Hydrometeorological Design Studies Center
Progress Report for Period
1 July to 30 September 2025

Office of Water Prediction
National Weather Service
National Oceanic and Atmospheric Administration
U.S. Department of Commerce
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DISCLAIMER

The data and information presented in this report are provided only to demonstrate current progress on the various tasks associated with these projects. Values presented herein are NOT intended for any other use beyond the scope of this progress report. Anyone using any data or information presented in this report for any other purpose does so at their own risk.

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I. INTRODUCTION

The Office of Water Prediction (OWP) of the National Oceanic and Atmospheric Administration's (NOAA) National Weather Service (NWS) updates precipitation frequency estimates for parts of the United States and affiliated territories, in coordination with stakeholder requests. Updated precipitation frequency estimates, accompanied by additional relevant information, are published as NOAA Atlas 14 and are available for download from the Precipitation Frequency Data Server (PFDS).

NOAA Atlas 14 is divided into volumes based on geographic sections of the country and affiliated territories. Figure 1 shows the states or territories associated with each of the volumes of the Atlas. To date, precipitation frequency estimates have been updated for AZ, NV, NM, UT (Volume 1, 2004), DC, DE, IL, IN, KY, MD, NC, NJ, OH, PA, SC, TN, VA, WV (Volume 2, 2004), PR and U.S. Virgin Islands (Volume 3, 2006), HI (Volume 4, 2009), Selected Pacific Islands (Volume 5, 2009), CA (Volume 6, 2011), AK (Volume 7, 2011), CO, IA, KS, MI, MN, MO, ND, NE, OK, SD, WI (Volume 8, 2013), AL, AR, FL, GA, LA, MS (Volume 9, 2013), CT, MA, ME, NH, NY, RI, VT (Volume 10, 2015), TX (Volume 11, 2018), and ID, MT, WY (Volume 12, 2024).

OWP is currently working on Volume 13. The Volume 13 project area covers the states of Delaware, District of Columbia, Maryland, North Carolina, Pennsylvania, South Carolina, and Virginia with an additional approximately 1-degree buffer around these states. Figure 1 shows the new and updated project areas included in NOAA Atlas 14, Volumes 1 to 13. For any inquiries regarding NOAA Atlas 14, please email hdsc.questions@noaa.gov.

OWP is developing and implementing NOAA Atlas 15, the future authoritative source and national standard for precipitation frequency information. For more information on the NOAA Atlas 15 development, please visit the NOAA Atlas 15 Informational Page or email us at atlas15.info@noaa.gov for any inquiries regarding NOAA Atlas 15.

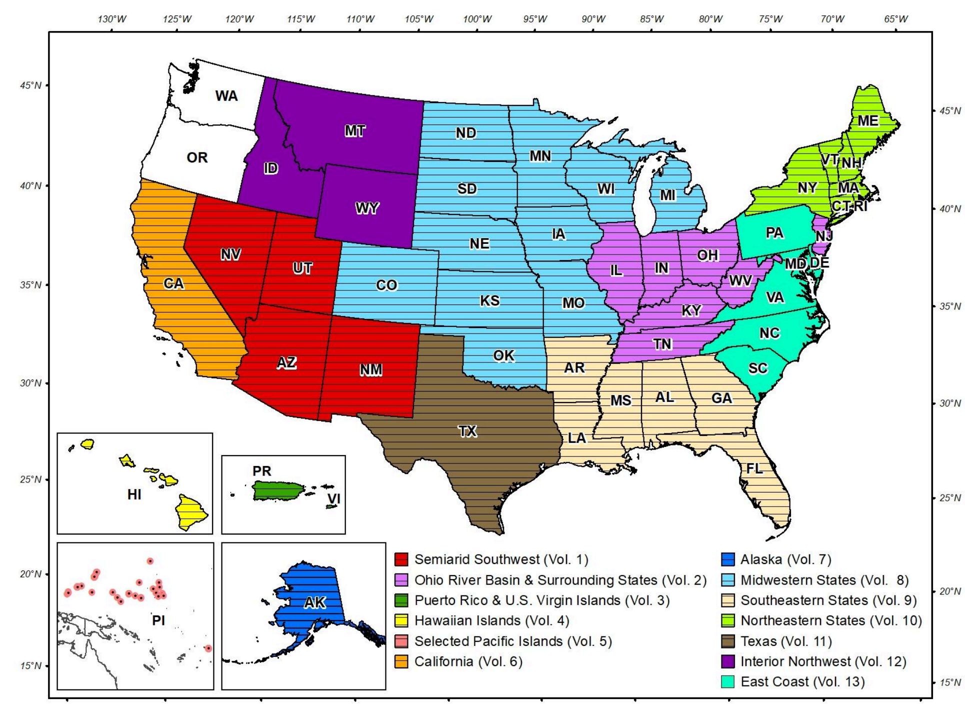

Figure 1. States or territories associated with each of the volumes of the Atlas.

II. CURRENT NOAA ATLAS 14 PROJECTS

1. VOLUME 13: EAST COAST STATES UPDATE

OWP commenced work on NOAA Atlas 14 Volume 13 on July 28, 2022. The precipitation frequency estimates for this volume include the states of Delaware, District of Columbia, Maryland, North Carolina, Pennsylvania, South Carolina, and Virginia and approximately a 1-degree buffer around these states (Figure 2). This project's expected completion date is the end of Q3 in fiscal year 2026.

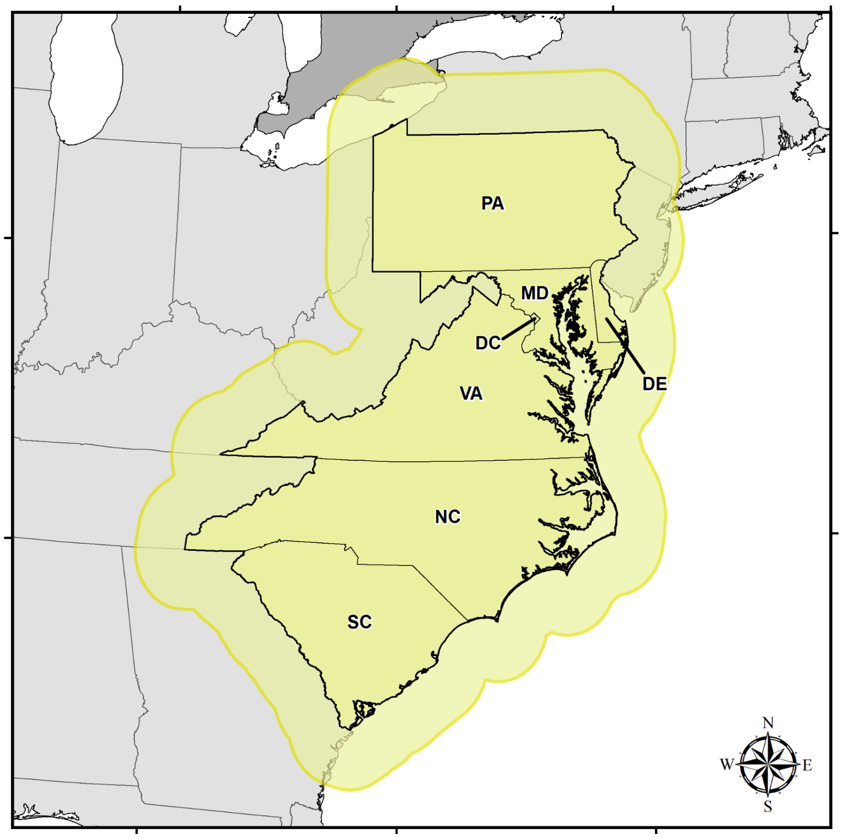

Figure 2. NOAA Atlas 14, Volume 13 extended project area (shown in yellow).

1.1. PROGRESS IN THIS REPORTING PERIOD (July - Sept. 2025)

In the reporting period, we completed and shared the preliminary estimates for review with individuals who expressed interest in the review and/or subscribed to our list server. The Peer Review commenced on August 12 and completed on September 30, 2025. In this period, we also compiled the received feedback and started to address it. We updated the high priority daily datasets, such as NCEI's Global Historical Climatology Network daily (GHCNd) through the end of the water year, September 2025.

For the sources of datasets considered, contacted, downloaded or formatted for the precipitation frequency analysis for NOAA Atlas 14 Volume 12, please see April - June, 2025 Progress Report.

1.1.1. Peer Review

All NOAA Atlas 14 Volumes are subject to peer review which provides critical feedback on the reasonableness of point precipitation frequency estimates, their spatial patterns, and station metadata. This allows us to incorporate the reviewers' local knowledge of rainfall patterns and rain gauge networks into the final product.

On August 12, 2025 we published the preliminary (Version 1) results for Volume 13 on the peer review page (see Figure 3) and sent an invitation for the review to individuals who expressed interest in the review and/or subscribed to our list server. The peer review process concluded on Tuesday, September 30, 2025. At that time, we consolidated and reviewed all comments, and started to address them accordingly.

We received 15 responses from federal (including National Weather Service Forecast Offices), state and local agencies, universities as well as the private sector. Concerns raised were regarding inconsistencies between durations, abrupt/abnormal increases/decreases relative to Volume 2 and differences in some locations when compared to previous NWS and private sector studies. HDSC began reviewing these comments and will address them accordingly.

We will publish all comments (anonymously) with our resulting action as Appendix of Volume 13 document. We greatly appreciate everyone who participated in the Peer Review to help improve the final precipitation frequency estimates for this project area.

For the review, we provided the following Volume 13 preliminary products and encouraged peer reviewers to make comments on:

a. Station metadata. A total of 16,718 stations from 26 datasets were grouped into three categories: a) stations inside the East Coast States that were used in frequency analysis (shown as green squares on the map in Figure 3), b) stations outside the East Coast States that assisted in the analysis (yellow squares), and c) stations that were examined but not retained for the analysis (red squares). We asked reviewers to examine the accuracy of stations' coordinates and provide comments on suggested stations' deletions, merges and co-locations.

b. At-station depth-duration-frequency (DDF) curves. We provided DDF curves for stations retained in analysis for durations between 60-minute and 10-days for average recurrence intervals from 2-year through 100-year. We asked reviewers to examine the curves and let us know if precipitation frequency estimates at the station are in line with expected values.

c. Spatially-interpolated estimates. We created cartographic maps of spatially-interpolated precipitation frequency estimates for 2-year and 100-year ARIs and for 60-minute, 6-hour, 24-hour and 10-day durations (8 maps total) and invited reviewers to comment on the overall and local spatial patterns. Figure 4 shows, as an example, a cartographic map of 100-year 24-hour estimates.

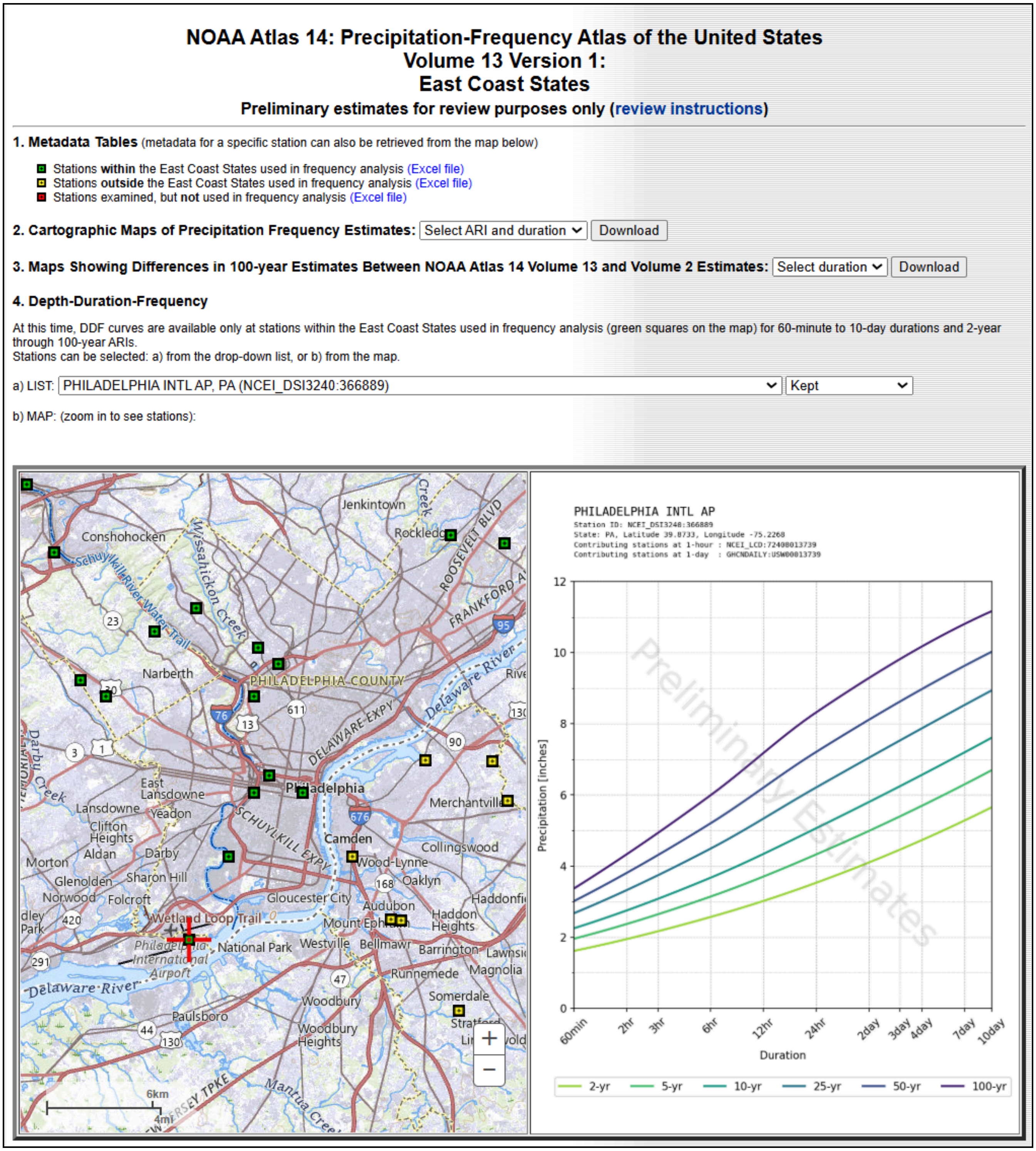

Figure 3. Peer review page for Volume 13.

To illustrate how much estimates changed in the project area, we also created cartographic maps for 100-year estimates showing differences between NOAA Atlas 14 Volume 13 and currently valid NOAA Atlas 14 Volume 2 estimates for 1-hour and 24-hour durations. The map in Figure 5 shows the differences in 100-year 24-hour estimates (in inches) between NOAA Atlas 14 Volumes 13 and 2. The differences in estimates between the two publications are attributed to a number of factors, including differences in frequency analysis, spatial interpolation techniques and in the amount of available data, both in the number of stations and their record lengths, etc.

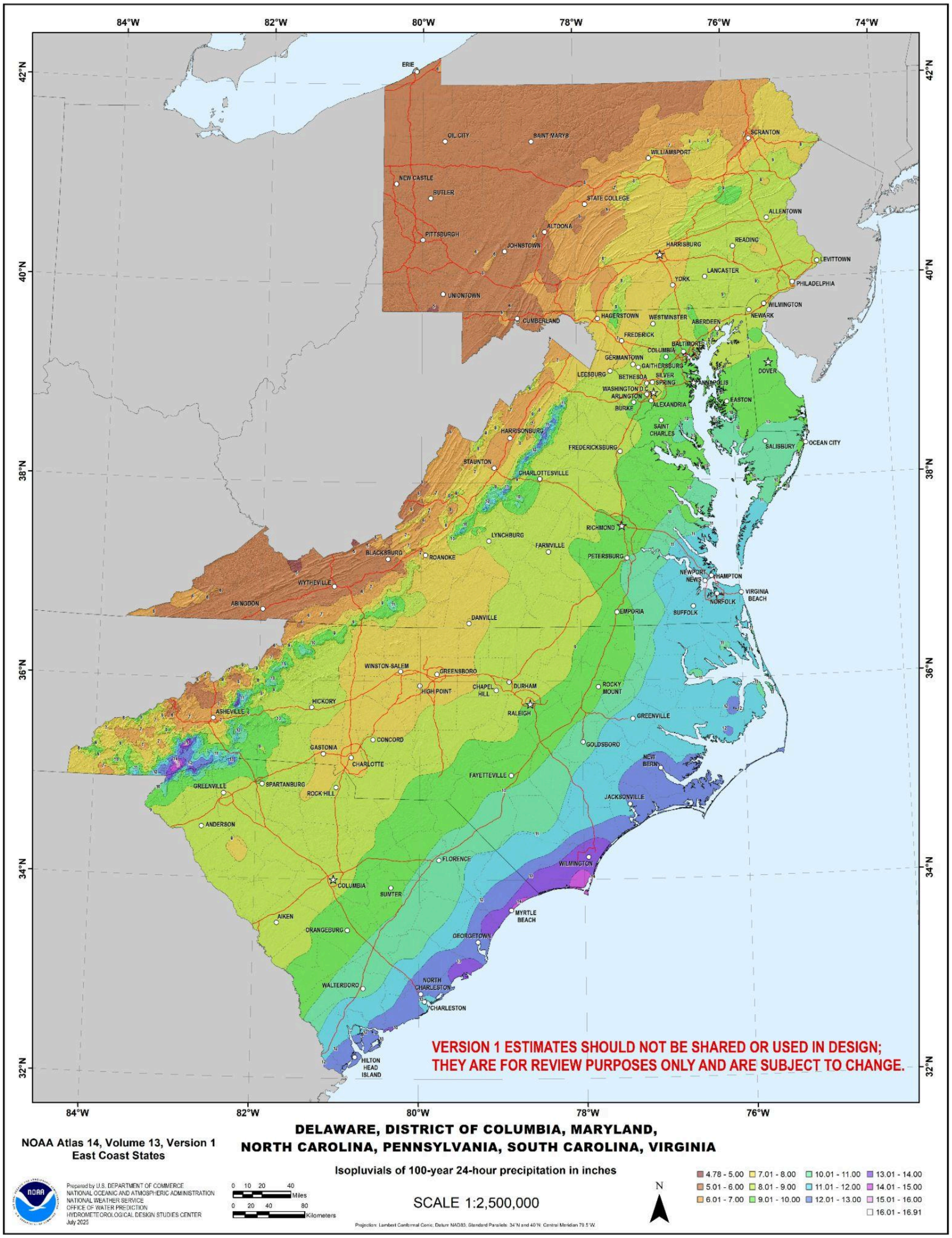

Figure 4. Cartographic map showing 100-year 24-hour estimates (in inches) from NOAA ATLAS 14 Vol 13 Version 1.

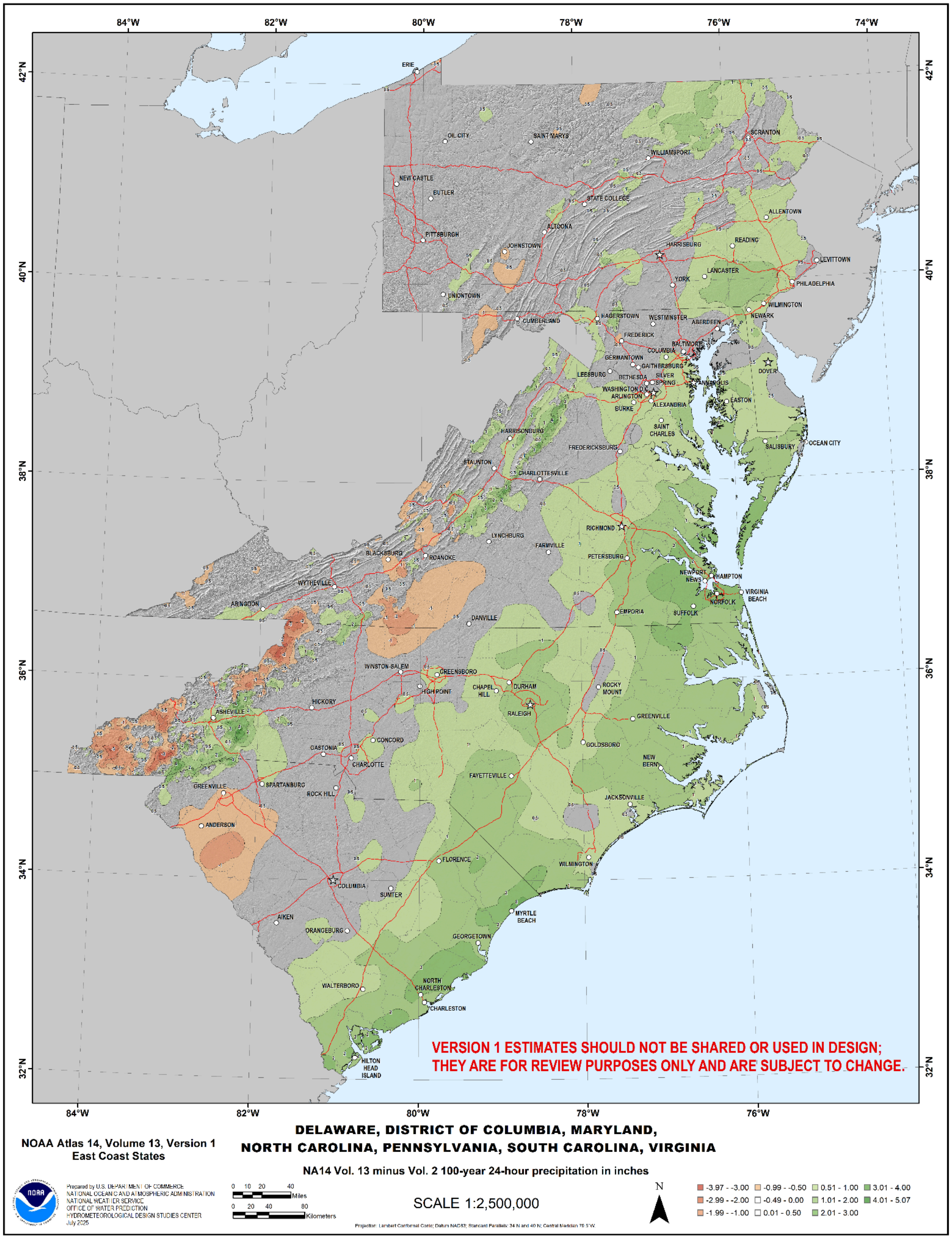

Figure 5. Map showing differences in 100-year 24-hour estimates (in inches) between NOAA ATLAS 14 Vol 13 Version 1 and NOAA Atlas 14 Volume 2.

1.1.2. Development of precipitation frequency estimates

The NOAA Atlas 14 methodology involves fitting the Generalized Extreme Value (GEV) distribution to quality-controlled, unconstrained annual maximum series (AMS) data from individual stations using a regional approach. For NOAA Atlas 14, Volume 13, a few changes have been made to some of the techniques used in previous volumes to align this study with the methodology currently being used in the development of NOAA Atlas 15, the next generation of the precipitation frequency standard. This new standard uses the nonstationary regional Maximum Likelihood approach, which is described in Section 4.3 of the Atlas 15 Pilot Technical Report (Perica at el., 2024). NOAA Atlas 14 Volume 13 is a stationary analog of the methodology employed in NOAA Atlas 15. Here is a summary of the changes compared to the previous NOAA Atlas 14 volumes:

- **Parameter Estimation Technique:** In earlier volumes of NOAA Atlas 14, distribution parameters and the resulting precipitation frequency estimates at each station were determined based on the mean of the annual maximum series at the station, as well as regionally derived higher-order L-moment statistics (e.g., Trypaluk et al., 2024). Instead of using L-moment statistics, maximum likelihood (MLE) parameter estimation techniques are used in this volume (Wilks, 1938, Landwehr et al., 1979, Martins and Stedinger, 2000, Coles, 2001, Katz et al., 2002, El Adlouni et al., 2007, Agilan and Umamahesh, 2016 & 2017).

- **Regionalization Mean**: The NOAA Atlas 14, Volume 13, follows a regionalization approach that closely mirrors the one used in the previous volumes, except that the regionalization is fully automated. This approach begins with the selection of regional stations located within a 160-km radius of each target station, and then regional stations are weighted based on similarity with the target station characteristics identified through spatial variables (i.e., attributes) listed in Table 1.

Table 1: Attributes and attribute's bounds

Attribute	Description	Min Bound	Max Bound
Search Radius	Geographic search area around the target station	70 km	160 km
dMAM	Percentage difference in Mean Annual Maximum precipitation	40%	75%
dMAP	Percentage difference in Mean Annual Precipitation	70%	105%
dElev	Difference in ground elevation	700 m	1200 m
elevR	Elevation range along the path	1200 m	1700 m
elevOH	Obstacle height along the path	600 m	1100 m
dDist2Coast	Relative difference in distance to coast	1	3

Each attribute for the regional stations had pre-defined minimum and maximum allowable value and if the attribute value was within the acceptable range, a weight was then computed using a triweight kernel function, which assigns a weight of 1 for values at the minimum bound and gradually decreases it to 0 as the value approaches the maximum bound. The final weight assigned to each regional station was the cumulative product of all individual attribute weights.

- **Mean Annual Maxima:** The NOAA Atlas 14, Volume 13, mean annual maxima (MAM) grids closely follow the methodology used in previous NOAA Atlas 14 volumes (Trypaluk et al, 2024). In the past, MAM grids were developed in partnership with the Oregon State University PRISM group (Daly et al., 2002; Appendix A.3. PRISM Report of Trypaluk et al., 2024). For this study, MAM grids are developed in partnership with the NOAA Atlas 15 technical team members, who are listed in alphabetical order in the Acknowledgements of the Atlas 15 Pilot Technical Report (Perica at el., 2024). Similar to previous volumes, MAM grids at daily durations (24-hour and longer) were fitted using a relationship between the PRISM Mean Annual Precipitation and the corresponding duration for the MAM. For example, the 24-hour MAM grid was produced using the following relationship:

$$MAM24h = a + b * sqrt(MAP),$$

where "a" and "b" are fitted coefficients. This fit is performed at each gridpoint independently, and stations are weighted by distance from the gridpoint, difference in MAP from the gridpoint, obstacle height (e.g. mountain between a station and the gridpoint), and difference of the relative distance to coast between the stations and the gridpoint.

For sub-daily durations, the relationship is proportional to the 24-hour MAM grid produced. For example, for the 6-hour duration:

$$MAM6h = a * MAM24h$$

Similar to daily durations, this fit is performed independently at each gridpoint. Station weights for these durations, however, are distance from the gridpoint and difference in MAP.

During this reporting period, estimates were reviewed for 60-minute, 6-hour, 24-hour and 10-day base durations at 2-year and 100-year average recurrence intervals ARIs). Inconsistent estimates or unreasonable patterns were resolved on a case-by-case basis in various ways: by manually adjusting the value to reflect expected patterns, omitting the station from the analysis, or by adding anchoring estimates at critical ungauged locations.

1.1.3. Additional data formatting

Additional observational networks, the Hydrometeorological Automated Data System (HADS) and Integrated Flood Observing and Warning System (IFLOWS), located along the Appalachian Mountains were investigated, collected, and formatted to enhance the accuracy of estimates in areas where preliminary hourly data has been scarce.

There is no standard archive for these datasets for their full records. We conducted a data search through multiple data sources, which included searching old Office of Hydrology (OH) archives and multiple online archives. These typically included decoding Standard Hydrometeorological Exchange Format (SHEF) filesWe currently limited our search to HADS and IFLOWS stations with at least 15 years of potential record lengths and formatting it into one dataset. We are working on QA/QC tasks, which are especially necessary for these data due to their real-time / "raw" nature. Stations with potentially 20 or more years of data (before QA/QC procedures, which could remove station-years) are shown in Figure 6 as black stars. These may significantly improve the hourly data coverage, especially in western Virginia. Over the next reporting period we will look to add similar stations for states around the buffer of the Volume 13 area (eg. West Virginia, Tennessee).

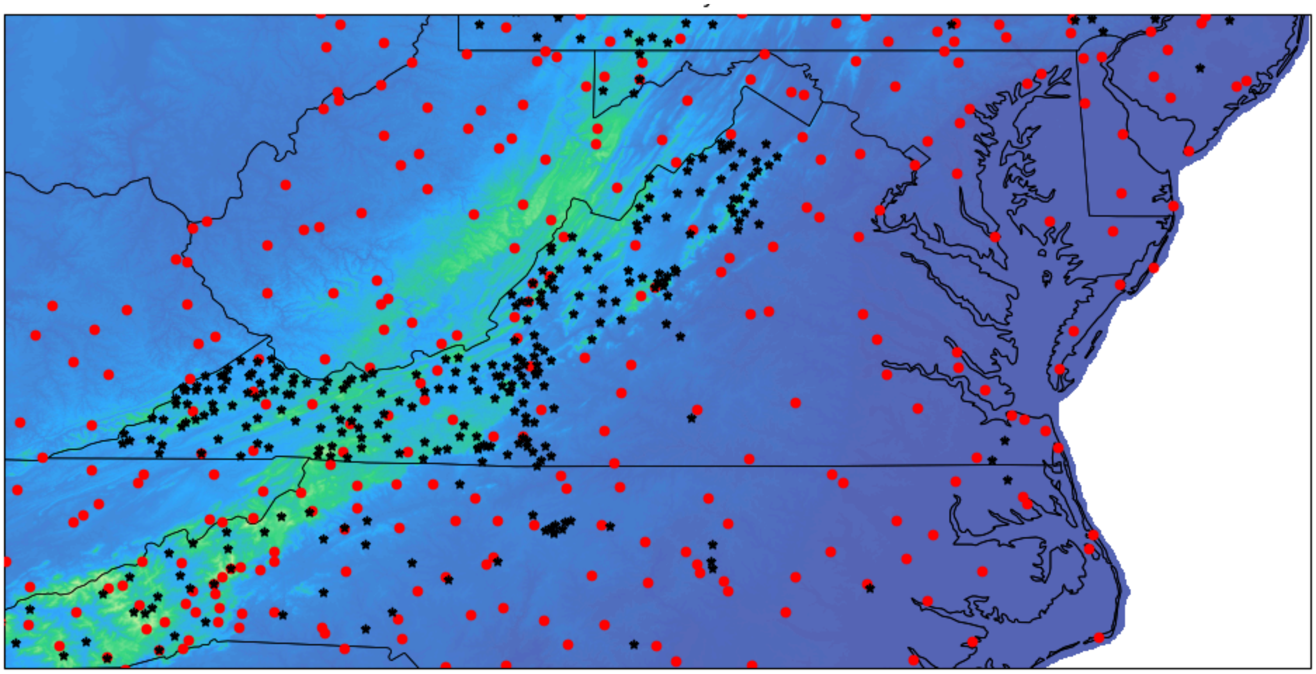

Figure 6. Map of stations reporting 1-hour or faster timesteps. The red dots represent stations used for frequency analysis in peer review. The black stars represent stations from the HADS/IFLOWS reconstructed archive that have potentially 20 or more years of data.

1.2. PROJECTED ACTIVITIES FOR THE NEXT REPORTING PERIOD (Oct - Dec 2025)

Quality control of new data from recently acquired stations from various data archives to data sparse areas in the Appalachian Mountains as well as the city of Charlotte-Mecklenberg. We will be reviewing and responding to Peer Review feedback, as well as initiate the subhourly analysis for the final estimates release.

1.3. PROJECT SCHEDULE

- Data collection, formatting, and initial quality control [Q1FY2025; Completed]
- Extraction of annual maximum series (AMS); additional quality control and data reliability tests (e.g., outliers, independence, consistency across durations, duplicate stations, candidates for merging)] [Q2FY2025; Completed]
- Regionalization and frequency analysis [Q2FY2025; Completed]
- Initial spatial interpolation of precipitation frequency (PF) estimates and consistency checks across durations [Q3FY2025; Completed]
- Peer review [Q4FY2025; Completed]
- Revision of PF estimates [Revised: Q2FY2026]
- Remaining tasks (e.g., development of precipitation frequency estimates for partial duration series, seasonality, temporal distributions, documentation) [Revised: Q3FY2026]
- Web publication [Revised: Q3FY2026]

III. ATLAS 15: PRECIPITATION FREQUENCY STANDARD UPDATE

NOAA is developing and implementing NOAA Atlas 15, the future authoritative source and national standard for precipitation frequency information. When published, NOAA Atlas 15 will have nationwide coverage and account for temporal trends, and represents a shift from a stationary assumption (i.e. extreme precipitation patterns do not change over time) to a nonstationary assumption.

In order to collect feedback early in the development process on the structure of NOAA Atlas 15 and the accompanying web dissemination strategy, OWP released the NOAA Atlas 15 Pilot over the state of Montana on September 26, 2024. The data and web dissemination strategy will be revised before the final studies are published in 2026 and 2027 for CONUS and oCONUS, respectively. After the NOAA Atlas 15 Pilot, NOAA plans to release preliminary NOAA Atlas 15 estimates for CONUS to initiate the peer review process. The NOAA Atlas 15 Preliminary Estimates are anticipated to be released in 2025 for CONUS, and in 2026 for oCONUS areas. Details about the public release of preliminary data and the user interface will be shared on NOAA Atlas 15 Informational Page pages. More information will be forthcoming.

When published, the NOAA Atlas 15 data and user interface will be available on the National Weather Service's new gateway for water information, the National Water Prediction Service (NWPS) (https://water.noaa.gov). See *Extreme Precipitation Estimates,* along the navigation bar towards the top of the NWPS homepage, for more information.

In this reporting period, the technical team worked on developing the preliminary estimates over CONUS, for both Volume 1 and Volume 2, and on integrating the public feedback collected during the NOAA Atlas 15 Pilot public review process. In addition, On September 11, 2025, the OWP hosted a virtual technical exchange between the Atlas 15 team and subject matter experts from ten federal agencies. This exchange was crucial for gathering insights on the analysis and results prior to the anticipated release of preliminary information. Dr. Lynne Trabachino, Dr. Janel Hanrahan, and Dr. Ken Kunkel delivered presentations on the NOAA Atlas 15 Volumes 1 Time Series Dataset, the Atlas 15 nonstationary methodology, and Volume 2 Adjustment Factors. The Atlas 15 technical team has since been actively incorporating this feedback into the ongoing dataset development.

For more information on NOAA Atlas 15 development, please visit the NOAA Atlas 15 Informational Page or email us at atlas15.info@noaa.gov for any inquiries regarding NOAA Atlas 15.

IV. OTHER

4.1 FREQUENCY ANALYSIS OF RECENT HISTORICAL STORM EVENTS

HDSC creates maps of annual exceedance probabilities (AEPs) for selected significant storm events for which observed precipitation amounts have AEP of 1/500 or less over a large area for at least one duration. AEP is the probability of exceeding a given amount of rainfall for a given duration at least once in any given year at a given location. It is an indicator of the rarity of rainfall amounts and is used as the basis of hydrologic design. For the AEP analysis, we look at a range of durations and select one or two critical durations to analyze which show the lowest exceedance probabilities for the largest area, i.e., the “worst case(s).” Since, for a given event, the beginning and end of the worst case period are not necessarily the same for all locations, the AEP maps represent isohyets within the whole event. The maps, occasionally accompanied with extra information about the storm, are available for download from the AEP Storm Analysis page.

4.1.1 Texas Hill Country

Catastrophic flooding occurred in the Texas Hill Country due to training thunderstorms associated with the remnant moisture and mid-level circulation from Tropical Storm Barry, which made landfall in Mexico days before on June 29, 2025.

We analyzed AEPs for this event for several durations and decided to create AEP maps for the 3-hour and 24-hour periods. Areas that experienced the maximum rainfall magnitudes with AEPs ranging from 1/10 (10%) to smaller than 1/1000 (0.1%) are shown on the maps in Figures 7-8. Precipitation frequency estimates used in the analysis were from NOAA Atlas 14 Volume 11. The underlying observed data came from the NCEI's multi-sensor Stage IV QPE Product.

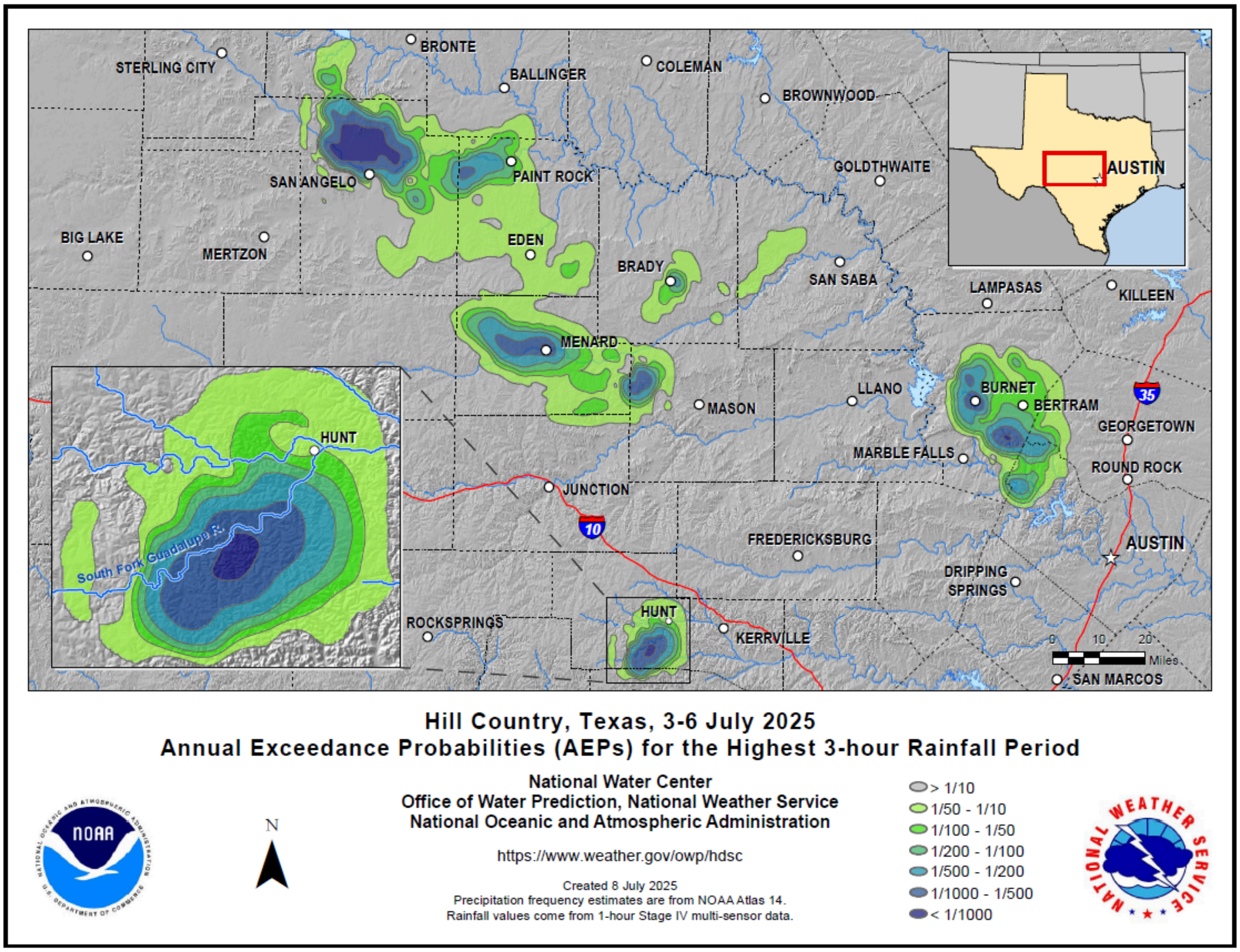

Figure 7. Annual exceedance probabilities for the worst case 3-hour rainfall during the Texas Hill Country event.

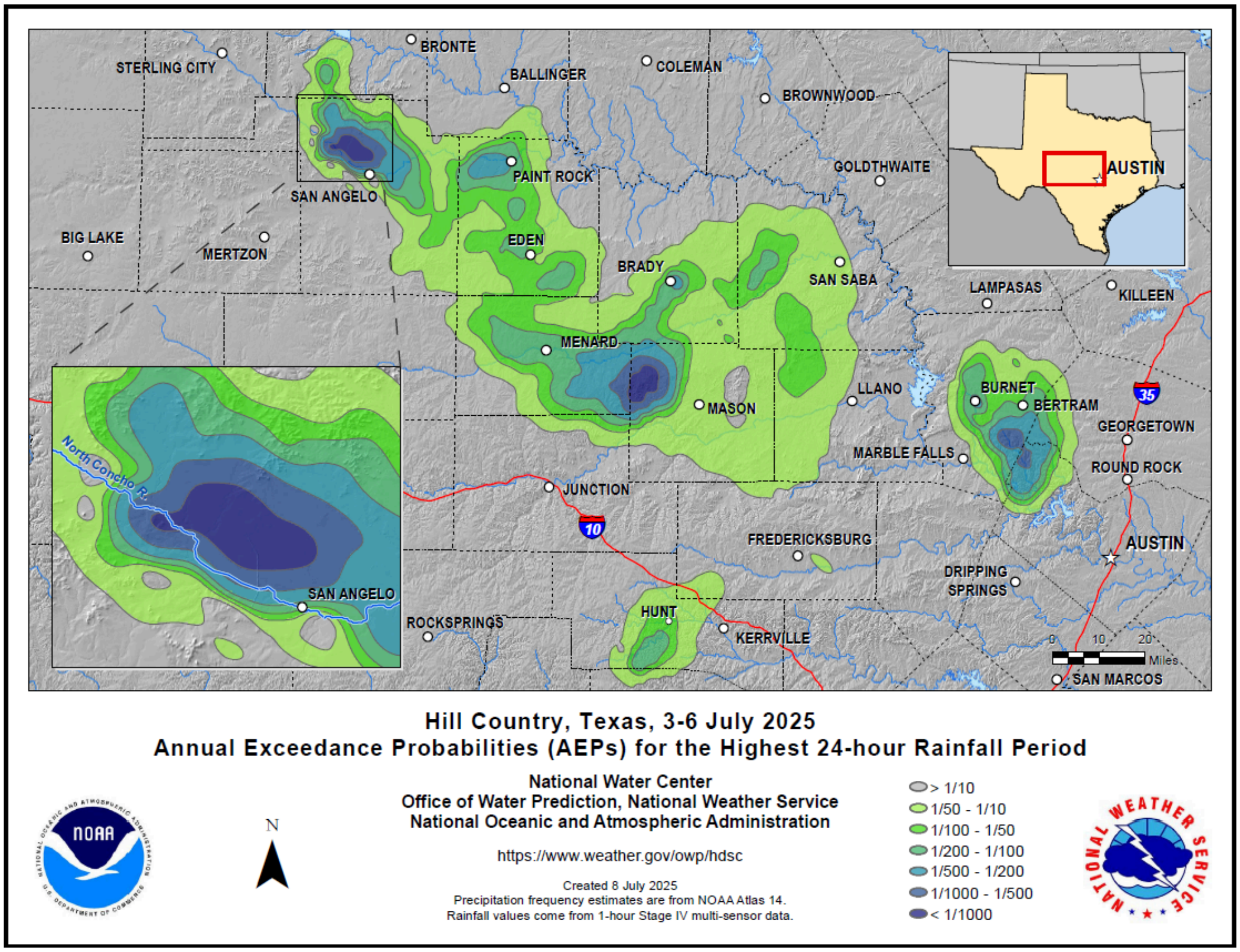

Figure 8. Annual exceedance probabilities for the worst case 24-hour rainfall during the Texas Hill Country event.

4.1.1 Milwaukee, Wisconsin

Catastrophic flooding occurred in the Milwaukee, Wisconsin area due to a stalled frontal boundary and an extremely moist air mass, which generated several rounds of thunderstorms over two days in the middle of August. The heaviest rain occurred over eastern Waukesha County and northern and western Milwaukee County where 10-13 inches of rain fell in just several hours. A summary of the event can be found here from the NWS Milwaukee forecast office.

We analyzed AEPs for this event for several durations and decided to create AEP maps for the 12-hour and 24-hour periods. Areas that experienced the maximum rainfall magnitudes with AEPs ranging from 1/10 (10%) to smaller than 1/1000 (0.1%) are shown on the maps in Figures 9-10. Precipitation frequency estimates used in the analysis were from NOAA Atlas 14 Volume 8. The underlying observed data came from the NCEI's multi-sensor Stage IV QPE Product.

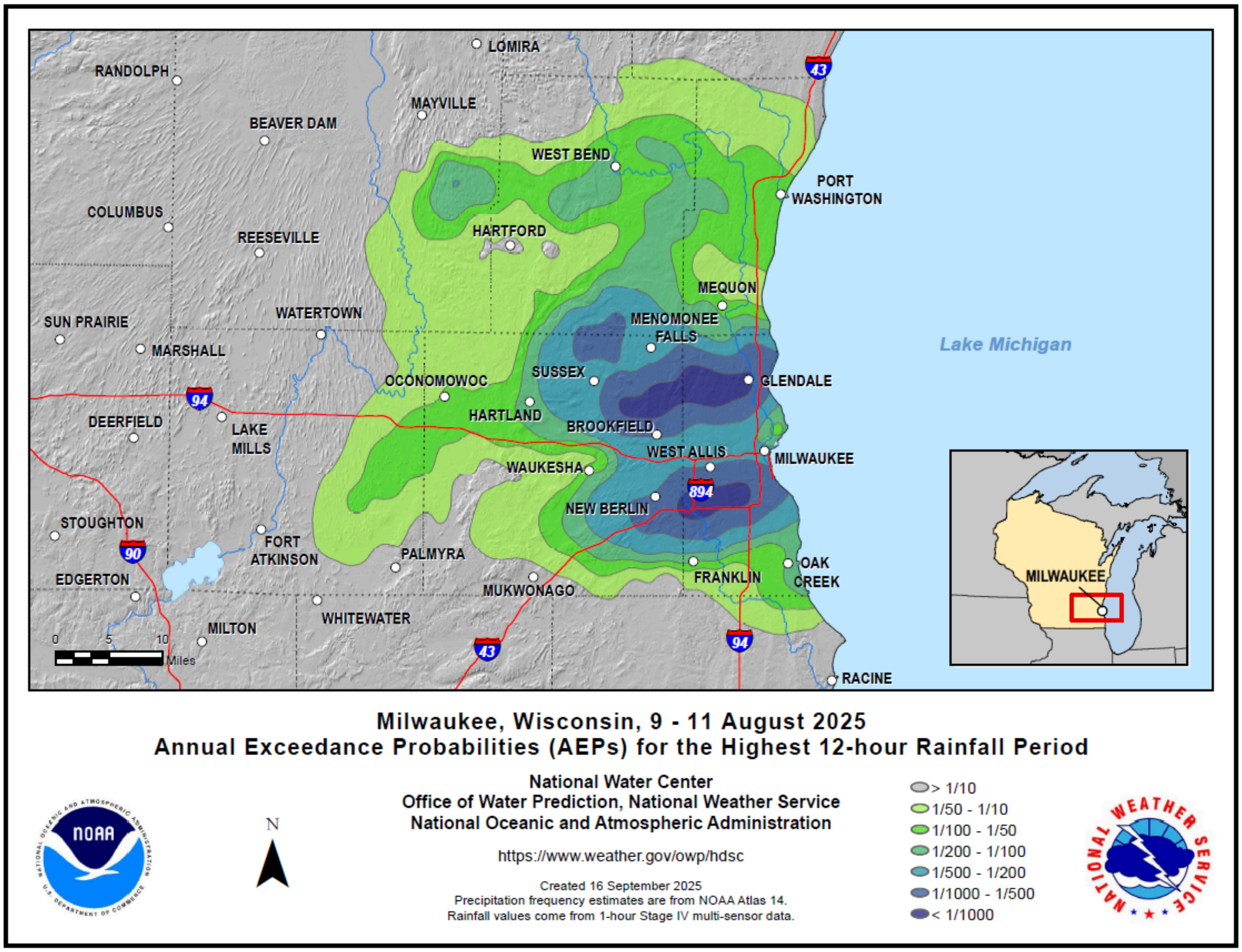

Figure 9. Annual exceedance probabilities for the worst case 24-hour rainfall during the Texas Hill Country event.

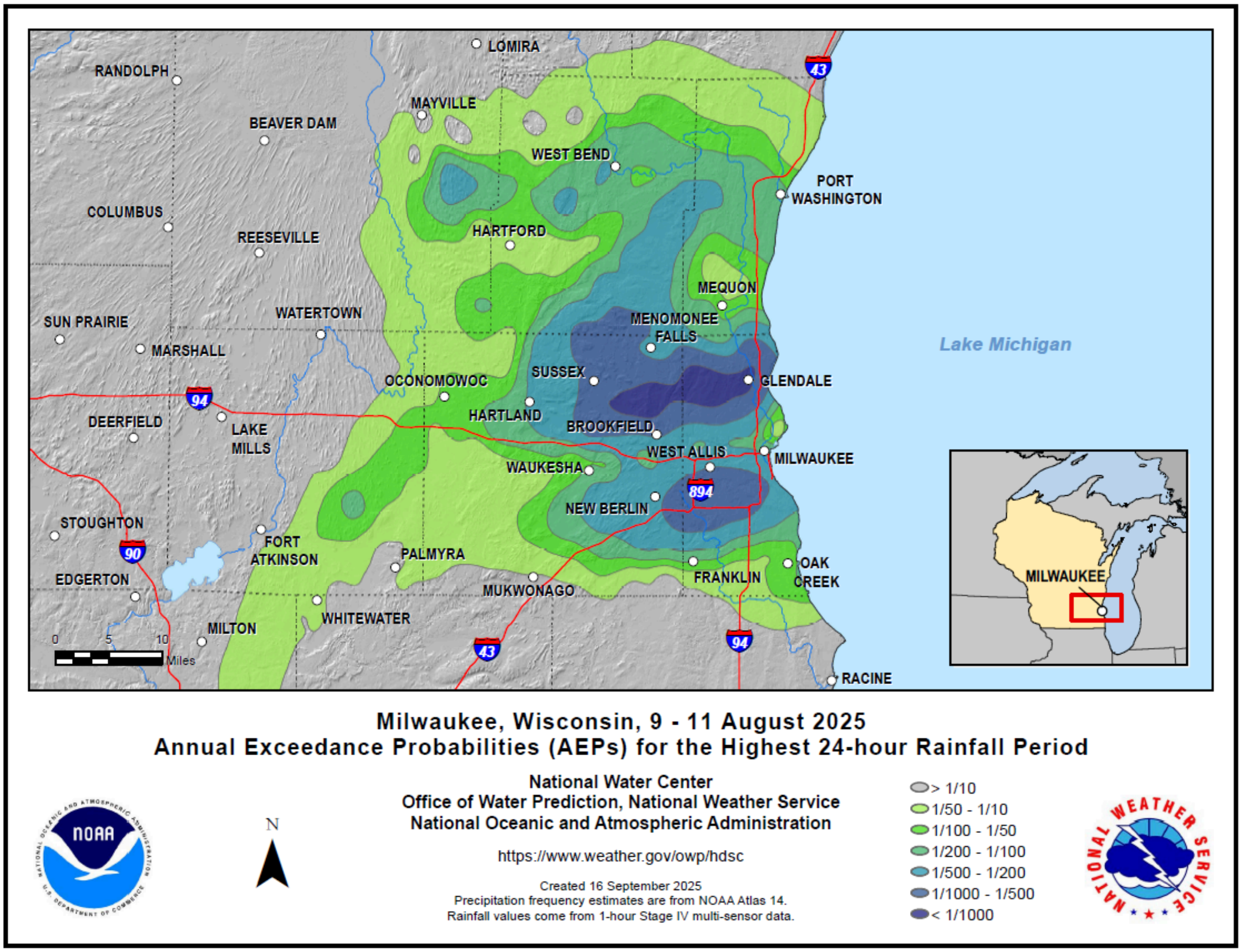

Figure 10. Annual exceedance probabilities for the worst case 24-hour rainfall during the Texas Hill Country event.

4.2 PRESENTATIONS, WORKSHOPS, AND CONFERENCES

Dr. Janel Hanrahan and Debbie Martin gave a presentation titled, “NOAA Atlas 15 — Generating Updated National Precipitation Frequency Estimates” for the WPTO Storm type Monthly Update on July 9, 2025. Dr. Janel Hanrahan gave a presentation titled, "NOAA Atlas 15 — Preliminary Authoritative Precipitation Frequency Estimates for CONUS" at the AASHTO TCHH Annual Meeting on August 12, 2025.

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