

# HYDROMETEOROLOGICAL DESIGN STUDIES CENTER

## QUARTERLY PROGRESS REPORT

1 April to 30 June 2018

Office of Water Prediction  
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National Oceanic and Atmospheric Administration  
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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 Hydrometeorological Design Studies Center (HDSC) within the Office of Water Prediction (OWP) of the National Oceanic and Atmospheric Administration's (NOAA) National Weather Service (NWS) has been updating precipitation frequency estimates for various parts of the United States and affiliated territories. Updated precipitation frequency estimates, accompanied by additional relevant information, are published in NOAA Atlas 14. All NOAA Atlas 14 products and documents 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, we have updated precipitation frequency estimates 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), and CT, MA, ME, NH, NY, RI, VT (Volume 10, 2015). Since May 2015, HDSC has been working on updating precipitation frequency estimates for the state of Texas. We expect to publish them in late 2018 in NOAA Atlas 14 Volume 11. OWP continues to work with FHWA and several Northwestern state agencies on securing funding to extend NOAA Atlas 14 coverage to the remaining five northwestern states: ID, MT, OR, WA, WY in Volume 12. For any inquiries regarding the status of this effort, please send an email to [HDSC.questions@noaa.gov](mailto:HDSC.questions@noaa.gov).

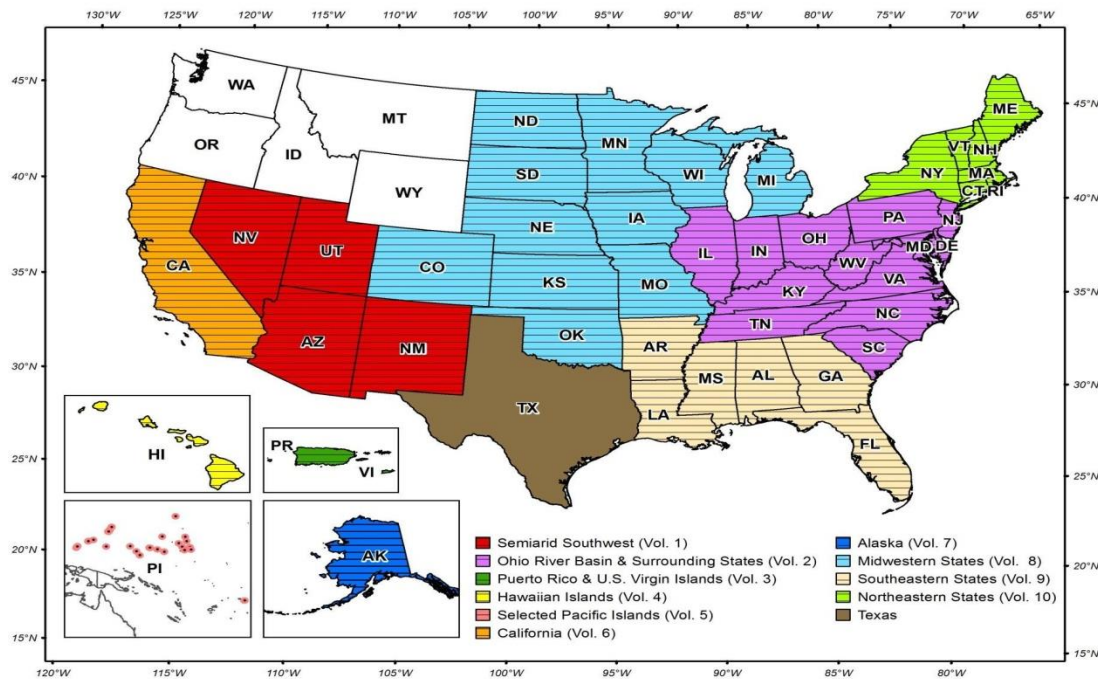


Figure 1. Current project area for Volume 11 (TX) and project areas included in published Volumes 1 to 10.

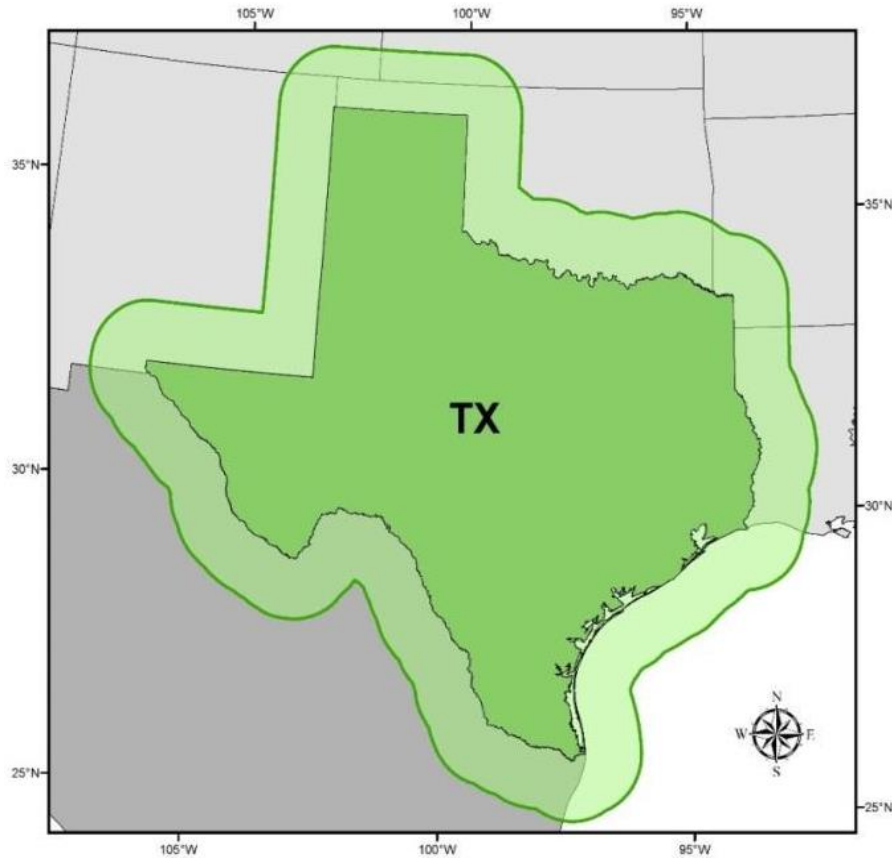
## **II. CURRENT PROJECTS**

### **1. NOAA ATLAS 14 VOLUME 10: NORTHEASTERN STATES**

Precipitation frequency estimates for the following seven northeastern states: Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island and Vermont were published in September 2015 as NOAA Atlas 14 Volume 10. The estimates for any location in the project area, along with all related products except documentation, are available for download in a variety of formats through the [PFDS](#). Work on documentation describing the station metadata, data and project methodology was delayed by funding issues, which are now resolved. Our estimate for the publication of NOAA Atlas 14 Volume 10 documentation is December 2018.

## 2. NOAA ATLAS 14 VOLUME 11: TEXAS

The extended project area for the NOAA Atlas 14 Volume 11 precipitation frequency project includes the state of Texas and approximately a 1-degree buffer around the state (Figure 2).



*Figure 2. NOAA Atlas 14 Volume 11 extended project area.*

The primary source of data for NOAA Atlas 14 Volumes is NOAA's National Centers for Environmental Information (NCEI). In addition to the NCEI's data, we gathered precipitation data collected by other Federal, State and local agencies for stations in Texas, as well as in adjacent portions of neighboring states (Arkansas, Louisiana, New Mexico, and Oklahoma) and also in Mexico to assist in data quality control and regionalization tasks. Since we started this project, we have contacted numerous agencies for assistance with the data and would like to thank all of those who responded to our inquiries and/or provided the data.

We have formatted data for almost 12,000 stations from 34 datasets listed in Table 1. Each formatted station was assigned a unique 6-digit identification number (ID), where the first 2 digits of the ID indicate the dataset. Stations were then screened for duplicate records, potential merges and for sufficient number of years with usable data. Stations with shorter or less reliable records in station dense areas were removed from the database. After all the screenings, approximately 2,000 stations were retained for frequency analysis. Until documentation for Volumes 10 and 11 is published in December, please see the [Volume 9 document](#) for more information on Atlas 14 methods and products.

*Table 1. List of formatted datasets.*

Data provider	Dataset name	Abbr.	Station IDs (common digits)	Base duration
National Centers for Environmental Information (NCEI)	Automated Surface Observing System	NCEI	78	15M
	DSI 3240, DSI 3260		03,05,14,16, 29,34,41*	15M, HLY
	Digitized data		99	HLY, DLY
	Global Historical Climatology Network (GHCN)		03,05,14,16,29, 34,41,69,79,90*	DLY
	Integrated Surface Data (Lite)		64	HLY, DLY
	Quality Controlled Local Climatol. Data		56	HLY
	Raw sub-daily precipitation data		66	15M
	Unedited Local Climatological Data		55	HLY
City of Austin	ALERT Network	COA	65	15M
City of Dallas	ALERT Network	COD	81	15M
Edwards Aquifer Authority		EAA	62	HLY
Guadalupe-Blanco River Authority		GBRA	77	15M
Harris County Flood Control District	Flood Warning System	HCFCF	60	15M
Jefferson County Drainage District 6	ALERT Precipitation and Stream Level Network	DD6	82	15M
Lower Colorado River Authority	Regional Meteorological Network	LCRA	63	15M
Midwestern Regional Climate Center	CDMP 19th Century Forts and Voluntary Observers Database	FORTS	52	DLY
Illinois State Water Survey	National Atmospheric Deposition Program	NADP	54	DLY
National Estuarine Research Reserve System		NERRS	57	15M, HLY
National Weather Service	Hydromet. Automated Data System	HADS	85	HLY
Oklahoma Climatological Survey	Oklahoma Mesonet	OKM	86	15M, DLY
San Antonio River Authority		SARA	91	15M
Sabine River Authority		SRA	58	DLY
Servicio Meteorologico Nacional, Mexico		SMN	61	DLY
Tarrant Regional Water District (Greater Fort Worth area)	Tarrant County Urban Flood Control Network	TRWD	83	15M, HLY
Texas Commission on Env. Quality	Air Quality Network	TCEQ	75	HLY
Texas Evapotranspiration Network		TEN	89	HLY, DLY
Texas Water Development Board		TWDB	84	HLY, DLY
Titus County Fresh Water Supply District No. 1		TCWS	53	DLY
U.S. Bureau of Reclamation	HydroMet	USBR	87	HLY, DLY
US Dept. of Agriculture (USDA)	Agricultural Research Service	USDA	94	15M
USDA, Forest Service	Remote Automated Weather Station Network	RAWS	76	HLY
USDA, National Resources Conservation Service	Soil Climate Analysis Network	SCAN	88	HLY
U.S. Geological Survey	National Water Information System	NWIS	59	15M
West Texas Mesonet		WTM	80	15M

\*03 - Arkansas, 05 - Colorado, 14 - Kansas, 16 - Louisiana, 29 - New Mexico, 34 - Oklahoma, 41 - Texas (DLY, HLY)  
69 - GHCN CoCoRaHS, 79 - GHCN, 90 - GHCN Mexico (DLY)

## **2.1. PROGRESS IN THIS REPORTING PERIOD (Jan - Mar 2018)**

### **2.1.1. Peer review**

From 20 November 2017 to 19 January 2018, HDSC conducted a peer review of preliminary precipitation frequency estimates for Texas. The following information was prepared and distributed for the review:

- metadata for stations whose data were used in precipitation frequency analysis;
- metadata for stations whose data were collected, but not used in the analysis;
- at-station depth-duration-frequency (DDF) curves for 60-minute to 10-day durations and for 2-year to 100-year average recurrence intervals (ARIs);
- maps of spatially-interpolated precipitation frequency estimates for 60-minute, 6-hour, 24-hour and 10-day durations and for 2-year and 100-year average recurrence intervals (ARIs).

The request for review was sent via email to over 750 subscribers to the HDSC list-server, as well as funding agencies and others who expressed interest in participating in the review. Potential reviewers were asked to evaluate the accuracy of station metadata and the reasonableness of point precipitation frequency estimates in addition to their spatial patterns.

The (anonymous) reviewers' comments with our responses and resulting actions will be published as Appendix 4 in the Volume 11 document. During this reporting period we addressed all comments and revised estimates as necessary. We prepared the Appendix and shared it, together with pertinent maps, with those who provided feedback during the peer review for final comments.

### **2.1.2. Revision of spatially interpolated precipitation frequency estimates**

In NOAA Atlas 14, the grids of mean annual maxima (MAM) at 30 arc-sec resolution, together with at-station precipitation frequency estimates, are the basis for calculation of gridded annual maximum series (AMS)-based and partial duration series (PDS)-based precipitation frequency estimates and corresponding upper and lower bounds of the 90% confidence interval. Mean annual maximum grids serve as the basis for calculation of the precipitation frequency estimates for the 2-year average recurrence interval (ARI), which are then used to calculate gridded 5-year estimates and so on. More information on this method will be provided in the Volume 11 document, which will be available for download from the PFDS web page in December 2018 (in the meantime, please check the [Volume 9 document](#) for more information).

During this reporting period we reviewed spatial patterns for the 2-year, 25-year, 100-year and 1000-year grids across all durations, and revisited and improved at-station and regional estimates where needed. The resulting adjustments were then carried through to other recurrence intervals in an iterative process. Typically, several iterations are required to ensure realistic spatial patterns and consistency in gridded estimates for 13 selected durations from 1 hour to 60 days (1-hr, 2-hr, 3-hr, 6-hr, 12-hr, 24-hr, 2-day, 4-day, 7-day, 20-day, 30-day, 45-day and 60-day).

To ensure consistency in grid cell values across all durations and frequencies (e.g., a 24-hour estimate has to be at least equal to the corresponding 12-hour estimate), we also conducted duration-based internal consistency checks across durations and frequencies.

### **2.1.3. Development of PFDS web pages for Volume 11**

We updated PFDS web pages for the new project area of Volume 11 and prepared pertinent Federal Geographic Data Committee (FGDC) compliant metadata. We also developed templates for all PFDS cartographic maps.

## **2.2. PROJECTED ACTIVITIES FOR THE NEXT REPORTING PERIOD (Jul - Sep 2018)**

During the next reporting period, we will develop final grids of PDS-based and AMS-based precipitation frequency estimates and corresponding bounds of 90% confidence interval as well as all supplementary products. We expect to publish estimates on the [PFDS](#) around September 30th.

## **2.3. PROJECT SCHEDULE**

Data collection, formatting, and initial quality control [Done]  
AMS extraction, additional quality control and data reliability tests [Done]  
Regionalization and frequency analysis [Done]  
Spatial interpolation of precipitation frequency (PF) estimates [Done]  
Peer review [Done]  
Revision of PF estimates [Done]  
Remaining tasks (e.g., development of precipitation frequency estimates for partial duration series, seasonality, temporal distributions) [July 2018]  
Web publication of data [around 30 September 2018]  
Web publication of documentation [mid-December 2018]

### 3. ANALYSIS OF IMPACTS OF NON-STATIONARY CLIMATE ON PRECIPITATION FREQUENCY ESTIMATES

The current approach used in NOAA Atlas 14 to calculate precipitation magnitude-frequency relationships assumes stationarity in the annual maximum series (AMS) data used for frequency distribution selection and fitting. We use several parametric and non-parametric statistical tests to detect trends in the AMS, but so far, tests have shown very little geographically consistent temporal change in these data (for more information, see the [Volume 9 document](#)).

There has been a growing concern among users of NOAA Atlas 14 products that they have been developed from AMS data using stationary frequency analysis methods and as such may not be appropriate in the presence of non-stationary climate. In an effort to understand the potential impact of non-stationary climate conditions on precipitation frequency estimates, the Federal Highway Administration tasked HDSC to conduct a pilot project to look into this issue, but preliminary findings were inconclusive. Despite the significant effort we put into this task, we did not produce a definite answer to whether non-stationary methods are advantageous in practice.

With help from academia, HDSC continued this investigation with the ultimate goal of developing credible precipitation frequency estimates which can be relied upon by Federal water agencies. Since 2016, HDSC has been working together with the Penn State University team on assessing the suitability of different non-stationary frequency analysis methods with respect to NOAA Atlas 14. As part of this effort, we evaluated estimates from various types of non-stationary models against the current NOAA Atlas 14 stationary model and investigated a number of related issues, such as performance of various AMS and PDS models, effects of de-clustering techniques and threshold selection mechanisms for the PDS models, effects of distribution parameterization techniques, etc. The details of methods tested and major findings will be shared in a report that will be published on the PFDS website in October 2018.

Work on testing the feasibility of incorporating future climate projections into precipitation frequency analysis started in May 2018. We are collaborating on this task with a team of researchers from the University of Illinois at Urbana-Champaign and University of Wisconsin-Madison.

### III. OTHER

#### 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, usually accompanied with extra information about the storm, are available for download from the following page: [AEP Storm Analysis](#). During this reporting period, we analyzed two rainfall events:

- 3-hour rainfall for a storm in Ellicott City, Maryland in May 2018
- 6-hour, 24-hour, and 72-hour rainfall for Michigan and Wisconsin in June 2018

##### 1.1. ELLICOTT CITY, MARYLAND – 27 MAY 2018

A series of training thunderstorms produced flooding rains over a localized area in and around Ellicott City, Maryland. This was the second extreme rainfall to occur in this area in two years ([previous storm in 2016](#)).

We analyzed AEPs for this event for several durations and decided to create an AEP map for the 3-hour period. Areas that experienced the maximum 3-hour rainfall magnitudes with AEPs ranging from 1/10 (10%) to smaller than 1/1000 (0.1%) are shown on the map in Figure 3. Precipitation frequency estimates used in the analysis were from NOAA Atlas 14 Volume 2. The underlying observed rainfall data came from Dual-polarization radar estimates, with slight bias adjustments from manually added gauges from COOP / CoCoRaHS / etc. Overall the dual-polarization radar estimates did well capturing the event, but slightly underestimated rainfall near Catonsville, MD.

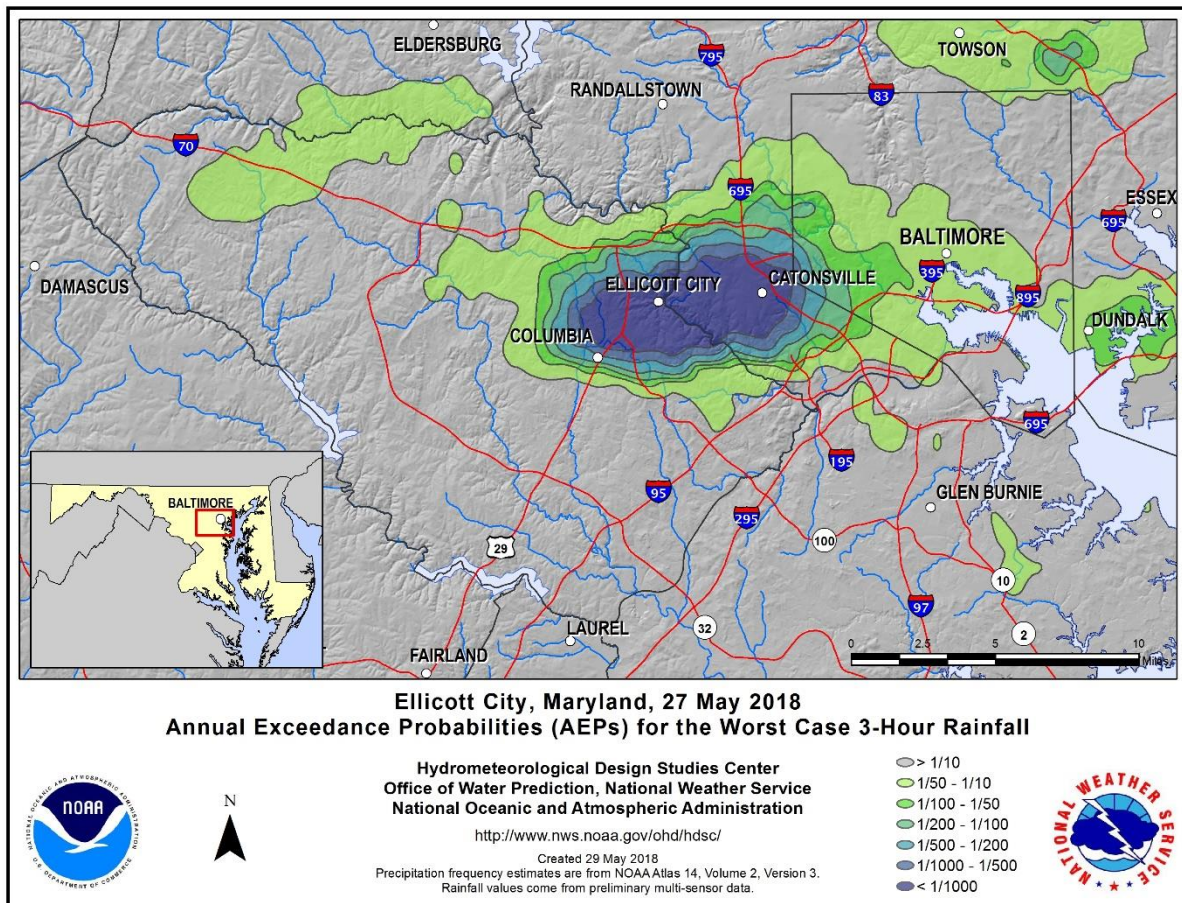


Figure 3. Annual exceedance probabilities for the worst case 3-hour rainfall during the Ellicott City event.

## 1.2. MICHIGAN AND WISCONSIN, 14-18 JUNE 2018

Separate bursts of heavy rains over Wisconsin, and subsequently over Michigan, caused major flooding during 14-18 June 2018. A similar area over northern Wisconsin saw its second major rainfall in two years ([previously in July 2016](#)).

We analyzed AEPs for this event for several durations and decided to create AEP maps for the 6-hour, 24-hour, and 72-hour periods. We chose multiple durations to show areas that were affected by the heavy shorter bursts of precipitation, as well as the cumulative effect of multiple days of bursts of rainfall. 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 4-6. 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](#).

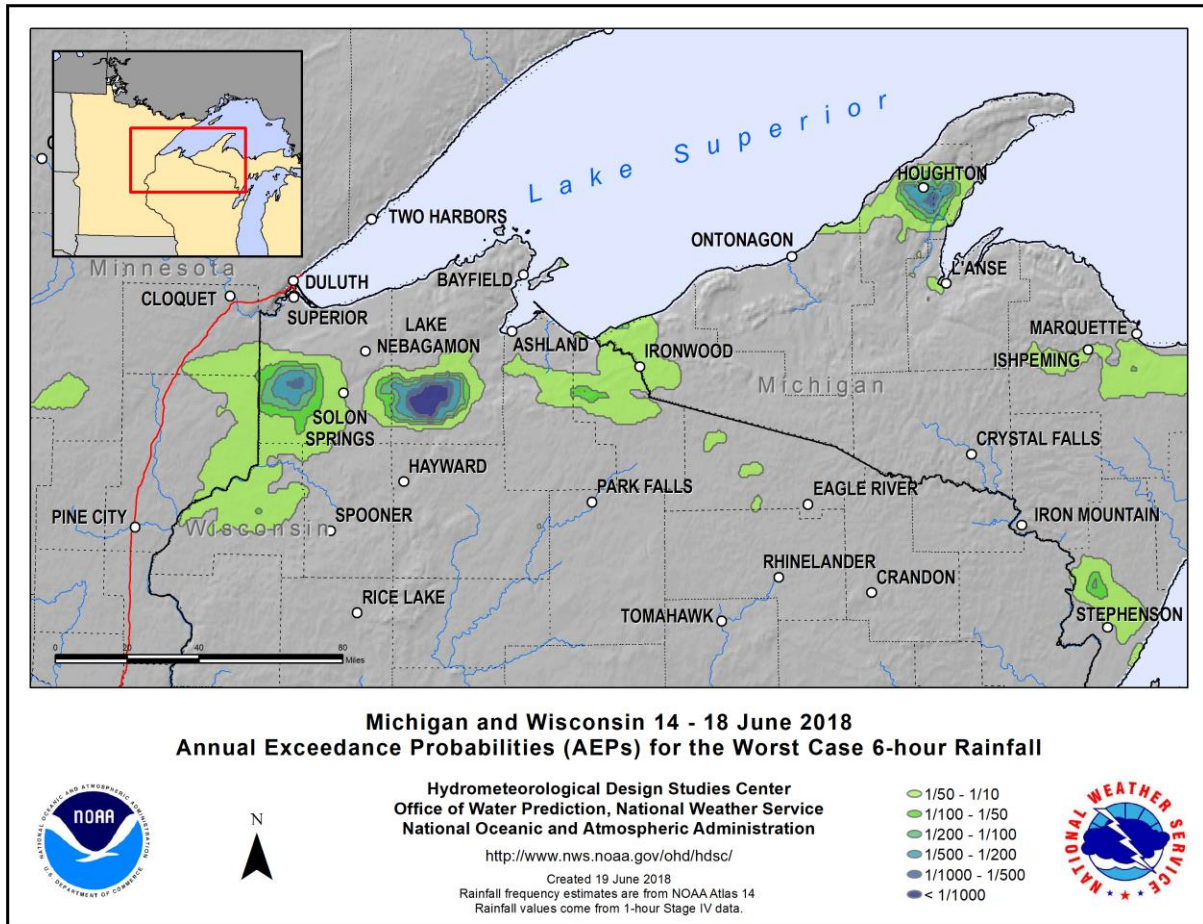


Figure 4. Annual exceedance probabilities for the worst case 6-hour rainfall during the Michigan and Wisconsin event.

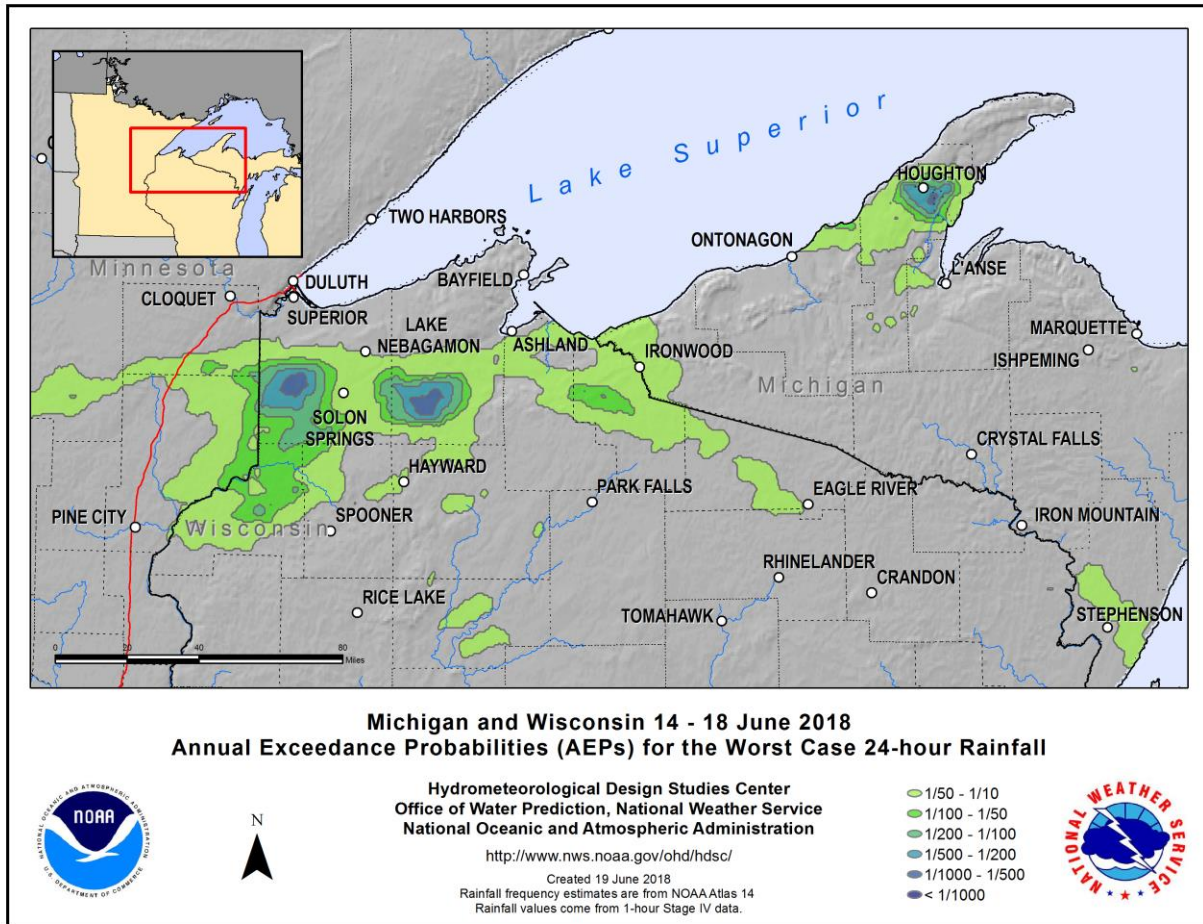


Figure 5. Annual exceedance probabilities for the worst case 24-hour rainfall during the Michigan and Wisconsin event.

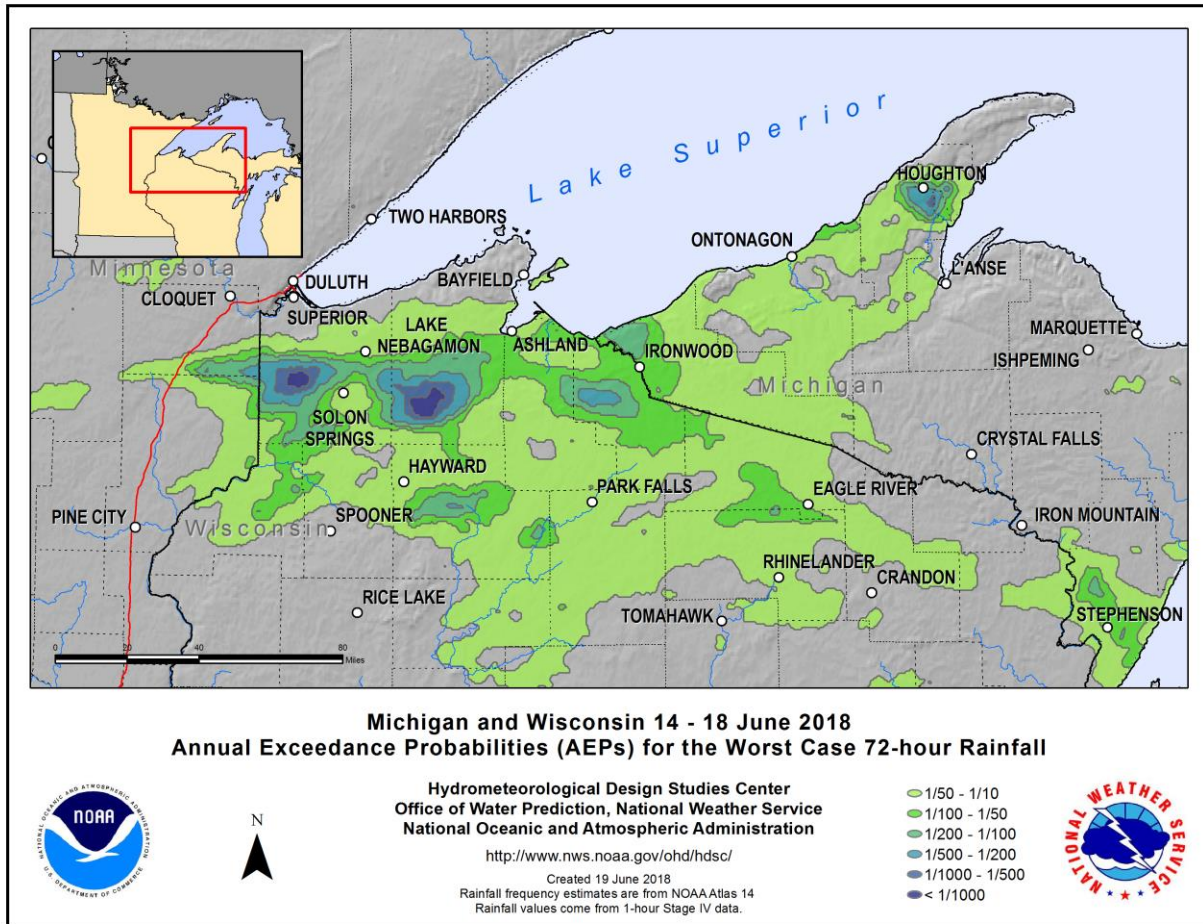


Figure 6. Annual exceedance probabilities for the worst case 72-hour rainfall during the Michigan and Wisconsin event.

## 2. RECENT MEETINGS AND CONFERENCES

HDSC group member Sandra Pavlovic gave a workshop presentation titled “NOAA Atlas 14: Precipitation Frequency Estimates of the United States” at the EWRI’s World Environmental & Water Resources Congress, in Minneapolis, MN Jun 3-7, 2018.