PUERTO RICO AND VIRGIN ISLANDS PRECIPITATION FREQUENCY STUDY

Update of *Technical Paper No. 42* and *Technical Paper No. 53*

Eighth Progress Report
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Hydrometeorological Design Studies Center
Hydrology Laboratory

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DISCLAIMER

The data and information presented in this report should be considered as preliminary and are provided only to demonstrate current progress on the various technical tasks associated with this project. 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 purpose other than for what it was intended does so at their own risk.

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1. Introduction.

The Hydrometeorological Design Studies Center (HDSC), Hydrology Laboratory, Office of Hydrologic Development, U.S. National Weather Service is updating its precipitation frequency estimates for Puerto Rico and the Virgin Islands. Current precipitation frequency estimates for the area are contained in *Technical Paper No. 42* "Generalized estimates of probable maximum precipitation and rainfall-frequency data for Puerto Rico and Virgin Islands" (U.S. Weather Bureau 1961) and *Technical Paper No. 53* "Two- to ten-day rainfall for return periods of 2 to 100 years in Puerto Rico and Virgin Islands" (Miller 1965). The new study includes collecting data and performing quality control, compiling and formatting datasets for analyses, selecting applicable frequency distributions and fitting techniques, analyzing data, mapping and preparing reports and other documentation.

The study will determine annual precipitation frequencies for durations from 5 minutes to 60 days, for return periods from 2 to 1000 years. The study will review and process all available rainfall data for the Puerto Rico and Virgin Island study area and use accepted statistical methods. The study results will be published as a Volume of NOAA Atlas 14 on the internet using web pages with the additional ability to download digital files.

The study area covers Puerto Rico and the U.S. Virgin Islands of St. Thomas, St. John and St. Croix. The study area is currently divided into 7 homogeneous climatic regions for analysis (Figure 1).

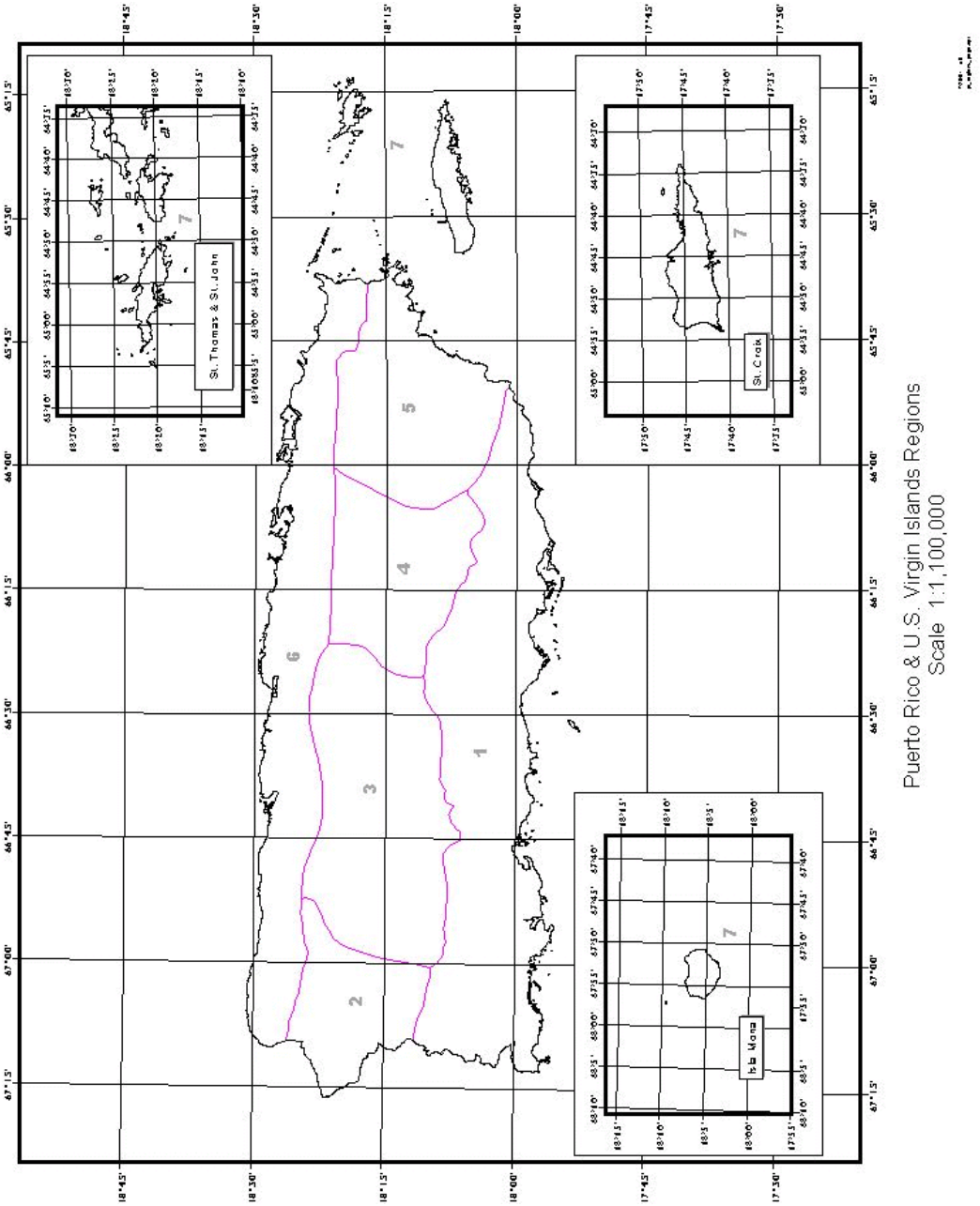

Figure 1. Puerto Rico Precipitation Frequency study area and region boundaries.

2. Highlights.

Software was developed to calculate the confidence intervals for all precipitation frequency estimates for all durations. Software was also developed to check the internal consistency of estimates and confidence intervals across durations. Additional information is provided in Section 4.1, Software Development.

Several changes were made to the password protected Precipitation Frequency Data Server (PFDS). Most important was the added function for selecting, either via a map or a list, an observing site. This function will allow for review of the point-precipitation frequency estimates before the interpolated grids are finalized. Additional information is provided in Section 4.2, Precipitation Frequency Data Server.

It was decided that when the data are ready two separate peer reviews will be held rather than a single review of all deliverables at once. The first review will be of the point precipitation frequency estimates. The second review will be of the spatially interpolated grids. Additional information is provided in Section 4.3, Peer Review.

Development of depth-area-duration (DAD) reduction relationships for areas from 10 to 400 square miles continues. Data has been gathered and quality controlled for 8 dense-area-networks. Software development has begun. Additional information is provided in Section 4.4, Depth Area Duration Study.

Decisions have been made to exclusively publish the study results electronically to avoid printing expenses and to publish monthly patterns of extreme precipitation but not compute monthly frequency estimates. Additional information is provided in Section 5, Issues.

3. Status.

3.1 Project Task List.

The following checklist shows the components of each task and an estimate of the percent completed per task. Past status reports should also be referenced for additional information.

Puerto Rico study checklist [estimated percent complete]:

Data Collection, Formatting and Quality Control [90%]:

- Multi-day
- Daily
- Hourly
- 15-minute
- N-minute

Table 1 shows the total number of daily, hourly, 15-minute, and n-minute stations in the study area. We will be adding the most recently available NCDC data to the daily, hourly, and n-minute stations. The digitized TD3206 daily dataset from NCDC for the time period before 1949 will also be added to the daily dataset.

Table 1. Information on total daily, hourly and n-minute datasets through October 1998.

	Daily	**Hourly**	**USGS 15-minute**	**N-minute**
No. of stations	152	30*	103	1
Longest record length (yrs) (Station ID)	98 (66-0152, 66-2801, 66-4702)	32 (66-8812)	9 (67 stations have 9 yrs)	25 (66-8812)
Average record length (yrs)	45	23	8	25

*2 of the stations included in this total have less than 1 year of data and therefore were not included in the average record length

L-Moment Analysis/Frequency Distribution for 5 minute to 60 days and 2 to 1000 years [0%]:

- Multi-day
- Daily
- Hourly
- 15-minute
- N-minute

Software has been developed to calculate 90% confidence intervals associated with precipitation frequency estimates. Software has been developed to check for internal consistency and mitigate any inconsistencies.

Spatial Interpolation [0%]:

- Create grids of interpolated means for each duration (1-hr, 2-hr, 3-hr, 12-hr, 24-hr, 48-hr, 4-day, 7-day, 10-day, 20-day, 30-day, 45-day, 60-day) using PRISM
- Subject grids of interpolated means to external review

HDSC delivered the Semiarid Southwestern U.S. point mean annual maxima (a.k.a. "index flood") values to the Spatial Climate Analysis Service (SCAS) at Oregon State University. The SCAS will use PRISM to spatially interpolate the values to grids. The procedure refinement developed during this work will be directly applicable to the Puerto Rico Study.

Peer Reviews [25%]

- Lead review of point precipitation frequency estimates
- Lead review of spatial interpolation grids

Precipitation Frequency Maps [0%]:

- Create smoothed regional growth factor (RGF) grids using GRASS
- Multiply appropriate RGF and distributed mean grids to produce precipitation frequency grids for durations 1-hr, 2-hr, 3-hr, 12-hr, 24-hr, 48-hr, 4-day, 7-day, 10-day, 20-day, 30-day, 45-day, and 60-day at return frequencies of 2-yr, 5-yr, 10-yr, 25-yr, 50-yr, 100-yr, 200-yr, 500-yr, and 1000-yr for a total of 162 maps
- Apply study-wide conversion factor to the 60-minute precipitation frequency grids to calculate the n-minute (5-, 10-, 15-, and 30-minute) grids
- Perform internal consistency checks (comparing rasters of sequential duration and frequency)

Data Trend Analysis [10%]:

- Analyze linear trends in annual maxima and variance over time
- Analyze shift in means of annual maxima between two time periods (i.e., test the equality of 2 population distribution means)

Temporal Distributions of Extreme Rainfall [10%]:

- Create graphs of percentage of precipitation maxima in each month of a year
- assemble hourly data by quartile of greatest precipitation amount and convert to cumulative rainfall amounts for each region
- sort, average, and plot time distribution of hourly maximum and median events for different climatological regions and seasons

Deliverables [15%]:

- Prepare data for web delivery
- Prepare documentation for web delivery
- Write hard copy of Final Report
- Publish hard copy of Final Report

The Precipitation Frequency Data Server displays precipitation frequency values and intensity-duration-frequency curves and tables. Additional station-specific functionality has been added to facilitate the review of point estimates.

Additional Work:

Spatial Relations (Depth-Area-Duration Study) [20%]:

- Obtain hourly data from dense-area reporting networks
- QC and format data from dense networks
- Compute maximum and average annual areal depth for each duration from stations from each network
- Compute ratio of maximum to average depth for all durations and networks and plot
- Prepare curves of best fit (depth-area curves) for each duration and network

Depth Area Duration (DAD) reductions for areas from 10 to 400 square miles are being updated for the entire United States and will be presented in a separate volume of NOAA Atlas 14.

4. Progress in this Reporting Period.

4.1 Software Development.

Software was developed to calculate the confidence intervals associated with each precipitation frequency estimate at all durations (1-hour through 10-day). These intervals will be provided as an upper bound and a lower bound at the 90% confidence level.

Software was written to provide internal consistency to the precipitation frequency estimates across durations. Cases where a shorter duration has an estimate that is higher than the next longer duration (e.g., 2-hr = 1.9 and 3-hr = 1.5) will be identified. These inconsistencies are not realistic but are an artifact of the data analysis. The calculation of precipitation frequency estimates uses the mean annual maximum and the L-skewness of the data. Inconsistencies result when durations have similar means but the shorter duration has higher skewness. Practical adjustments using ratios with the previous durations will be made where appropriate to mitigate such inconsistencies. This type of adjustment will also be made for inconsistencies in confidence intervals.

4.2 Precipitation Frequency Data Server.

Several changes were made to the password protected Precipitation Frequency Data Server (PFDS) this quarter. Functionality to extract data for a specific observing site was added. A user can now select an observing site from a pull-down list or by simply clicking on it from a map. This has allowed peer-reviewers to evaluate the point precipitation frequency estimates for the Semiarid southwest study before the spatial maps are complete.

In order to accommodate the observing site selection option, the PFDS interface changed slightly, as did the output page. Changes include, but are not limited to: output duration changed from 10-days to 60-days, return periods extended to 1000-years, added index maps to the output page, removed the seasonality option, added a link to the National Climatic Data Center (NCDC) showing nearby observing sites and sources of climate data, and made the background of the state maps color-shaded elevation (instead of a black and white hill shade).

4.3 Peer Review.

It was decided that when the data are ready two separate peer reviews will be held rather than a single review of all deliverables at once. The first review will be of the point precipitation frequency estimates. The second review will be of the spatially

interpolated grids. The peer review of the Semiarid Southwestern U.S. point precipitation frequency estimates was begun in June and serves as the first review of results from the new statistical methods.

4.4 Spatial Relations (Depth Area Duration Study).

During the second quarter of 2002, processing of data continued for study areas being used to develop depth-area-duration (DAD) relationships applicable to basins ranging in area size from 10 to 400 square miles. Currently, 12 study areas are being considered (See Table 2). The areas were selected based on the following criteria: 1) Availability of a dense area of hourly reporting rain gauges; 2) location, as there is a desire to include as many geographically and orographically diverse study areas of the US as possible; and 3) minimum period of record for reporting gauges (at least 15 years of record).

Data has been collected and prepared as shown in Table 2. Also, if additional dense-area-networks are identified, they will be added after the current software development phase of the projected is completed.

Table 2. Dense Area Rain Gauge Networks in DAD Study.

Depth Area Duration Study Areas	**Data Processed**
Walnut Gulch, AZ	✓
Reynolds Creek,ID	✓
Tifton, GA	✓
Hastings, NE	✓
Alamogordo Creek, NM	
Safford, AZ	
Santa Rita, AZ	
Cochocton, OH	✓
Danville, VT	✓
Chicago, IL (NCDC stations)	✓
Riesel, TX	✓

5. Issues.

5.1 Seasonality

We reviewed the meaning, utility and computational difficulties associated with frequency estimates computed by season. Because of the noise in the data, seasonal estimates do not combine to give annual estimates. This incongruity cannot be resolved without arbitrary limits being placed on results. We are uncomfortable with imposing arbitrary limits but at the same time are concerned about the confusion that may be caused by publishing incongruous results. Furthermore, after checking with a variety of partners we found no consensus of demand for the estimates nor a consensus on how such results would be used. Accordingly we have decided not to prepare seasonal frequency estimates.

5.2 Publication

Printing of the final documents is expensive and time consuming. Furthermore, we have found no reasonable way to avoid ongoing infrastructure costs of delivering and billing for the printed documents. Accordingly, we have decided to avoid both the costs and delay by publishing the documents in PDF format on the Internet.

6. Projected Schedule.

The following list provides a tentative schedule with completion dates. Brief descriptions of tasks being worked on next quarter are also included in this section.

Data Collection and Quality Control [August 2002]
Trend Analysis [September 2002]
Temporal Distributions of Extreme Rainfall [October 2002]
L-Moment Analysis/Frequency Distribution [November 2002]
Peer Review Point Estimates [January 2003]
Spatial Interpolation [March 2003]
Precipitation Frequency Maps [May 2003]
Documentation [May 2003]
Publication [May 2003]

Spatial Relations (Depth Area Duration Studies) [January 2003]

6.1 Data Collection and Quality Control.

During the next quarter, daily and hourly station data will be updated with the most recently-made available NCDC data and pre-1949 daily data. One additional year of n-minute data is available and will be added to the dataset. The tasks involved with data collection, formatting and quality control will take roughly 3 weeks for all regions in the Puerto Rico and Virgin Islands study area.

6.2 L-Moment Analysis/Frequency Distribution.

A comprehensive L-moment statistical analysis will be done on both daily and hourly completed datasets to provide the best quantile estimates. The tasks involved with the precipitation frequency analysis will take roughly two months for the Puerto Rico and Virgin Islands study area.

6.3 Spatial Relations (Depth Area Duration Study)

The method to be used for computing the DAD curves has been selected. Software to decode and format the data files and the DAD computations will be developed. If additional dense-area-networks are available, they will be added to our database.

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