Stantec

Memo

From: Stantec Consulting Services, Inc.

RE: Bulletin 17C Analysis for TWDB Task Order 3

Date April 8, 2024

Reference: Bulletin 17C Analysis for TWDB Task Order 3

This memo presents an overview of the Bulletin 17C analysis performed in support of the hydrologic and hydraulic modeling for Texas Water Development Board (TWDB) Task Order 3 (TO3). Four stations within the TO3 boundaries were analyzed using USGS software PeakFQ[1] (Version 7.3) to determine 100-year (0.01 annual exceedance probability [AEP]) flood frequency estimates. The Bulletin 17C analyses performed within PeakFQ utilized the Expected Moments Algorithm (EMA; Cohn et al. 1997, Cohn et al. 2001). EMA was adopted as the approved method for performing a Bulletin 17C analysis (England et al. 2019) and is currently implemented in the PeakFQ software as well as HEC-SSP[2]. EMA integrates systematic observations (i.e., the stream gage flow record), as well as historical (e.g., high water marks), paleoflood reconstructions, and perception thresholds for periods of missing data. The following sections describe the considerations that went into the Bulletin 17C analyses and presents the results and final recommendations.

STREAMFLOW GAGE LOCATIONS

Table 1 lists the details of the streamflow gages located within the TO3 study area, including the corresponding HUC-8, contributing drainage area, geospatial coordinates, period of record, and the number of annual maximum streamflow observations available for the Bulletin 17C analyses. Figure 1 presents a map of the streamflow gage locations with the TO3 HUC-8 boundaries for reference. Note that three additional streamflow gages are shown in Figure 1 that are not included in Table 1—this is because they are not included in the Bulletin 17C analyses. Station USGS 07227420 (Cramer Ck at US Hwy 54 nr Dalhart, TX) only has three non-zero peak discharge observations, making it unsuitable for Bulletin 17C analysis. Station USGS 07227890 (Big Blue Ck nr Fritch, TX) has 12 observations, but five of them are low outliers thus shrinking the sample size to seven, which is insufficient for a Bulletin 17C analysis. Station USGS 07227900 (Lk Meredith nr Sanford, TX) provides water surface elevation only, thus no peak discharge observations are available at this site.

Table 1. Details of USGS streamflow gages included in Bulletin 17C analyses.

USGS Station ID	Station Name	HUC-8	Contrib. Drainage Area (mi^2)	Longitude	Latitude	Period of Record	N. Obs.
07227500	Canadian Rv nr Amarillo, TX	11090105	15,376	101.879	35.470	1964-2021	58
07228000	Canadian Rv nr Canadian, TX	11090106	18,178	100.370	35.935	1964-2021	58
07235000	Wolf Ck at Lipscomb, TX	11100203	475	100.275	36.239	1938-2022	66

[1] https://water.usgs.gov/software/PeakFQ/
[2] https://www.hec.usace.army.mil/software/hec-ssp/

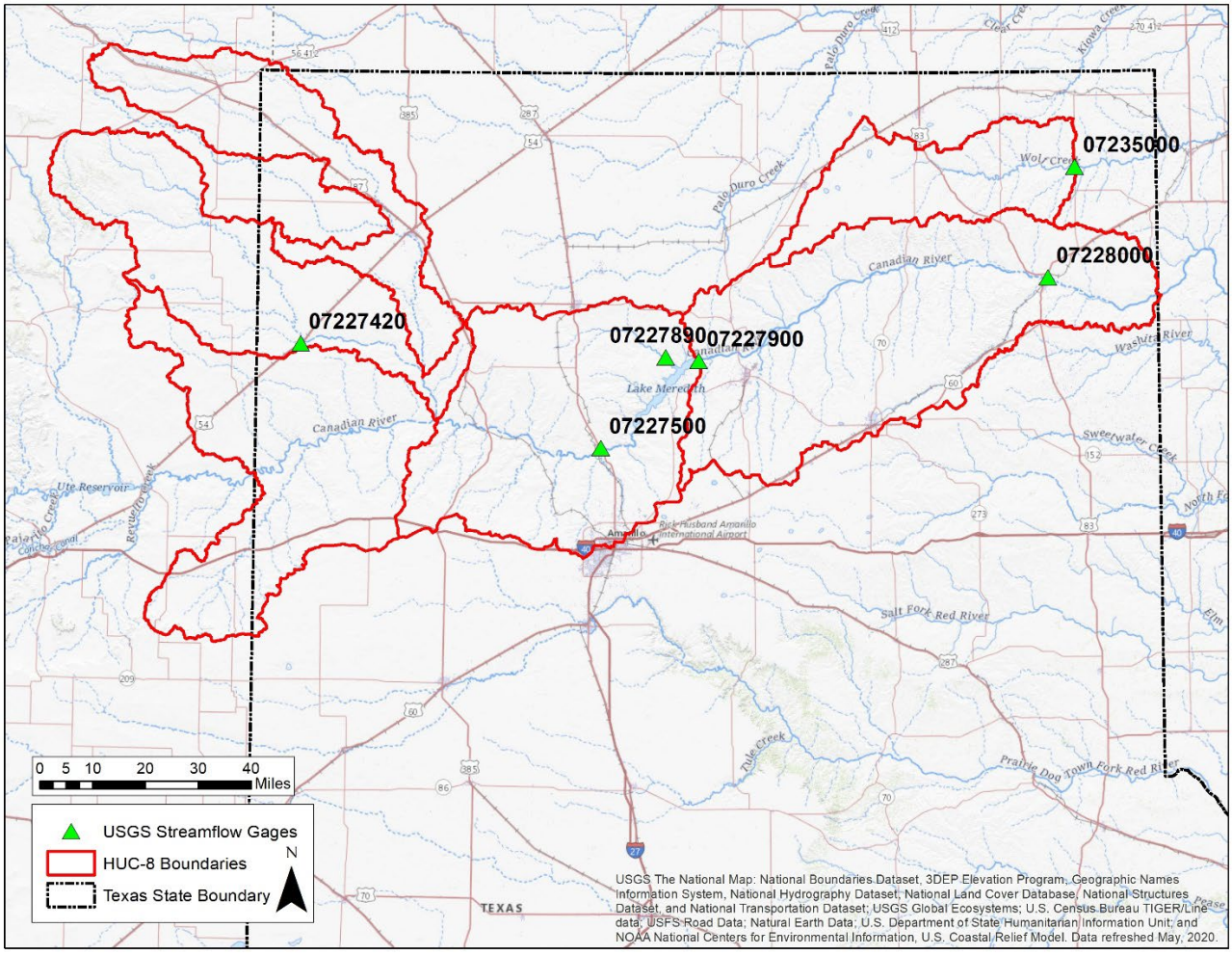

Figure 1. USGS streamflow gage locations and HUC-8 boundaries.

PEAK DISCHARGE DATA

Peak discharge data for the USGS streamflow gages listed in Table 1 were obtained from the USGS NWIS[3]. Specifically, the peakfq (watstore) format files are downloaded for each streamflow gage, as these are formatted to be directly compatible with the PeakFQ software. A qualitative analysis of the peak discharge data indicates there are significant impacts of regulation and/or diversion on the values presented by the USGS. Bulletin 17C guidelines (England et al. 2019) dictate that the method is to be used in undeveloped and unregulated watersheds. By performing Bulletin 17C analyses on peak discharge observations that have been flagged by USGS as being impacted by regulation and/or diversion, the resulting peak discharge frequency estimates may be unreliable. Significant regulation can cause attenuation of a flood wave, thus reducing the peak discharge observation. Additionally, regulation can have an unknown impact on the

[3] USGS National Water Information System: https://nwis.waterdata.usgs.gov/usa/nwis/peak

assumption of stationarity, which is a fundamental assumption of any Bulletin 17C analysis. Considering the potential violation of the core assumptions of Bulletin 17C analyses, care must be taken when interpreting the resulting peak discharge frequency estimates.

REGIONAL SKEW

The regional skew values used in the Bulletin 17C analyses were obtained from the Texas Skew Study (Cleveland and Fang 2021b), using a tool developed as part of the study (Cleveland and Fang 2021a). The Texas Skew Study provides two gridded regional skew maps: one developed using the streamflow gage coordinates within the generalized additive modeling (GAM) routine, and another developed using the watershed centroid coordinates within the GAM routine. The authors of the Texas Skew Study (Cleveland and Fang 2021b) recommend use of the gridded regional skew values developed using the watershed centroid GAM routine, which was adopted for these Bulletin 17C analyses. The tool is written in the R statistical language (R Core Team 2021) and is accessible via remote desktop connection. Table 2 presents the regional skew values for the USGS streamflow gages listed in Table 1. The standard error associated with the regional skew value is assumed to be 0.465 for all locations, as described in the Texas Skew Study (Cleveland and Fang 2021b). Also presented in Table 2 are the calculated station skew and resulting weighted skew. The station and weighted skew are results of the PeakFQ software but are included here for consistency with the presentation of the regional skew values.

Table 2. Regional skew (from Texas Skew Study), calculated station skew (from PeakFQ), and weighted skew (from PeakFQ).

USGS Station ID	Regional Skew	Station Skew	Weighted Skew
07227500	-0.377	0.346	0.063
07228000	-0.335	-0.045	-0.132
07235000	-0.334	-1.012	-0.484

PEAKFQ SETUP

The peakfq (watstore) files for the streamflow gages presented in Table 1 were imported into PeakFQ software (Version 7.3). Upon opening the PeakFQ software and loading the peakfq (watstore) file for a streamflow gage, additional information must be provided:

- Toggle between “Weighted”, “Regional”, and “Station” for the Skew Option
- Input the regional skew and associated standard error (Table 2)
- Toggle the “Urban/Reg Peaks” to select “Yes”

Each streamflow gage is analyzed using each of the three Skew Options, for completeness. As mentioned earlier, one of the fundamental assumptions of a Bulletin 17C analysis is that the data are unregulated. Therefore, the default setting for “Urban/Reg Peaks” is “No”, such that peak discharge observations flagged as being impacted by regulation and/or diversion are omitted from the analysis. By toggling this selection to “Yes”, the flagged peaks will be included in the analysis. Figure 2 shows an example of the PeakFQ Station Specifications tab.

Reference: **Bulletin 17C Analysis for TWDB Task Order 3**

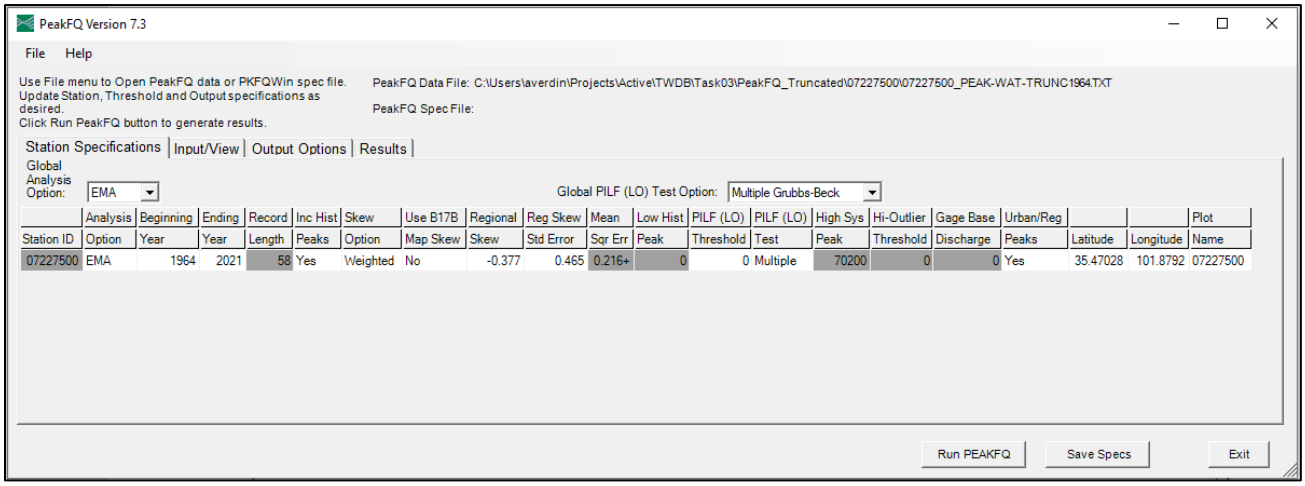

Figure 2. Station specifications tab for station USGS 07227500. Skew Option was selected to "Weighted"; Regional Skew and Reg Skew Std Error were manually entered; Urban/Reg Peaks was toggled to "Yes".

In addition to the Station Specifications tab, the Input/View tab may need to be updated. When there are numerous missing periods within the period of record, only the first Perceptible Range is automatically populated in the Input/View tab, which results in an error when running PeakFQ. Manual entry of Perceptible Ranges to address the remaining missing periods is required before PeakFQ executes without error. For TO3, however, all streamflow gages have one or fewer missing periods within the period of record, thus no manual entry is required. Figure 3 through Figure 5 show the final Input/View tabs for the streamflow gages presented in Table 1.

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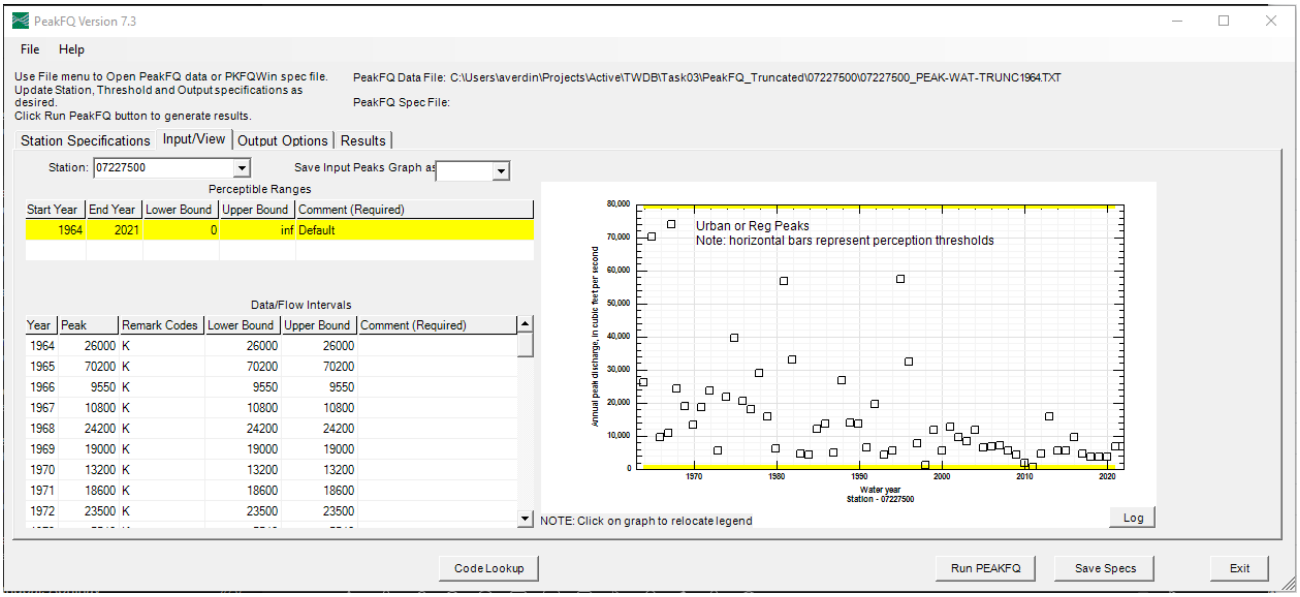

Figure 3. Input/View tab for station USGS 07227500.

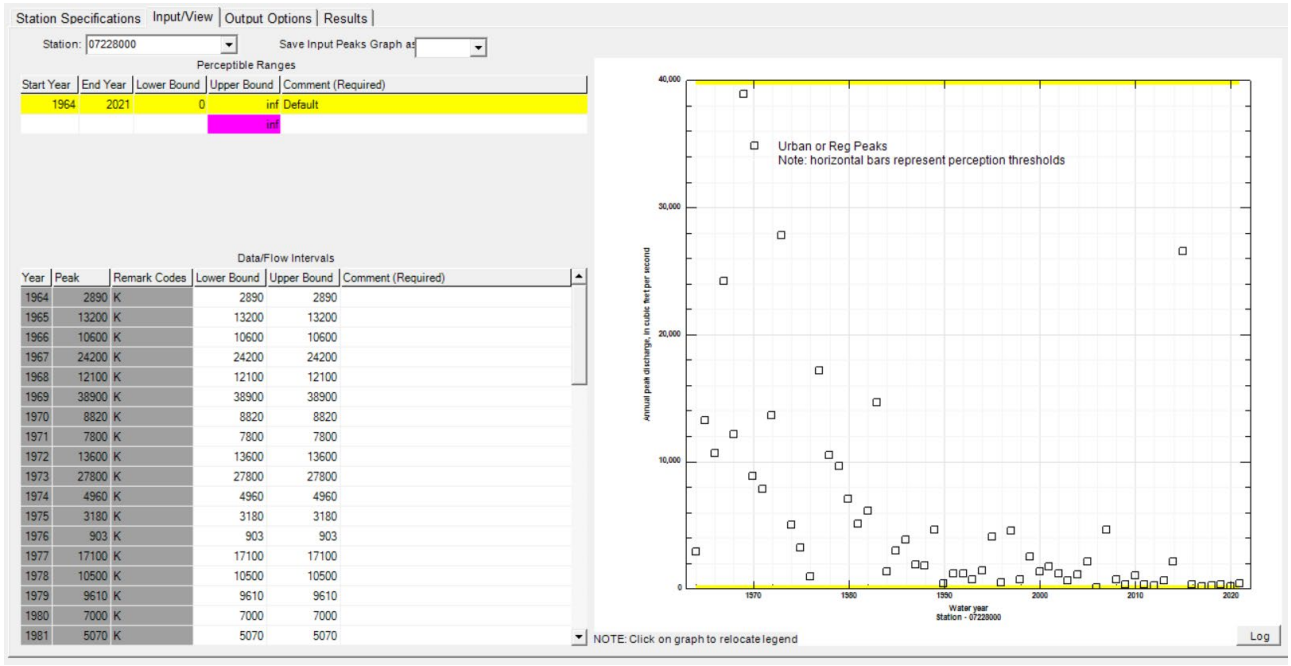

Figure 4. Input/View tab for station USGS 07228000.

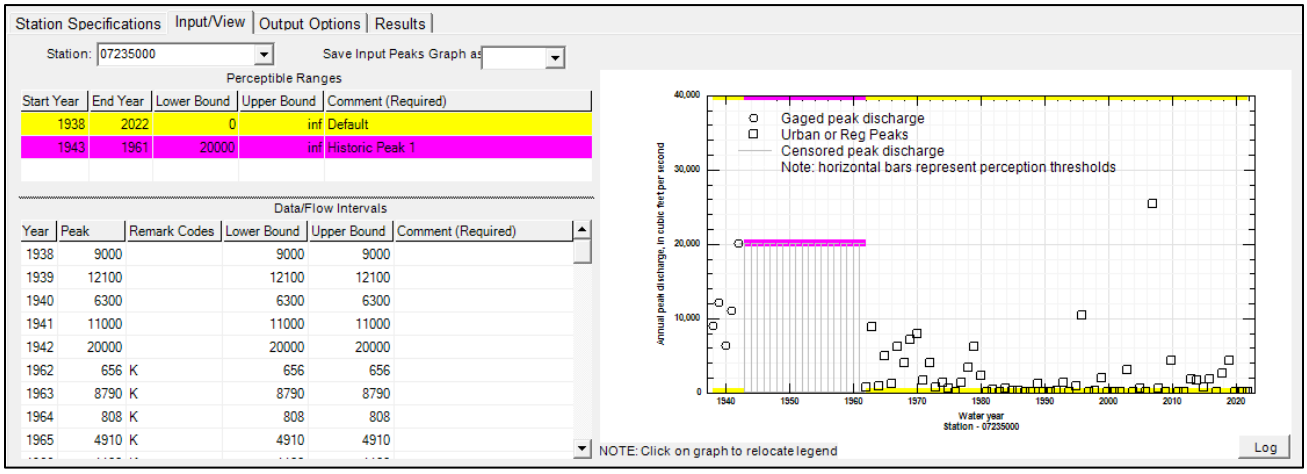

Figure 5. Input/View tab for station USGS 07235000.

RESULTS

The 100-year peak discharge frequency results from the PeakFQ Bulletin 17C analyses are summarized in Table 3. Results are presented for analyses using the regional skew, station skew, and weighted skew. It is usually recommended to use the results from the weighted skew analysis unless there is a compelling reason. The data for stations USGS 07227500 and USGS 07228000 were truncated to begin in water year 1964 due to the construction of two large flood control reservoirs (Ute and Conchas Lakes) upstream of the task order. For stations USGS 07227500 and USGS 07228000, the results from the weighted skew analyses are recommended. For station USGS 07235000, the estimates calculated using only the regional skew are recommended because the calculated station skew is excessively negative (i.e., see Table 2). The recommended results are bolded in Table 3. Figure 6 through Figure 8 show the resulting peak discharge frequency plot for the streamflow gages presented in Table 1 for the recommended skew method.

Table 3. 100-year peak discharge frequency estimates using weighted skew, regional skew, and station skew options within PeakFQ. Bold entries indicate recommendation.

USGS Station ID	100-Year Peak Discharge (Regional Skew)	100-Year Peak Discharge (Station Skew)	100-Year Peak Discharge (Weighted Skew)
07227500	58,120	87,520	**74,900**
07228000	49,330	68,610	**62,190**
07235000	**46,980**	26,610	41,950

Reference: **Bulletin 17C Analysis for TWDB Task Order 3**

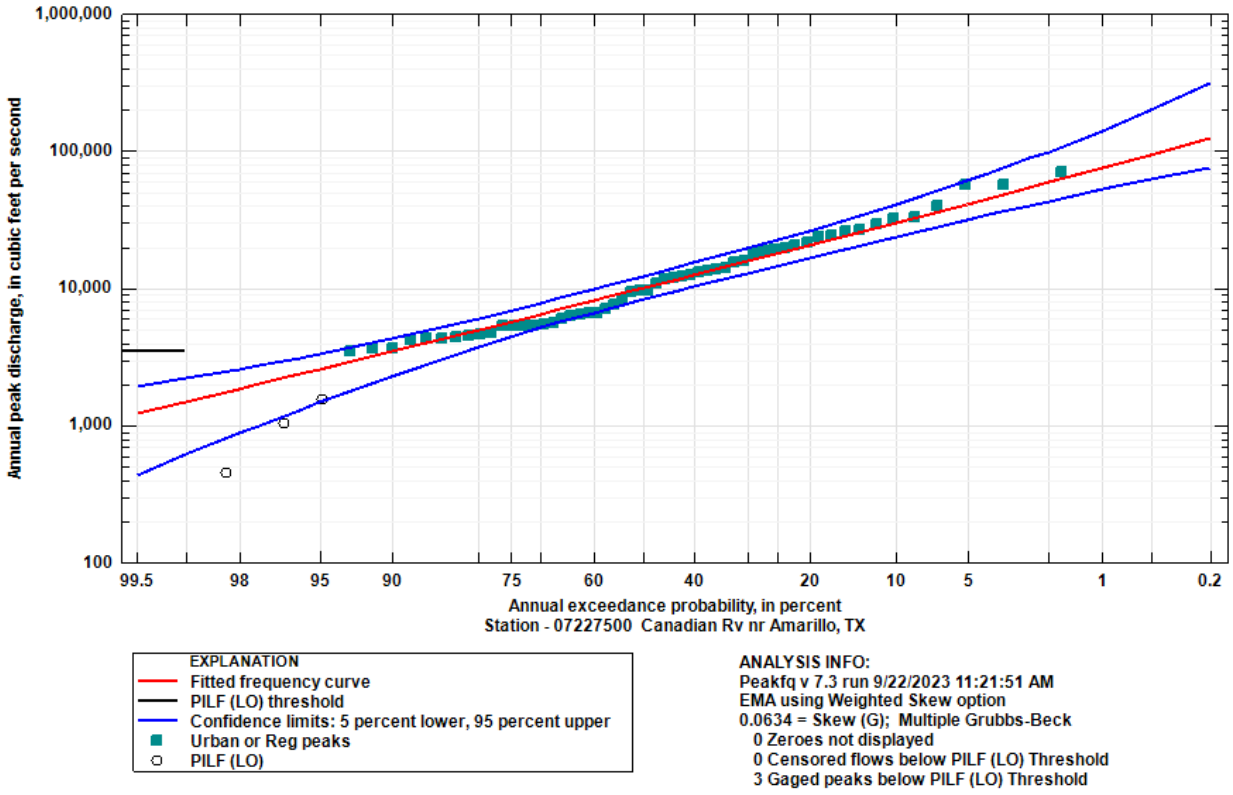

Figure 6. Peak discharge frequency analysis for station USGS 07227500 using Weighted Skew Option.

Reference: **Bulletin 17C Analysis for TWDB Task Order 3**

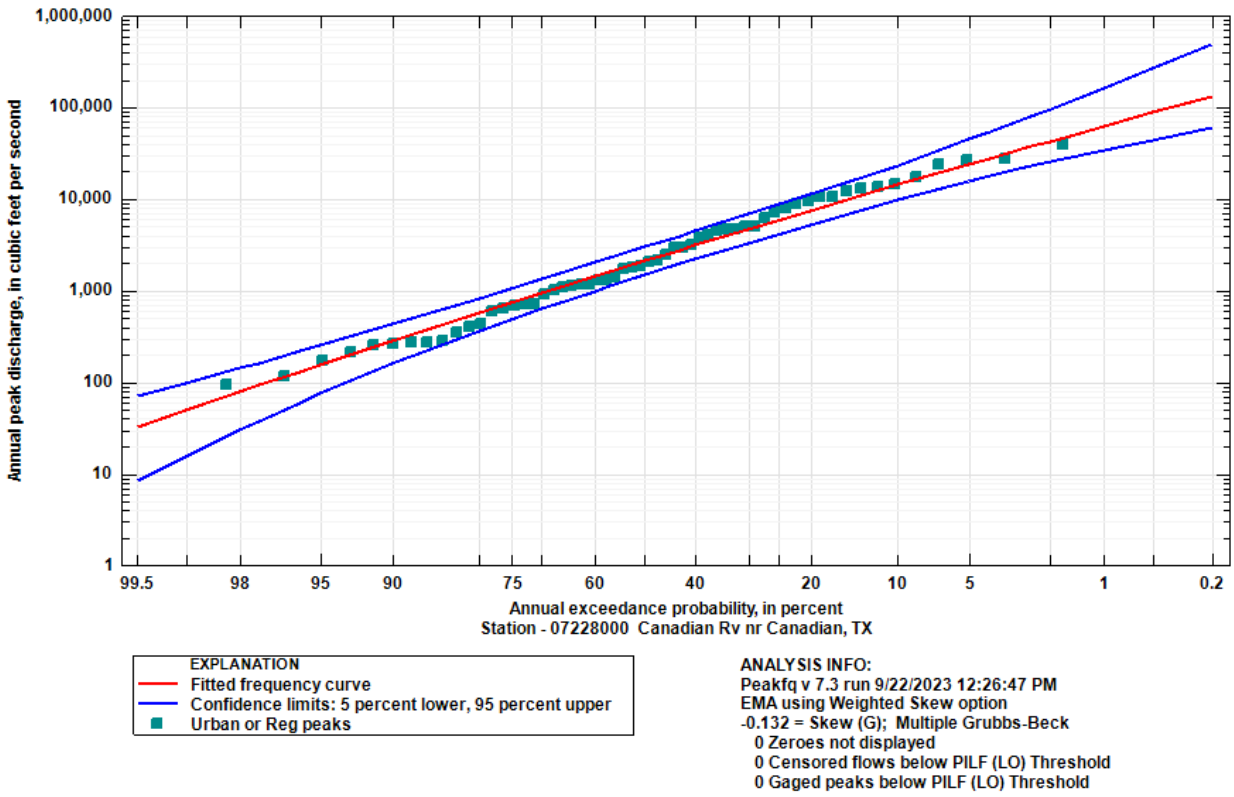

Figure 7. Peak discharge frequency analysis for station USGS 07228000 using Weighted Skew Option.

Reference: **Bulletin 17C Analysis for TWDB Task Order 3**

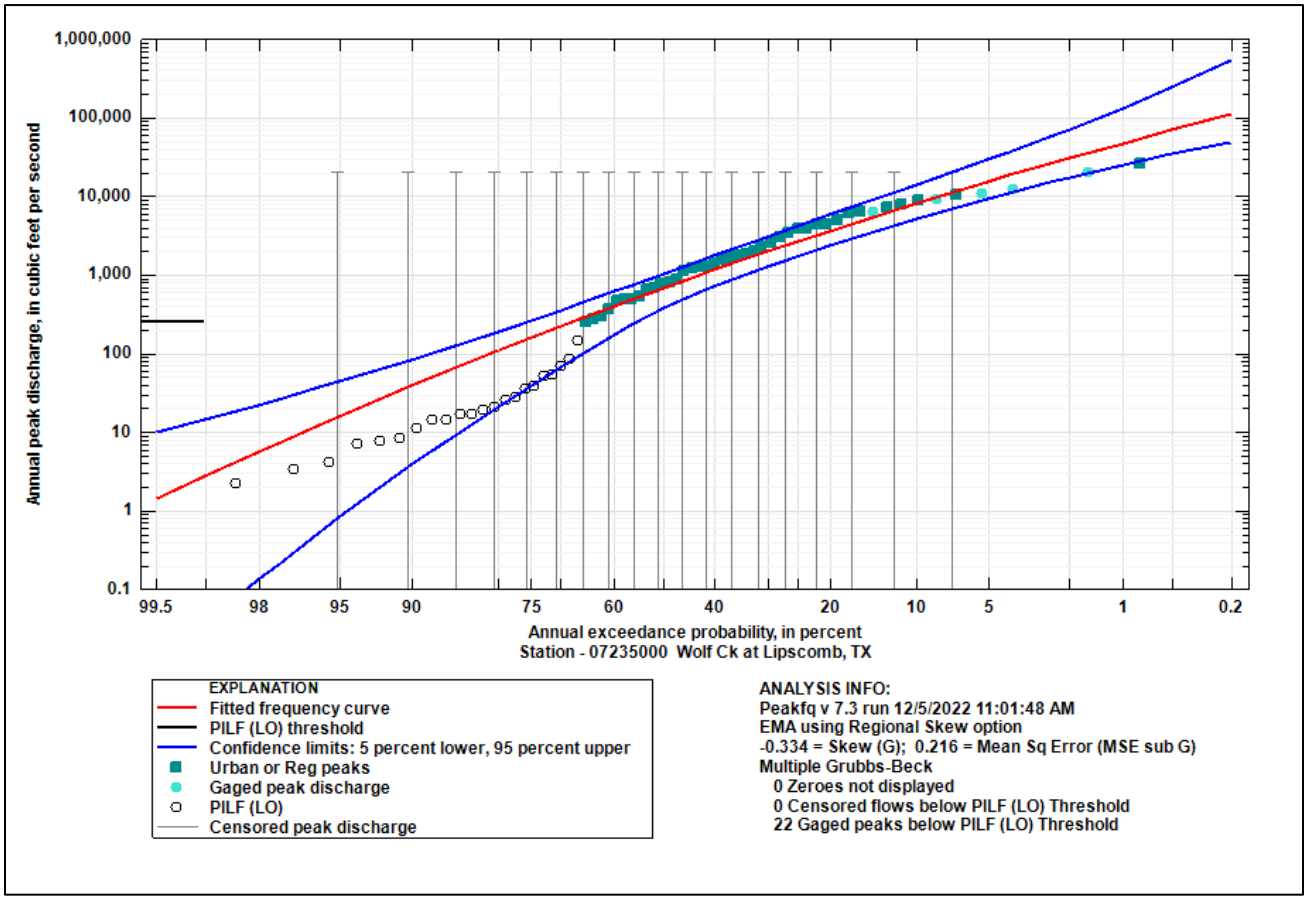

Figure 8. Peak discharge frequency analysis for station USGS 07235000 using Regional Skew Option.

REFERENCES

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