SPEAKER SESSION 10b

SHORT DURATION RAINFALL FOR DESIGN STORMS

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Abstract:

The January 1995 storms in California produced flooding that was locally severe. The flooding was due primarily to extremely intense rainfall of short duration but of limited area extent. Observed rainfall data are compared with design rainfall amounts for design storms from county hydrology manuals and NOAA Atlas 2. For periods of less than one hour the rainfall totals at a number of locations were greater than the 100 yr rainfall values given by agency design storm procedures.

The procedures for applying design rainfall are reviewed in this paper in regards to the time increment for runoff calculations and areal reduction factors. It is suggested that using unit hydrographs for the full upstream contributing area above a watershed control point rather than using multiple subbasins and routing flow between control points is a more appropriate procedure. This procedure can be applied using standard hydrologic models such as HEC-1 and some examples are presented.

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Characteristics of Northern California Storms

The proper application of design rainfall requires an understanding of storm types and characteristics.) Houze and Hubbs (1982) studied the organization and structure of cloud systems in which precipitation was occurring. They carefully assessed the studies of a large number of investigators who had studied frontal types of storms. Typically frontal precipitation is organized into rainbands of various sizes. Raincells are imbedded in these bands. These cells grow and decay, producing very intense short-duration rainfall as the band passes a point on the earth's surface.

This frontal structure was studied and modeled by Amorocho and Wu (1975). Figure 1 shows a simulation of a typical storm pattern in central California. A number of other investigators have also model rainband and storm cell structures. an example is shown in Figure 2.

During the 1995 storms in California the recent acquisition of Doppler radar images by commercial television weather reports has allowed the general public to see the storm images in "real-time" in their living rooms.

Recording rain gage records also show that rainfall tends to occur in periods of intense rainfall during the period that a rainfall band passes over a rain gage. When there are multiple bands these show up as periods of intense rain separated by periods of low rainfall (see Figure 3).

Implications for Hydrologic Modeling

How do these observed spatial and temporal rainfall patterns affect the application of hydrologic models?

The majority of hydrologic studies rely on rainfall data to compute runoff from rainfall associated with a given recurrence frequency. Most procedures rely on a nested design storm of a specified frequency for the rainfall input. Other approaches use a historical rainfall sequence from a rain gage located near the study area in connection with a continuous runoff model (such as the SWMM model). The resulting flood hydrograph is used to provide a record of flood peaks to provide discharge data four a flood flow frequency analysis.

In each of these cases the rainfall is usually assumed to be uniformly distributed over the entire watershed, unless the modeler uses special procedures to deal with spatial distribution of precipitation. Usually an areal reduction factor is used for the computation of basin average rainfall. Also, for watersheds with multiple subbasins, the sharp peak associated with a design storm can produce hydrographs that are not correct. The peak rainfall does not occur simultaneously over all portions of the watershed. The *actual* watershed runoff processes have the effect of integrating and smoothing out of the rainfall peaks to a certain degree due to surface ponding and other effects. Models that use a very short time step or exaggerate the rainfall peak may produce erroneously high flood peaks.

Suggested Alternative Procedure

It is common practice to apply a design storm to a multilpe subbasin model using the same rainfall for the entire basin with a intense peak occurring simultaneously at all points in the basin. It may be more appropraite to develop a single unit hydrograph for the entire area contributing flow to the pointy of interest and then apply the design storm to the watershed with an appropriate time increment for the rainfall This will give a more accurate representation of the runoff.

References

Amorocho, J., and P. Wu (1975) Mathematical Models for the Simulation of Cyclonic Storm Sequences and Precipitation Fields, in *Precipitation Analysis for Hydrologic Modeling,* National Symposium sponsored by the Precipitation Committee of the AGU Section of Hydrology, Davis, California.

Houze and Hubbs (1982)

Short Duration Rainfall

Observed & Design Storms

Variation in time & spac

Characteristics of design storms

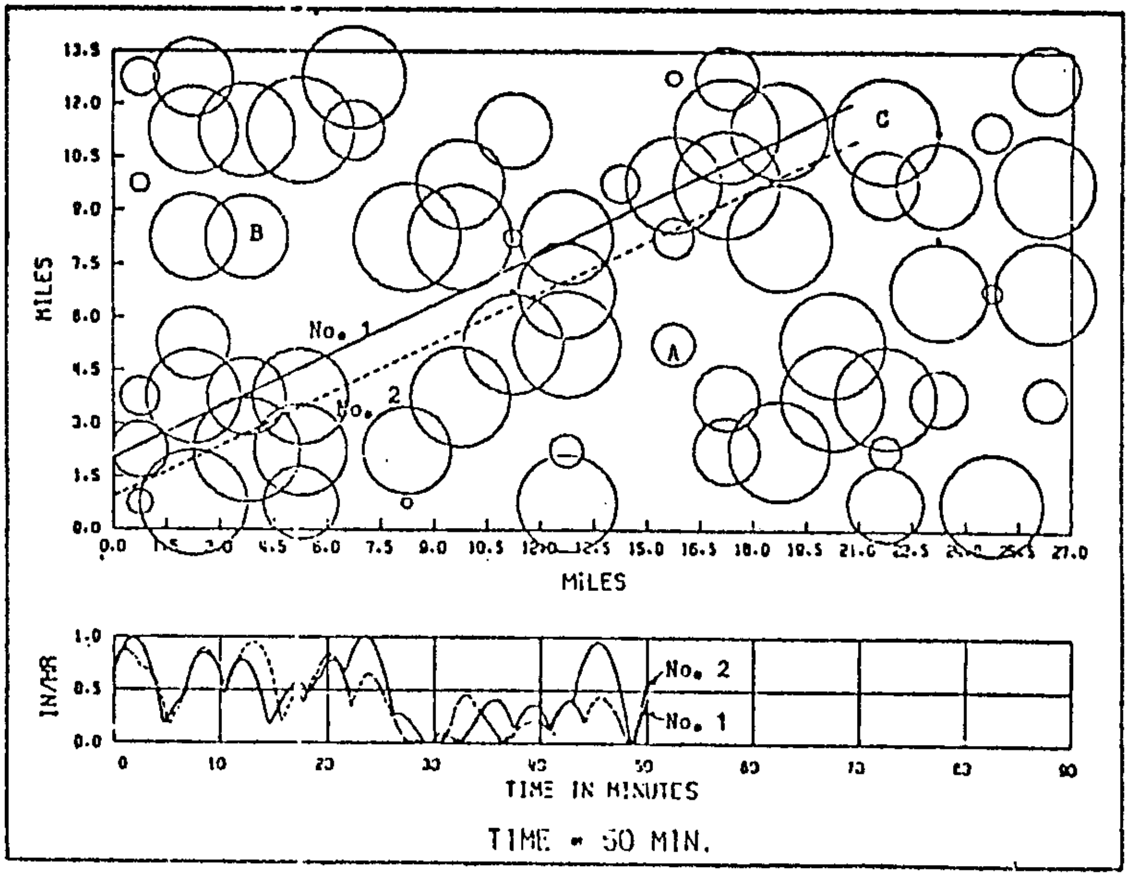


Figure 1 - Instantaneous Display of Precipitation Field Simulation, and of Rain Catch "Records" For Two Gages (Nos. 1 and 2) at Arbitrary Locations.

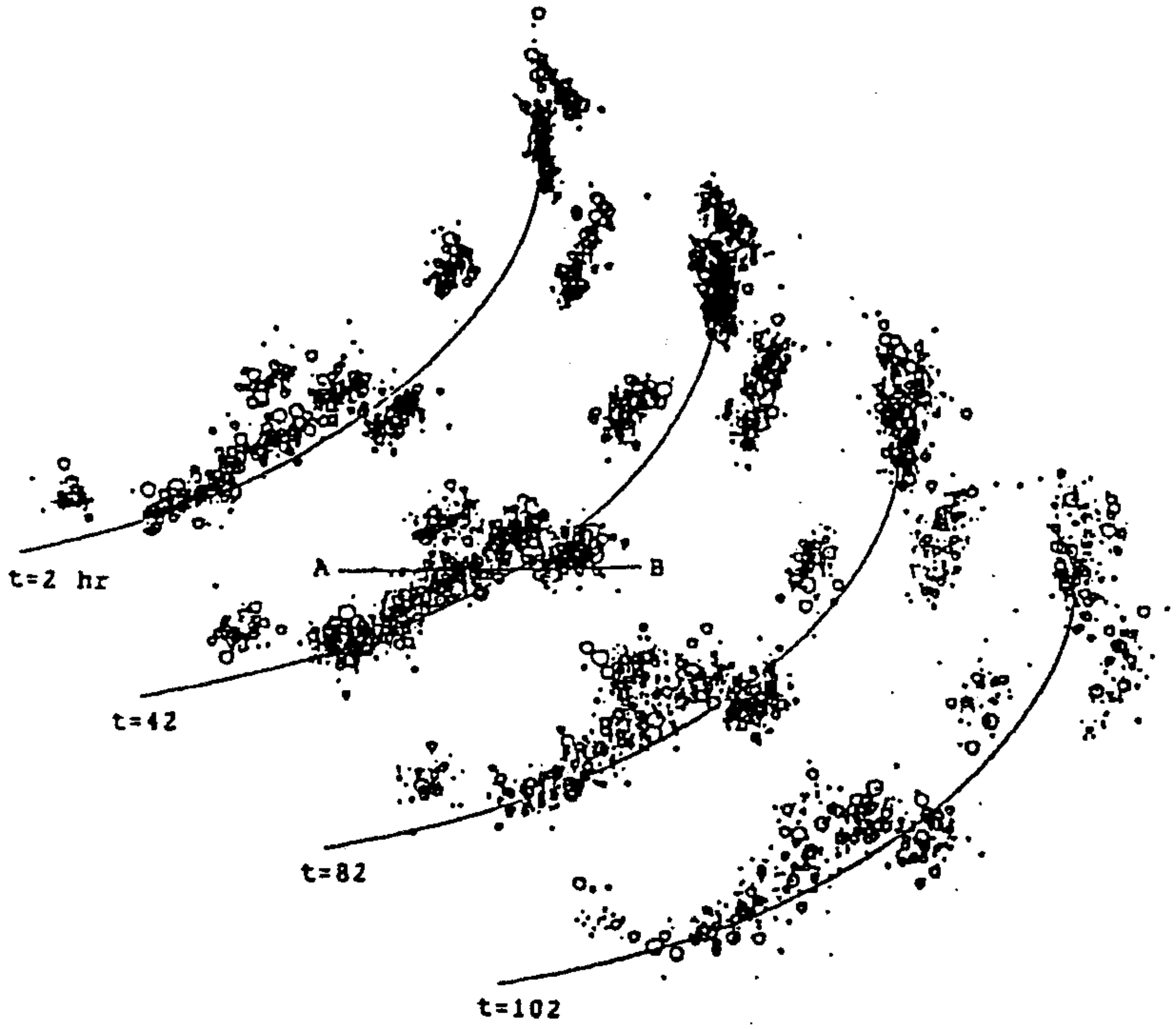


Fig. 2 The simulated front, rainbands and CPAs at time $t=2$, 42, 82, 102 hr.

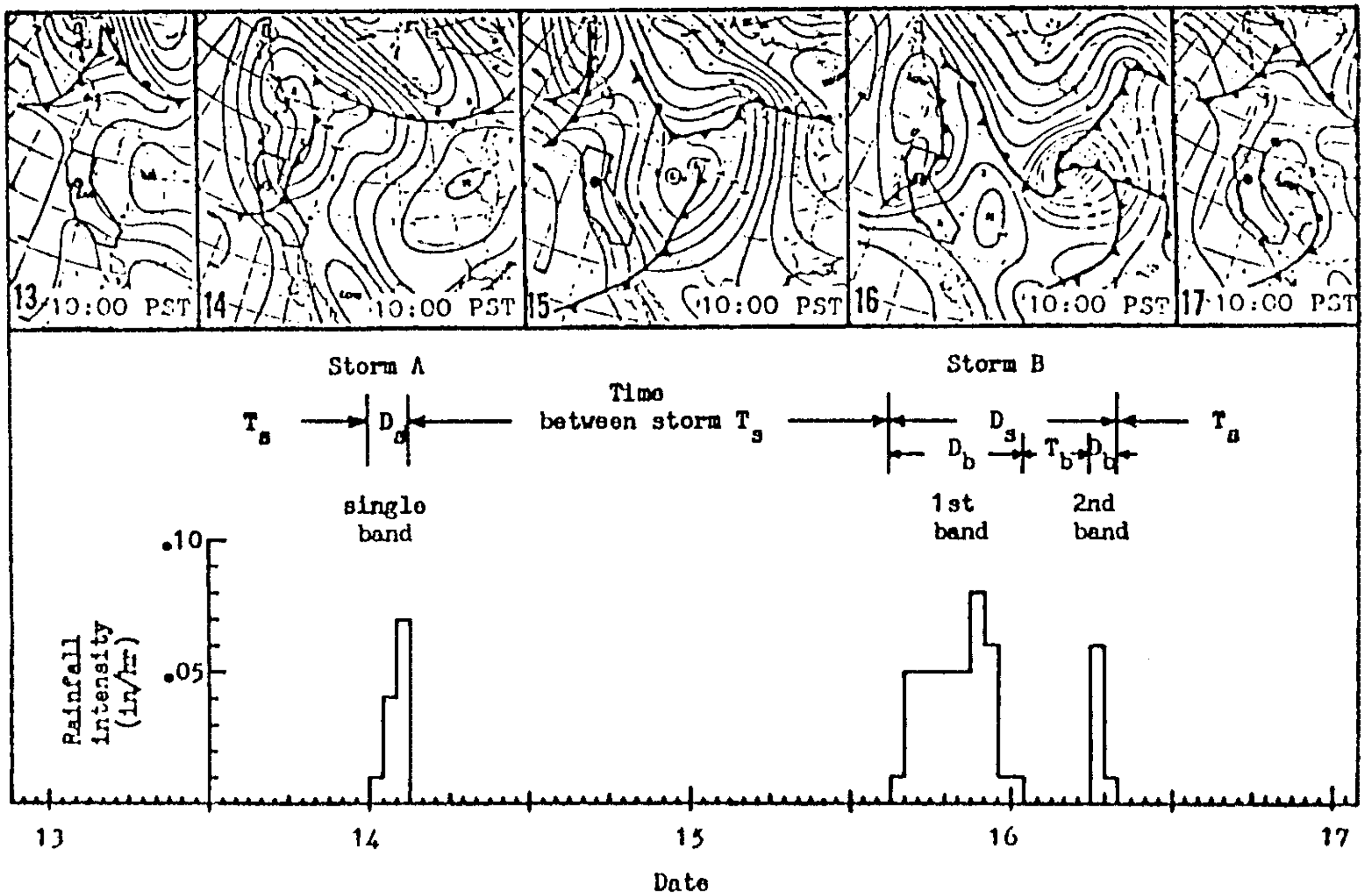
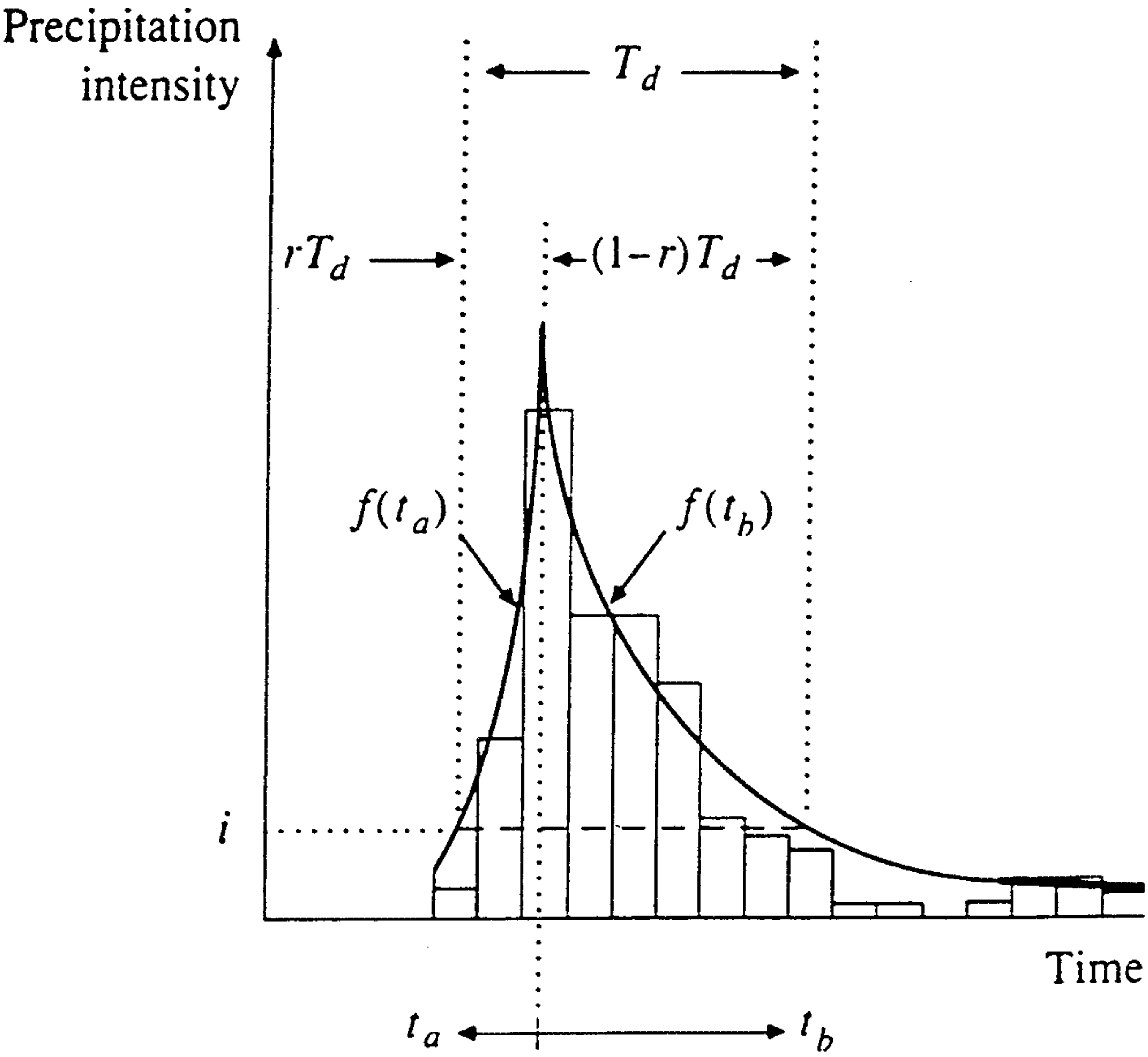


Figure 3 - Typical Separation of Storms and Rain Bands. March 14-17, 1963.

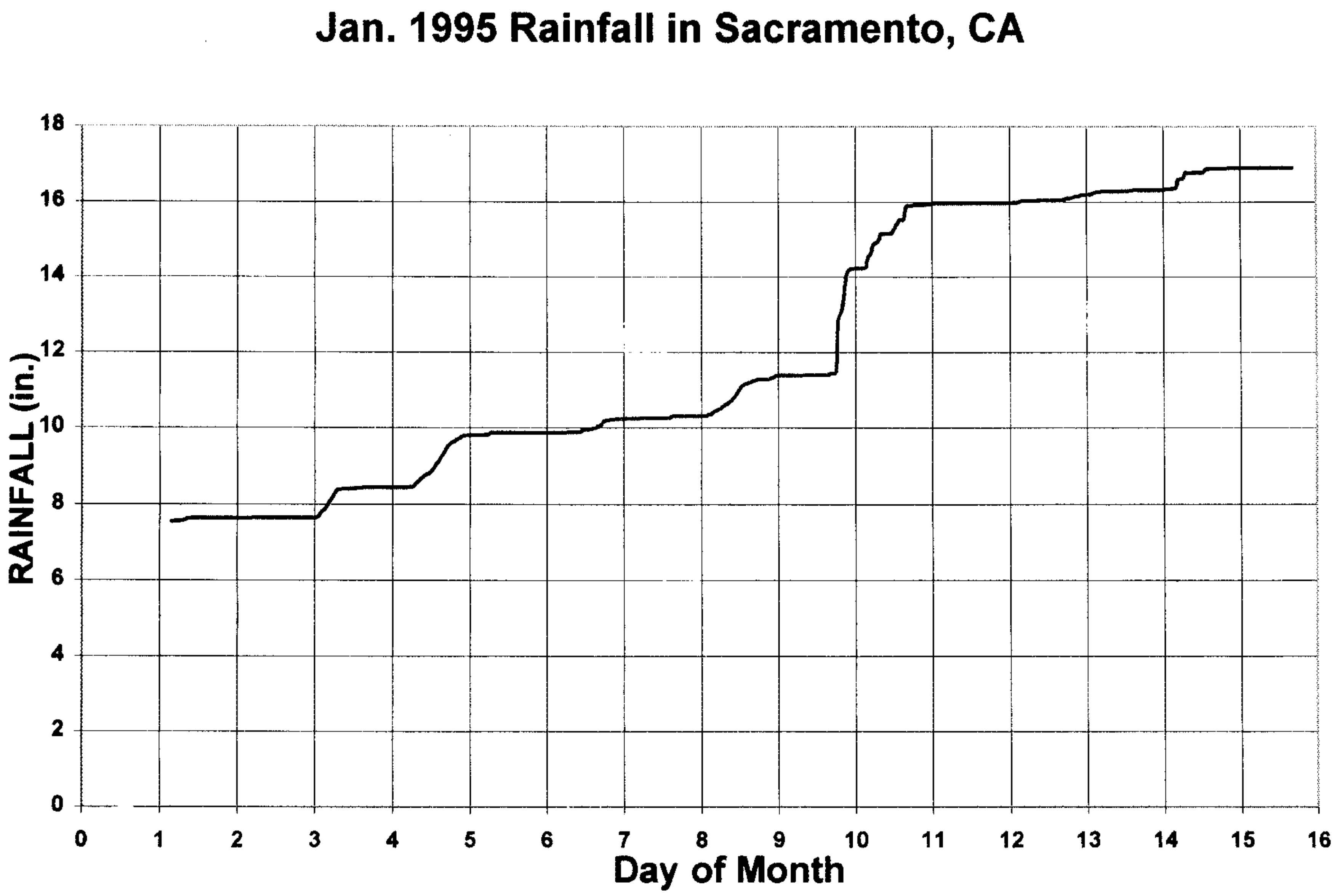


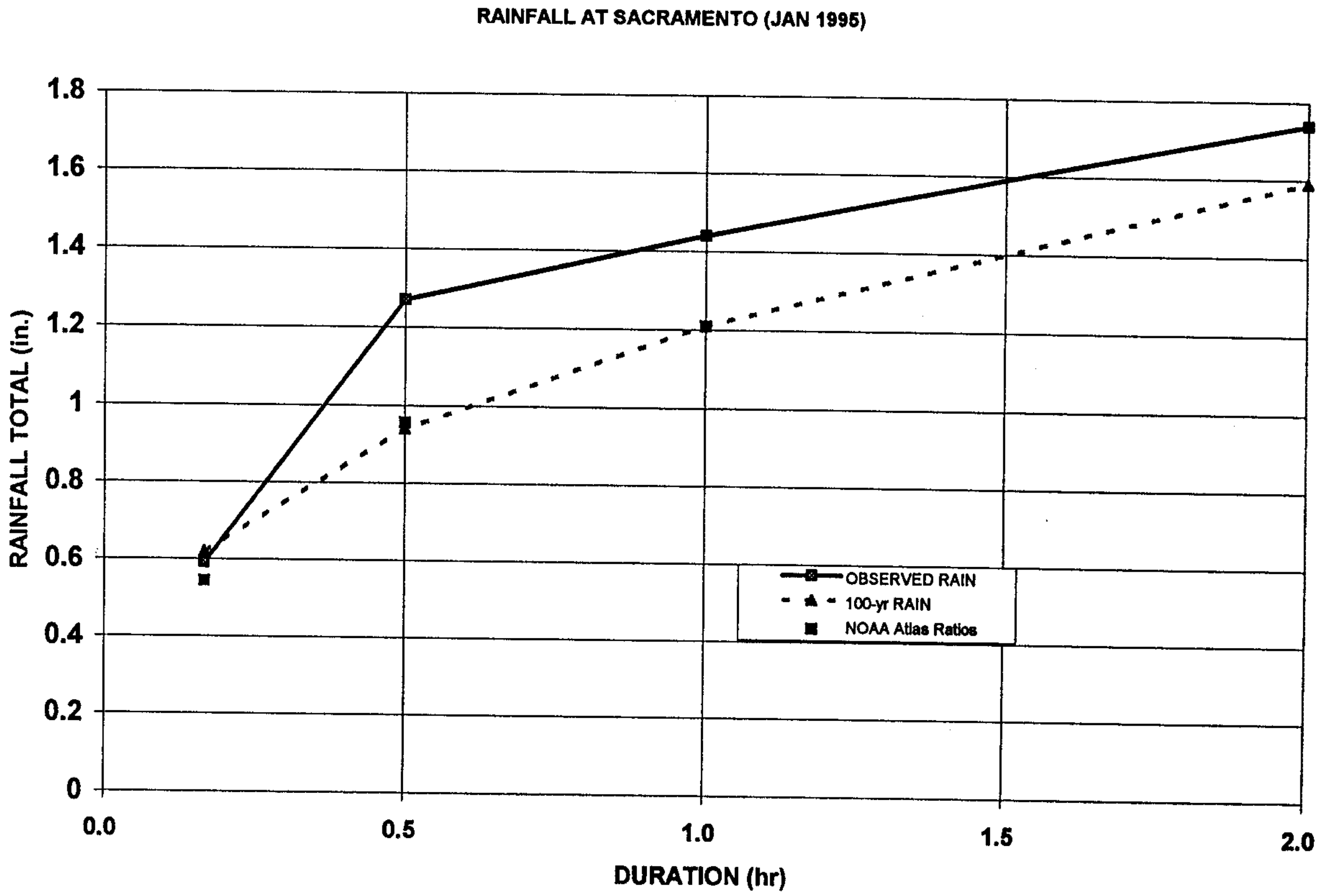
Precipitation intensity
T_d
rT_d
$(1-r)T_d$
$f(t_a)$
$f(t_b)$
i
Time
t_a
t_b

SACRAMENTO POST OFFICE RAIN
INCHES

	JANUARY 1995	RETURN PERIOD	PREVIOUS RECORD	
10 MIN	.59	1,000	.62	APRIL 1935
30 MIN	1.27	10,000	0.97	APRIL 1935
1 HOUR	1.44	1,000	1.65	APRIL 1935
2 HOUR	1.74	500	2.62	APRIL 1935
24 HOUR	4.47	100	7.24	APRIL 1880

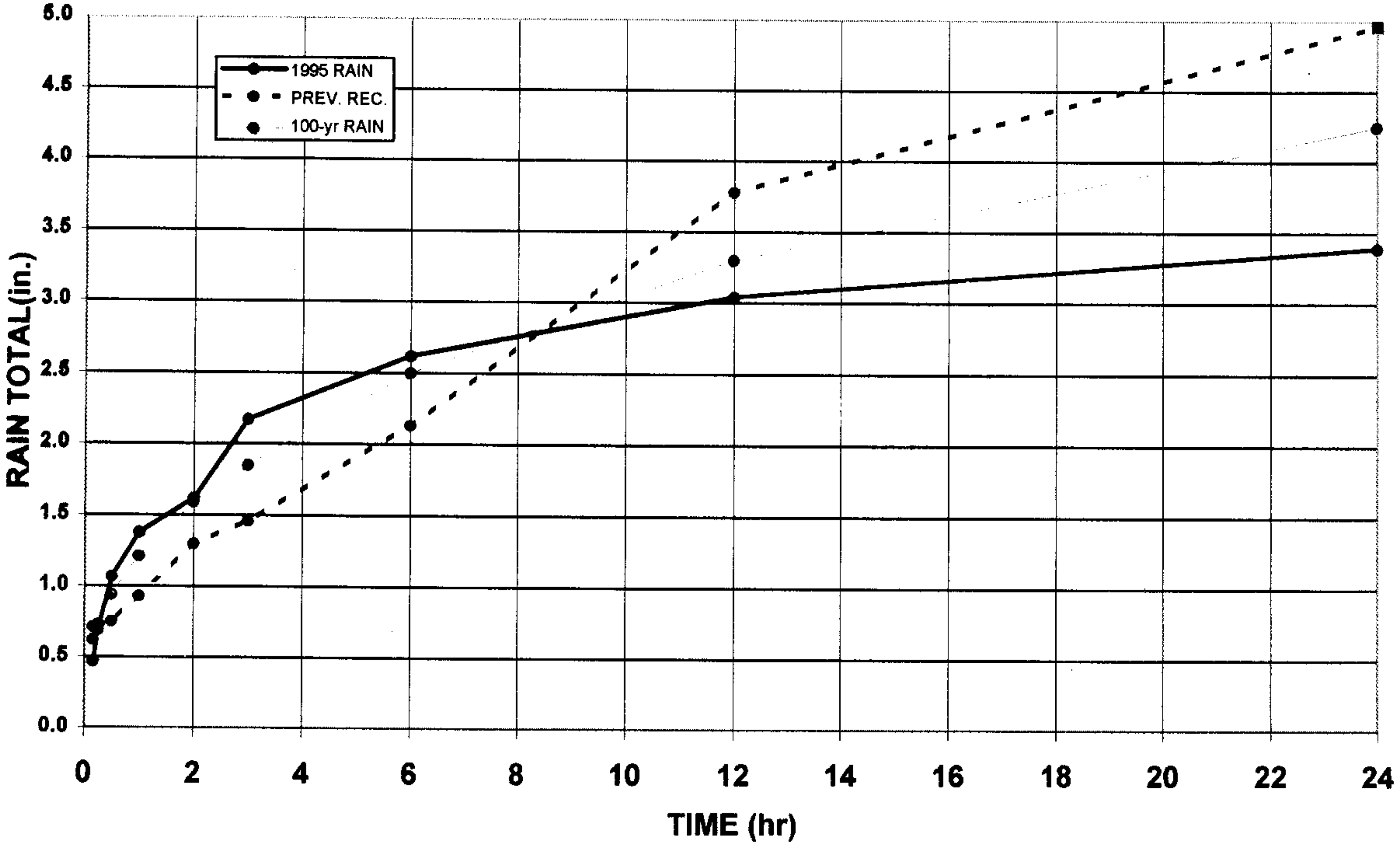
BASED ON 91 YEARS 1903-93


Jan. 1995 Rainfall in Sacramento, CA
RAINFALL (in.)
Day of Month
0
2
4
6
8
10
12
14
16
18
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16

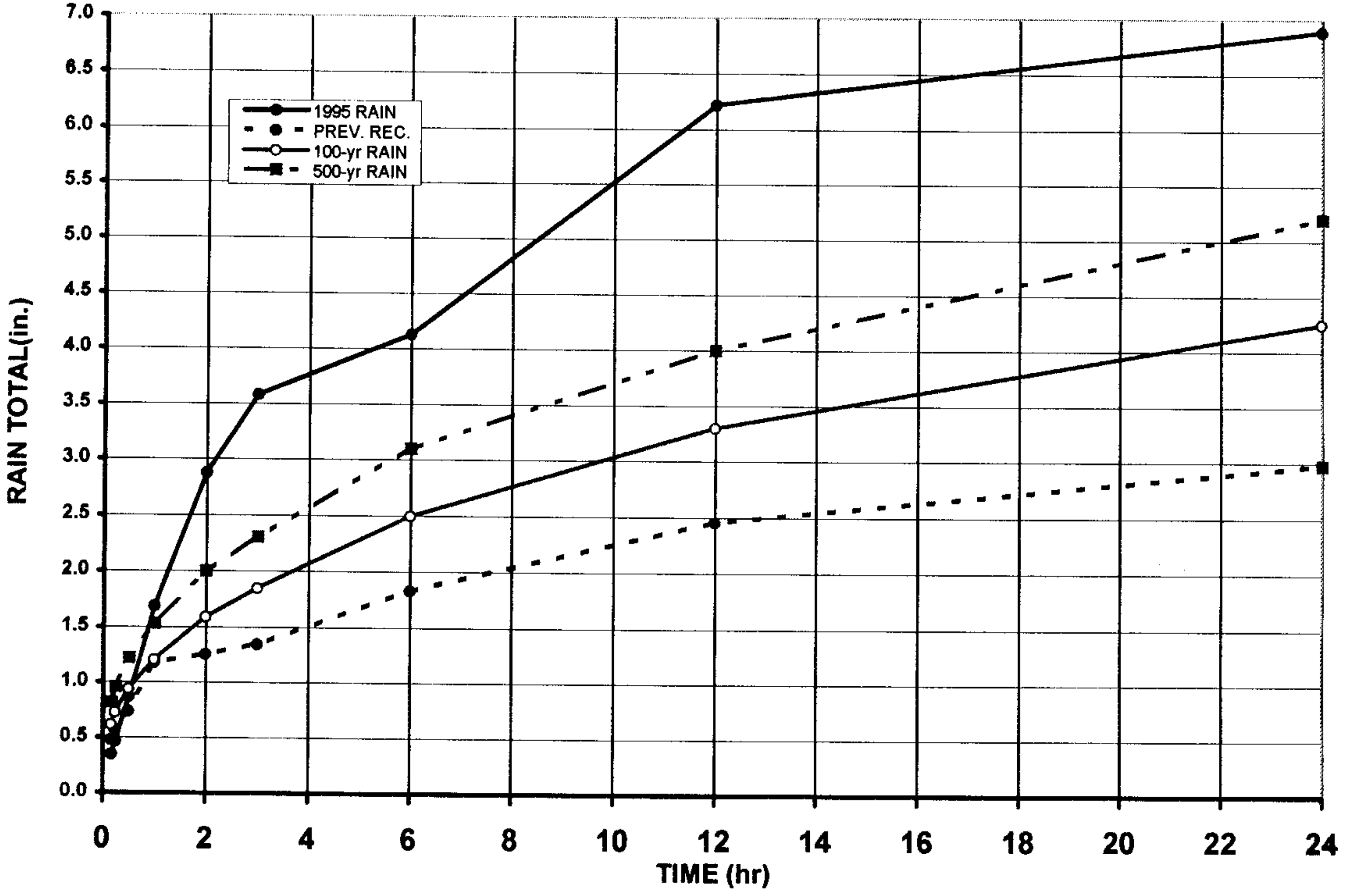


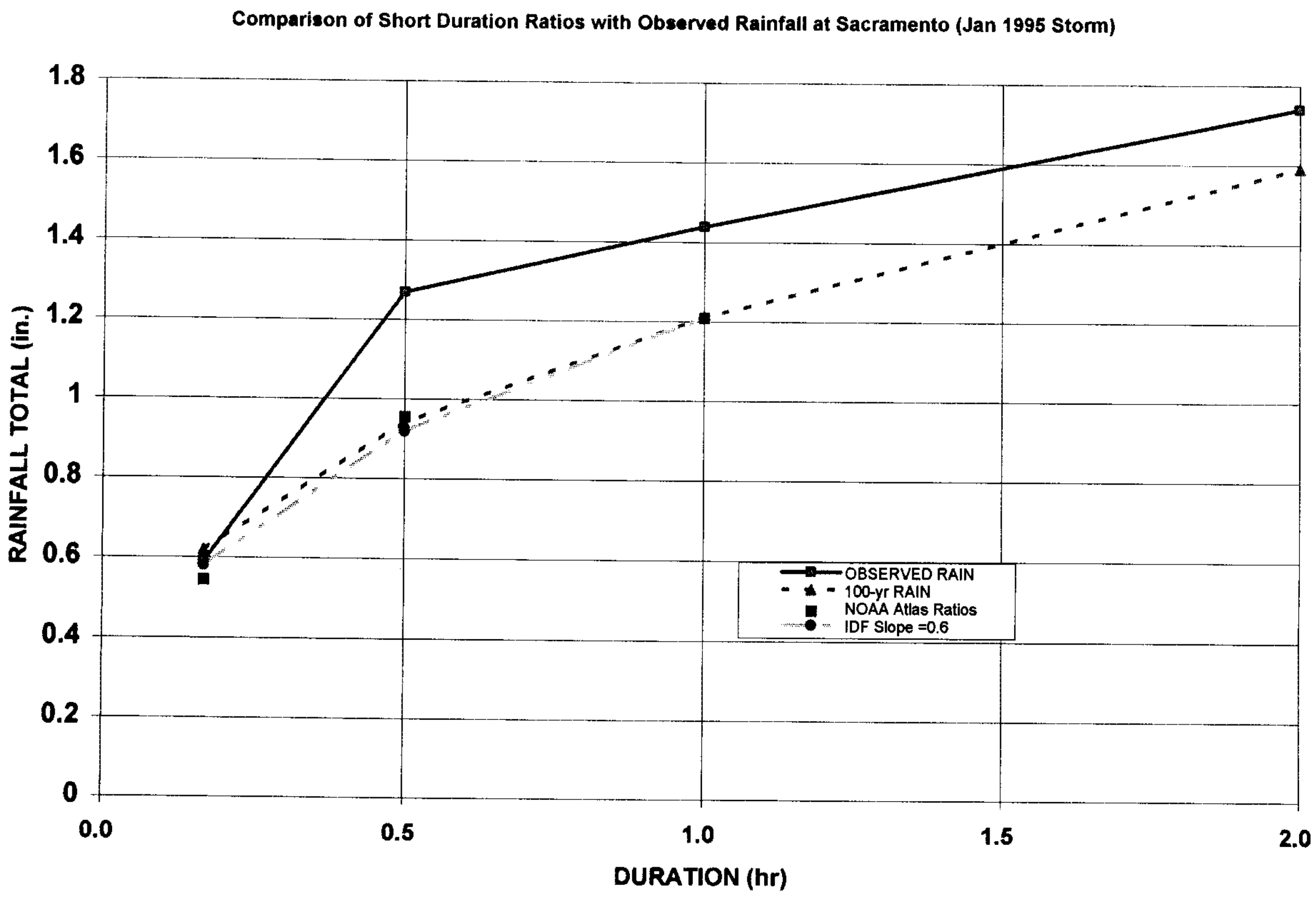
RAINFALL AT SACRAMENTO (JAN 1995)
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
RAINFALL TOTAL (in.)
0.0
0.5
1.0
1.5
2.0
DURATION (hr)
OBSERVED RAIN
100-yr RAIN
NOAA Atlas Ratios

RIO LINDA RAINFALL



ROSEVILLE RAINFALL




Comparison of Short Duration Ratios with Observed Rainfall at Sacramento (Jan 1995 Storm)
RAINFALL TOTAL (in.)
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.0
0.5
1.0
1.5
2.0
DURATION (hr)
OBSERVED RAIN
100-yr RAIN
NOAA Atlas Ratios
IDF Slope =0.6