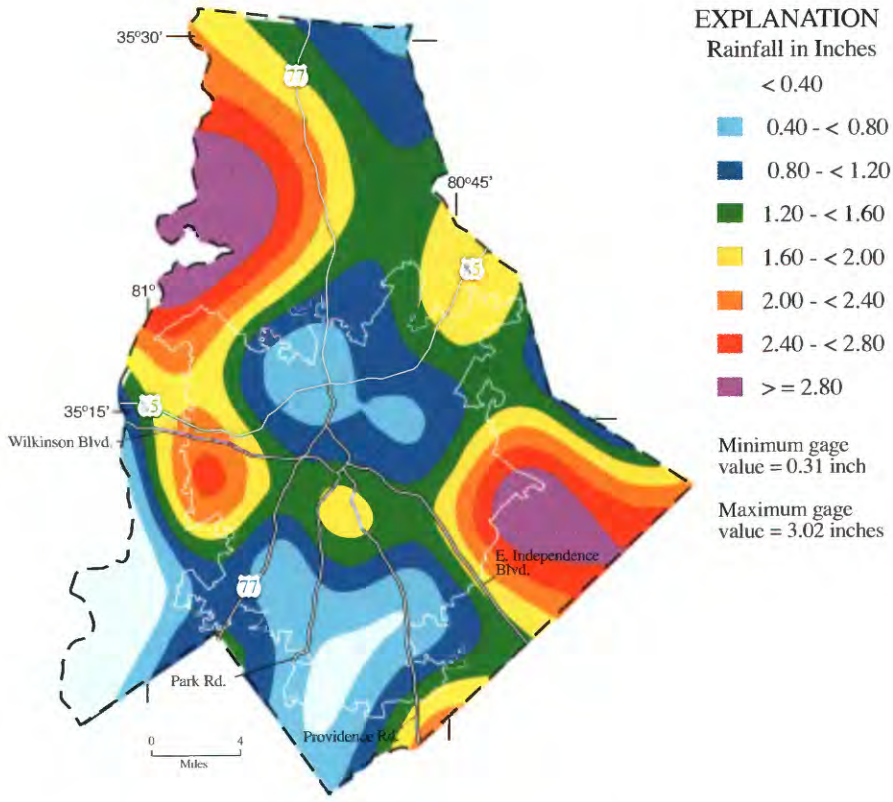

Figure 3. Total rainfall amounts in Mecklenburg County for the period 9:45 a.m., June 19,1996, through 8:00 a.m. June 20, 1996.

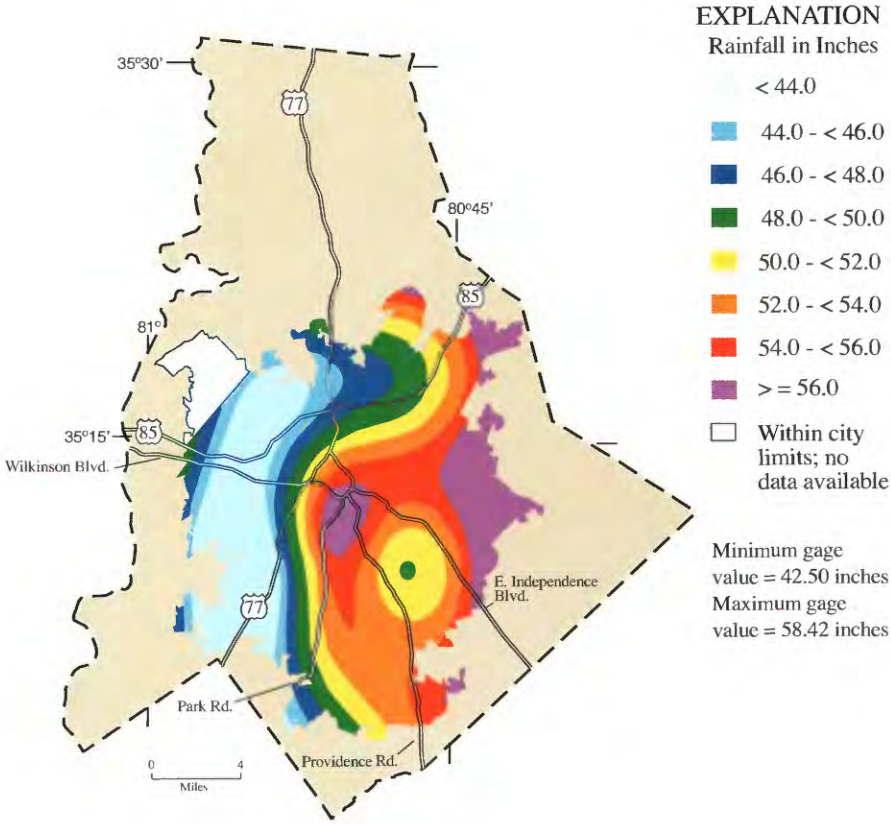

Figure 4. Total rainfall amounts in the City of Charlotte for 1995.

August 26-27, 1995, ranged from less than 1 year to more than 100 years for a 24-hour event (fig. 6). This information allows managers and mitigation personnel to quickly identify areas in the county where the capacity of drainage structures may have been exceeded, or other problems may have occurred during a storm.

Benefits

The Mecklenburg County rainfall measurement network provides both short- and long-term benefits to the citizens of Charlotte and Mecklenburg County, to city and county personnel, stormwater managers, and to scientists and engineers who provide information to help guide the management of Mecklenburg County water resources and flood-prone areas. Data from the network have been used to provide immediate information to the public on the magnitude of rainfall events. Maps such as figure 3 have been published by The Charlotte Observer and have been displayed on local television news reports. The data are used by city and county personnel to document the magnitude of storms and the associated performance of drainage structures, as well as to assess the performance of sedimentation-prevention practices. Because stormwater runoff can contain large amounts of pollutants, the small streams which drain much of the county must be sampled during and immediately following rainfall in order to determine pollutant loadings (fig. 7). Real-time rainfall data which can be obtained without site visits allow county and USGS personnel to efficiently plan and conduct water-quality sampling throughout Mecklenburg County.

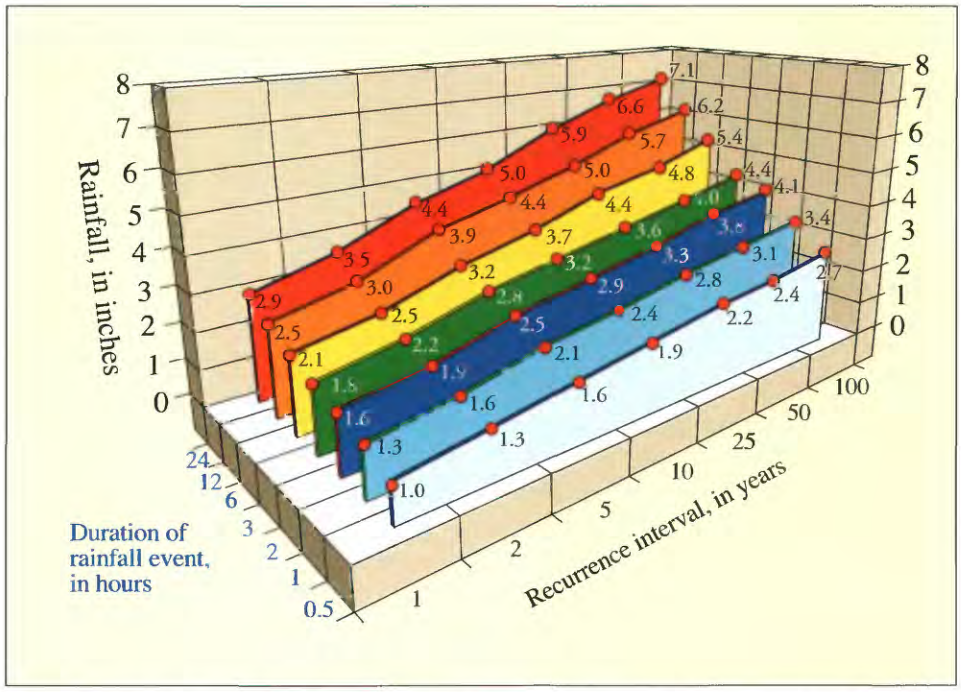

Figure 5. Rainfall amounts (in inches) for selected storm durations and recurrence intervals in Mecklenburg County, North Carolina (adapted from Hershfield, 1961).

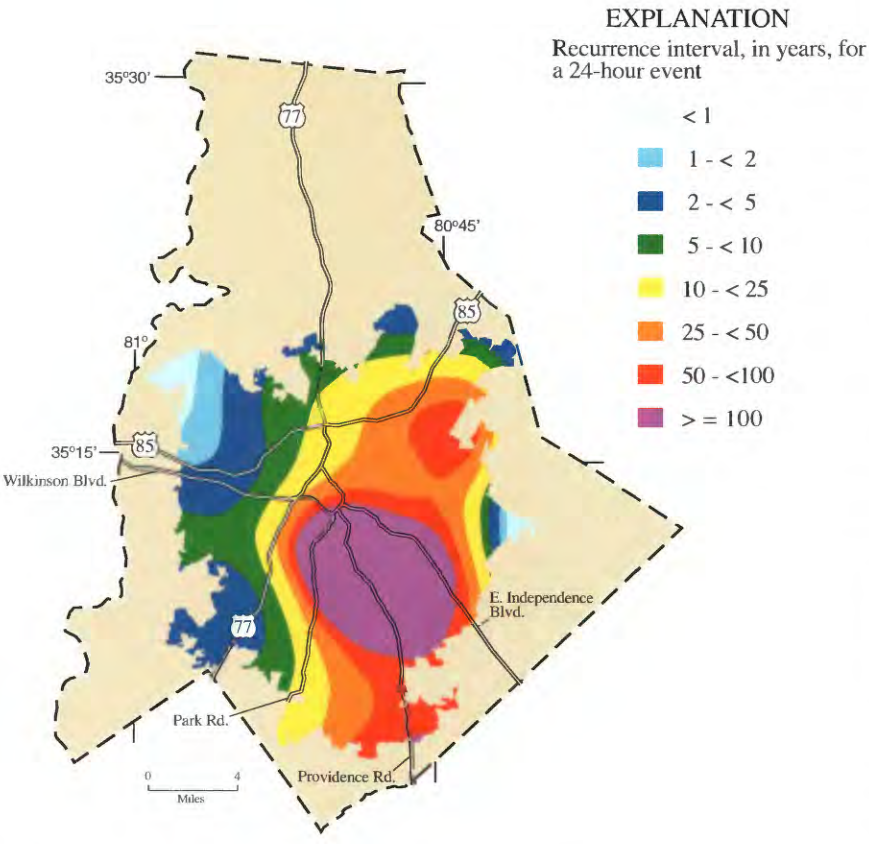

Figure 6. 24-hour recurrence intervals in the City of Charlotte for the storm of August 26-27, 1995.

The rainfall frequency-duration relations (Hershfield, 1961) for Mecklenburg County were developed almost 40 years ago using somewhat limited data. Following collection of about 10 years of data in the Mecklenburg County network, these frequency-duration relations can be re-evaluated using more current data. Moreover, more detailed information on rainfall variations throughout the county will be available.

In addition to the raingage network, the USGS operates a network of 24 streamflow gages in Charlotte and Mecklenburg County. The rainfall data can be used in conjunction with streamflow data to develop rainfall-

runoff models for selected basins in the city and county. These models can be useful for projecting the effects of land-use change, channel alterations, detention ponds, and other drainage structures on streamflow.

Figure 7. Water-quality sampling in McAlpine Creek, Charlotte.

References

Hershfield, W.M., 1961, Rainfall frequency atlas of the United States for durations from 30 minutes to 24 hours and return periods from 1 to 100 years: Washington, D.C., U.S. Weather Bureau, Technical Paper 40.

Robinson, J.B., Hazell, W.F., and Garrett, R.G., 1996, Precipitation, streamflow, and water-quality data from selected sites in the city of Charlotte and Mecklenburg County, North Carolina, 1993-95: U.S. Geological Survey Open-File Report 96-150, 136 p.

Produced by the USGS, Raleigh, N.C.,
J. Caras, Illustrator.

Fact Sheet FS-052-97

In cooperation with several agencies, the USGS conducts other studies in the City of Charlotte and Mecklenburg County.

These studies include:

- Operation of 24 streamflow gaging stations in the County.
- Collection of streamflow and water-quality data from 7 small, single land-use basins in the City of Charlotte in order to determine the relation between land-use and pollutant loadings.
- Collection of streamflow and water-quality data from Gar Creek (1 site) and McDowell Creek (2 sites) to determine the effects of land-use change on water-quality and to quantify pollutant loadings from these basins to Mountain Island Lake.
- Collection of water-quality data in Cowans Ford Dam tailwaters, several locations in Mountain Island Lake, and downstream of Mountain Island Dam to determine inputs to, outputs from, and changes in Mountain Island Lake water quality.
- Development of a dynamic water-quality model for Mountain Island Lake to evaluate the effects of changes in pollutant loadings on lake water quality.

For additional information, contact any of the following:

District Chief
U.S. Geological Survey
3916 Sunset Ridge Road
Raleigh, NC 27607
Phone: (919) 571-4000

The North Carolina District Home Page on the World-Wide Web at http://wwwnc.usgs.gov

The Charlotte Storm Water Services Home Page at http://www.charmeck.nc.us/cistorm/

The Mecklenburg County Storm Water Services Home Page at http://www.charmeck.nc.us/coeng/stwater.htm