APPENDIX

ANALYSIS OF EXTREME RAINFALL EVENTS OCCURRING AT ODESSA, TEXAS

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1.0 PURPOSE

The purpose of this report is to define extreme rainfall intensities at Odessa, Texas for storms of predetermined length and return period. Due to local observations on rainfall patterns and flooding, the City felt the existing rainfall analysis developed by the U. S. Weather Bureau presented in Technical Paper No. 40 (Hershfield, 1961) were not accurately describing local rainfall. Since a Class "A" weather station which keeps records of short duration extreme rainfall events was not established in the Odessa area until 1955 there was not sufficient data at that time to accurately describe short duration rainfall intensities. The rainfall intensities developed in this report are based on twenty years of detailed data compiled at the Class "A" weather station located at the Midland-Odessa Airport. Additional data on twenty-four hour rainfall events was analyzed to substantiate the results.

Section 2.0 of this report describes the statistical techniques employed to derive the results displayed in Section 3.0.

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2.0 METHODOLOGY

The approach used in analyzing the data of extreme events was developed by Fisher and Tippett in 1928 which resulted from their investigation of the distribution of extreme values. One of the first published hydrological applications of the Fisher-Tippett work was by E. J. Gumbel in 1941. To apply the technique a series of N observations of a random variable y is divided into n subsamples each of size m, so that N = mn. The largest occurrence in each subsample is selected, thus creating a set of random variables X_i, i = 1, 2,...., n, which can be described by a Gumbel distribution.

The probability density function takes the form

$$f_X(x) = \alpha \exp\left[-\alpha(x-\beta)-e^{-\alpha(x-\beta)}\right] \qquad (1)$$

where

$$-\alpha \leq X \leq \alpha$$

and the cumulative distribution function is given by

$$F_X(x) = \exp\left[-e^{-\alpha(x-\beta)}\right] \qquad (2)$$

The two parameters that locate and shape the distribution (β and α) are the mode and a measure of the dispersion of the data, respectively. The mean (μ), standard deviation (σ), and the median (M) are defined by,

$$\mu = \beta + \gamma/\alpha; \quad \sigma = \pi/(\alpha\sqrt{6}); \quad M = \beta + 0.3665/\alpha$$

where γ is Euler's constant (0.577). The skewness of a Gumbel distribution has a constant value of 1.1396.

As the size of the sample approaches infinity, the sample mean and standard deviation approach the population mean and standard deviation, therefore,

$$\alpha = 1.281/\sigma \text{ and } \beta = \mu - 0.45\,\sigma.$$

Because our samples are not infinite, the sample mean and standard deviation ($\hat{\mu}$, $\hat{\sigma}$) are used for the population statistics resulting in

$$\alpha = a/\hat{\sigma} \text{ and } \beta = \hat{\mu} - b/\alpha.$$

Table I is a set of values for a and b obtained by least-square analysis that was done by Gumbel (1954).

TABLE I

Years	b	a	Years	b	a
20	0.52	1.06	80	0.56	1.19
30	0.54	1.11	90	0.56	1.20
40	0.54	1.14	100	0.56	1.21
50	0.55	1.16	150	0.56	1.23
60	0.55	1.17	200	0.57	1.24
70	0.55	1.19	∞	0.57	1.28

The Gumbel distribution has been widely used to analyze extremes in hydrological events, e.g., flood discharge, wind gust, rainfall, etc. This analysis is used by the U.S. Weather Bureau to establish the frequency of extreme rainfall events (see Hershfield, 1961).

3.0 ANALYSIS

Table II is a listing of the rainfall durations and their corresponding period of record that was analyzed.

TABLE II

DURATION (Min.)	PERIOD OF RECORD	LENGTH OF RECORD (Yrs.)
5	1955-1969, 1971-1975	20
10	1955-1969, 1971-1975	20
15	1955-1969, 1971-1975	20
30	1955-1969, 1971-1975	20
60	1955-1975	21
120	1955-1975	21
180	1955-1975	21
1440	1955-1975	21

Table III shows the sample mean and standard deviation for the different durations of annual maximum rainfall.

TABLE III

DURATION (Min.)	MEAN DEPTH (in.)	STANDARD DEVIATION (in.)
5	.413	.127
10	.669	.234
15	.879	.302
30	1.23	.472
60	1.39	.636
120	1.53	.726
180	1.70	.978
1440	2.36	1.21

Taking twice the logarithm of Eq. (2) yields

$$\alpha(x-\beta) = -\ln \left[-\ln F_X(x)\right] \quad (3)$$

where

$$F_X(x) = 1 - P \left[X \geq x\right]$$

therefore

$$x = \{-\ln(1-P \left[X \geq x\right]))\}(\hat{\sigma}/a) + \hat{\mu} - (b\hat{\sigma}/a).$$

Letting $k = -\ln(-\ln(1-P \left[X \geq x\right]))$

gives $x = \hat{\sigma}/a \; (k - b) + \hat{\mu}.$ (4)

For a given return period, i.e., $T_R = 1/P \left[X \geq x\right]$, and the mean and standard deviation for a particular duration, a depth of rainfall can easily be calculated from Eq. (4).

Results of this analyses are depicted graphically in Fig. 1. Table IV is a tabular comparison of rainfall depth vs. return period from TP-40, this analysis and the data currently used by the City of Odessa.

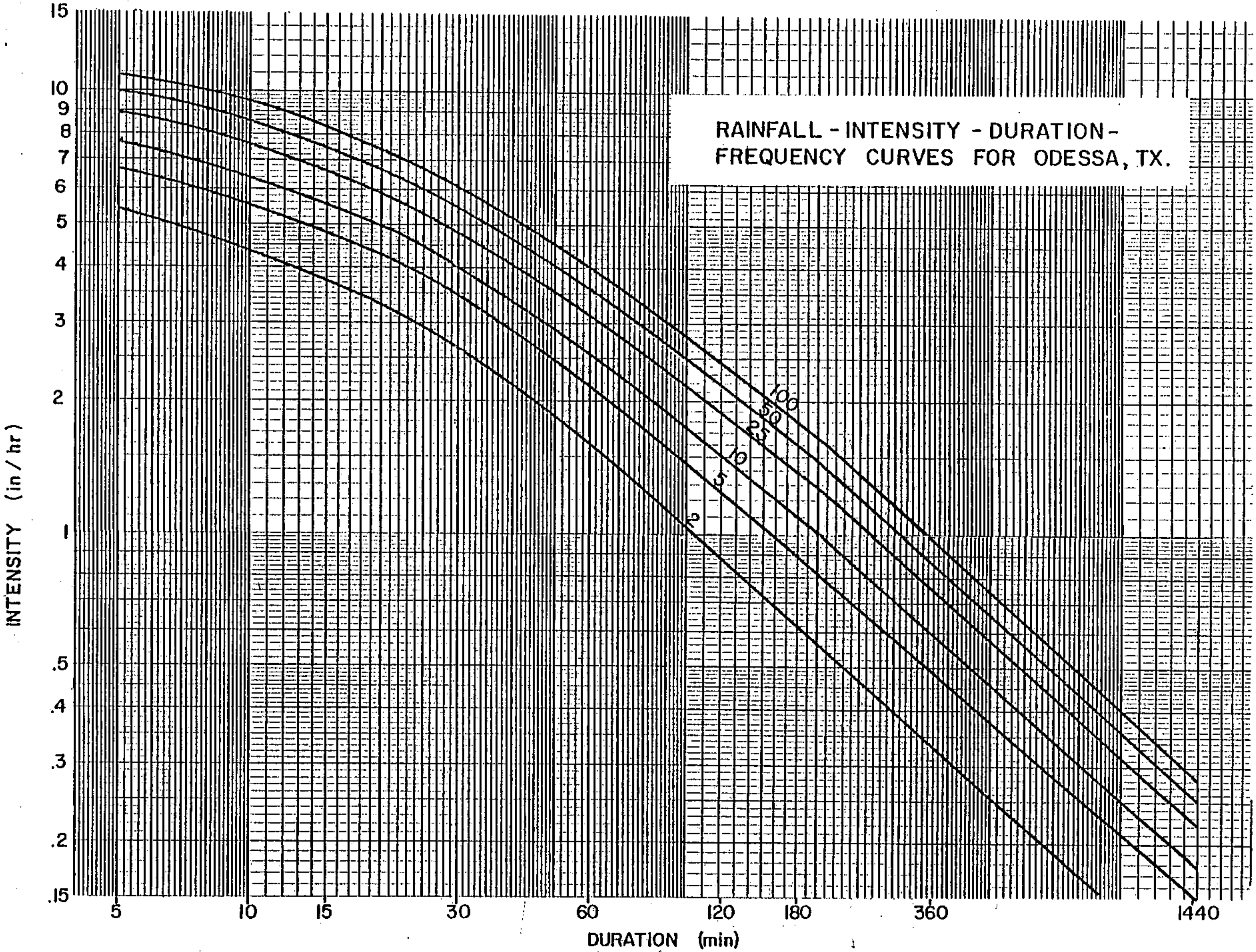

Fig. 1 Rainfall Intensity vs. Duration for Selected Return Periods.

TABLE IV

RAINFALL DEPTH VS. RETURN PERIODS
(all values in inches)

D/T_R		2	5	10	25	50	100
5	TP40	NA	NA	NA	NA	NA	NA
	EH&A	.45	.55	.63	.73	.82	.90
	City	NA	.47	.51	.58	.60	NA
10	TP40	NA	NA	NA	NA	NA	NA
	EH&A	.72	.92	1.06	1.26	1.42	1.57
	City	NA	.73	.83	.97	1.03	NA
15	TP40	NA	NA	NA	NA	NA	NA
	EH&A	.95	1.20	1.39	1.64	1.84	2.04
	City	NA	.83	.95	1.28	1.38	NA
30	TP40	1.0	1.4	1.6	1.9	2.2	2.5
	EH&A	1.32	1.73	2.02	2.42	2.74	3.05
	City	NA	1.35	1.60	1.95	2.10	NA
60	TP40	1.3	1.8	2.1	2.5	2.8	3.1
	EH&A	1.60	2.17	2.55	3.12	3.59	4.01
	City	NA	1.75	2.10	2.60	2.85	NA
120	TP40	1.5	2.2	2.6	3.0	3.3	3.8
	EH&A	1.75	2.50	3.02	3.76	4.36	4.90
	City	NA	2.1	2.6	3.1	3.8	NA
180	TP40	1.6	2.3	2.7	3.2	3.6	4.2
	EH&A	1.86	2.70	3.32	4.17	4.81	5.46
	City	NA	NA	NA	NA	NA	NA
1440	TP40	2.7	3.7	4.5	5.2	6.0	6.7
	EH&A	2.48	3.61	4.37	5.41	6.21	7.00
	City	NA	NA	NA	NA	NA	NA

NA - not available

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