Estimate of PMF - Degrees of Conservatism

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First PMP Study

- The first PMF study was a result of the cooperative agreement between the National Weather Service who developed the first PMP estimate in 1936 and the U.S. Army Corps of Engineers. Since then all PMF studies were based on NWS Hydrometeorological Reports.

PMF Definition by Corps of Engineers

- The term probable maximum flood (PMF), as used in the official documents of the Corps of Engineers, identifies estimates of hypothetical flood characteristics (peak discharge, volume, and hydrograph shape) that are considered to be the most severe "reasonably possible" at a particular location, based on relatively comprehensive hydrometeorological analyses of critical runoff-producing precipitation (and snowmelt, if pertinent) and hydrologic factors favorable for maximum flood runoff.

PMF Definition - FERC

- The definition of the PMF contained in the FERC Engineering Guidelines is:

  …the flood that may be expected from the most severe combination of *critical* meteorological and hydrologic conditions that is *reasonably* possible in the drainage basin under study.

Reasonableness of PMF by definition

- None of the two PMF definitions use the word "conservative," but rather require that the resulting PMF should be reasonable for the specific basin under study. Both definitions use the word "critical" but not the word "conservative."

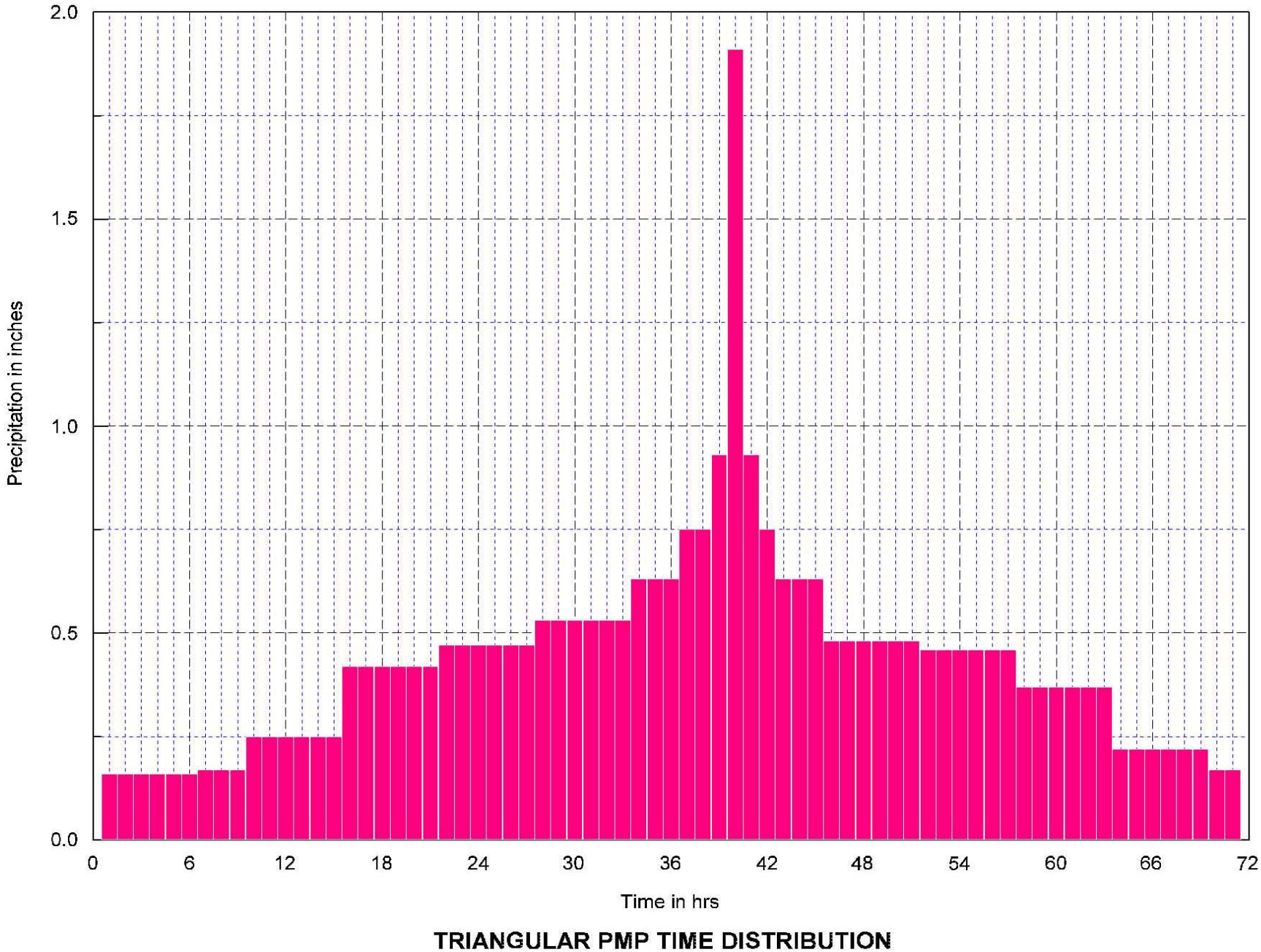
Topics of Presentation

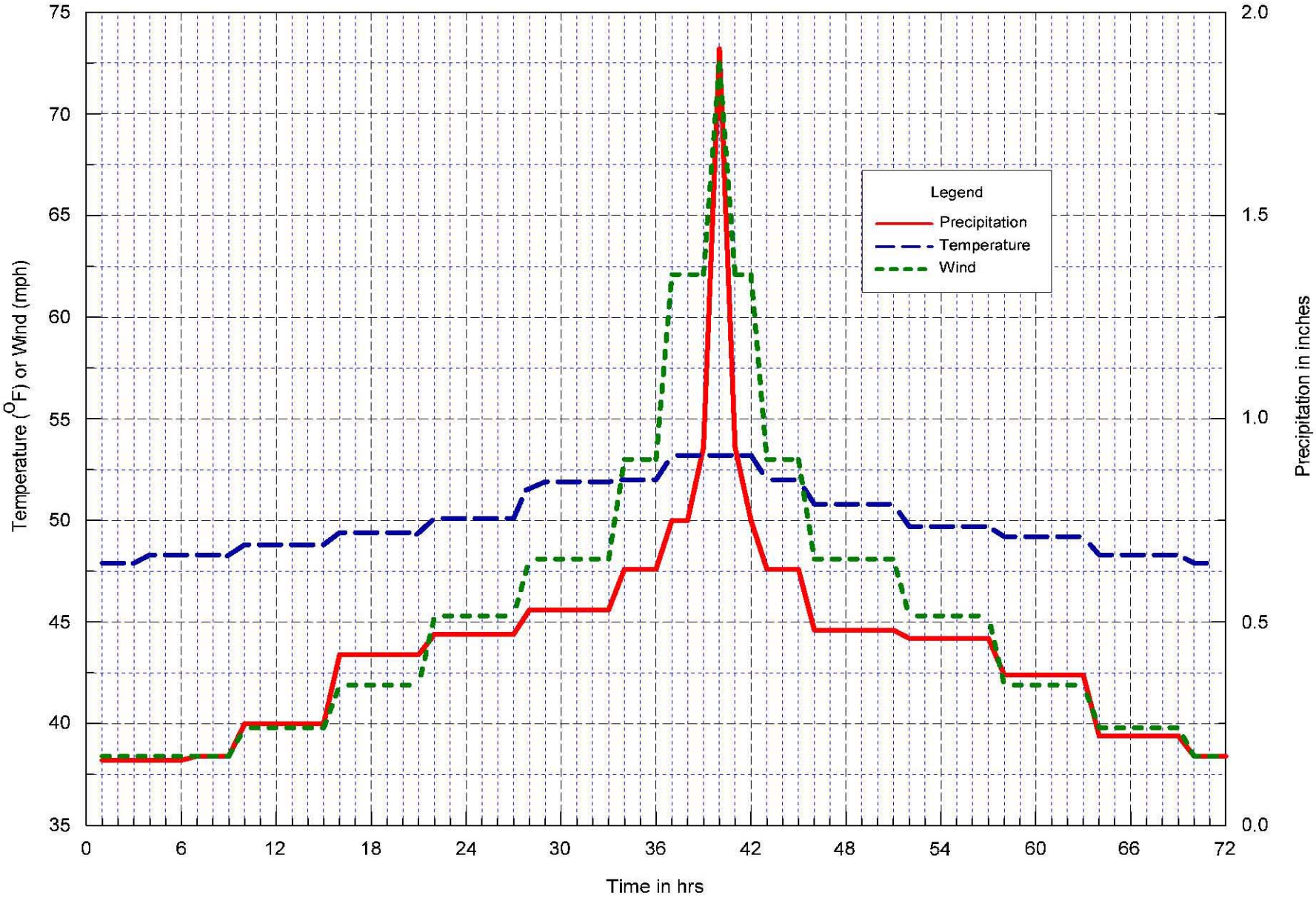
This presentation will discuss four aspects in PMF determination that affect the reasonableness or unreasonableness of the resulting PMF. These are:

- Time-Sequence or Temporal-Distribution of the PMP
- Spatial Distribution of the PMP
- Unit Hydrograph
- Snowpack and Snowmelt

Time-Sequence or Temporal-Distribution of the PMP

- This part of the PMF determination is very significant in the development of the PMF for a given watershed especially for watersheds consisting of several small sub-basins under the "rain-on-snow" condition.


2.0
1.5
1.0
0.5
0.0
Precipitation in inches
0
6
12
18
24
30
36
42
48
54
60
66
72
Time in hrs
TRIANGULAR PMP TIME DISTRIBUTION



TRIANGULAR DAILY TIME DISTRIBUTION WITH TEMPERATURE AND WIND

Explanation of unreasonableness of triangular distribution

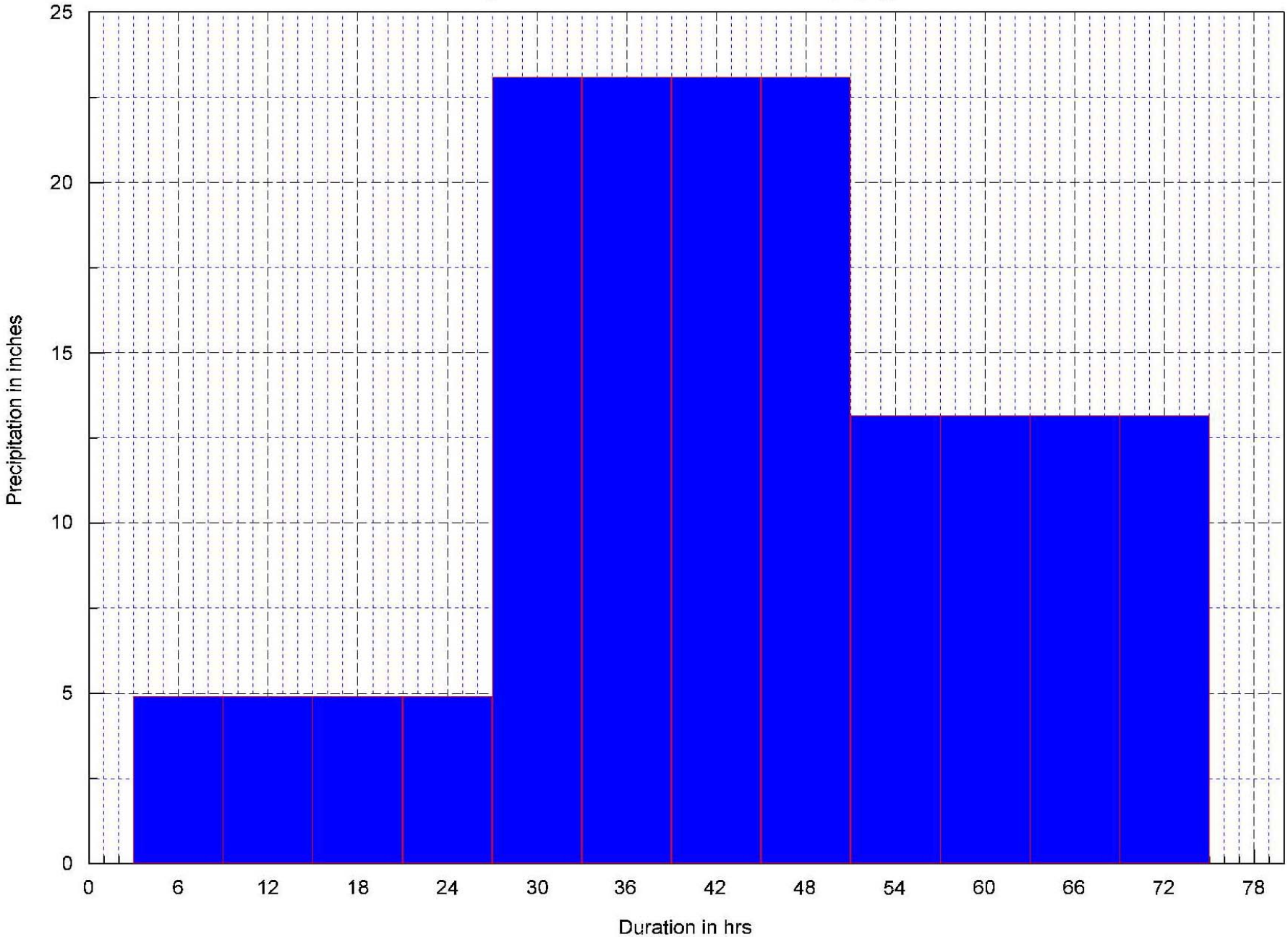
- The triangular distribution assumes that the earth stands still for 72 hours.
- Such assumption is not applicable especially for rain-on-snow event. In other words, the triangular distribution is not meteorologically correct.
- It does not consider the variation of days within the 72 hour duration.
- In a 3-day distribution, the maximum temperature occurs at day time (around 3:00 pm) and the minimum occurs at night.

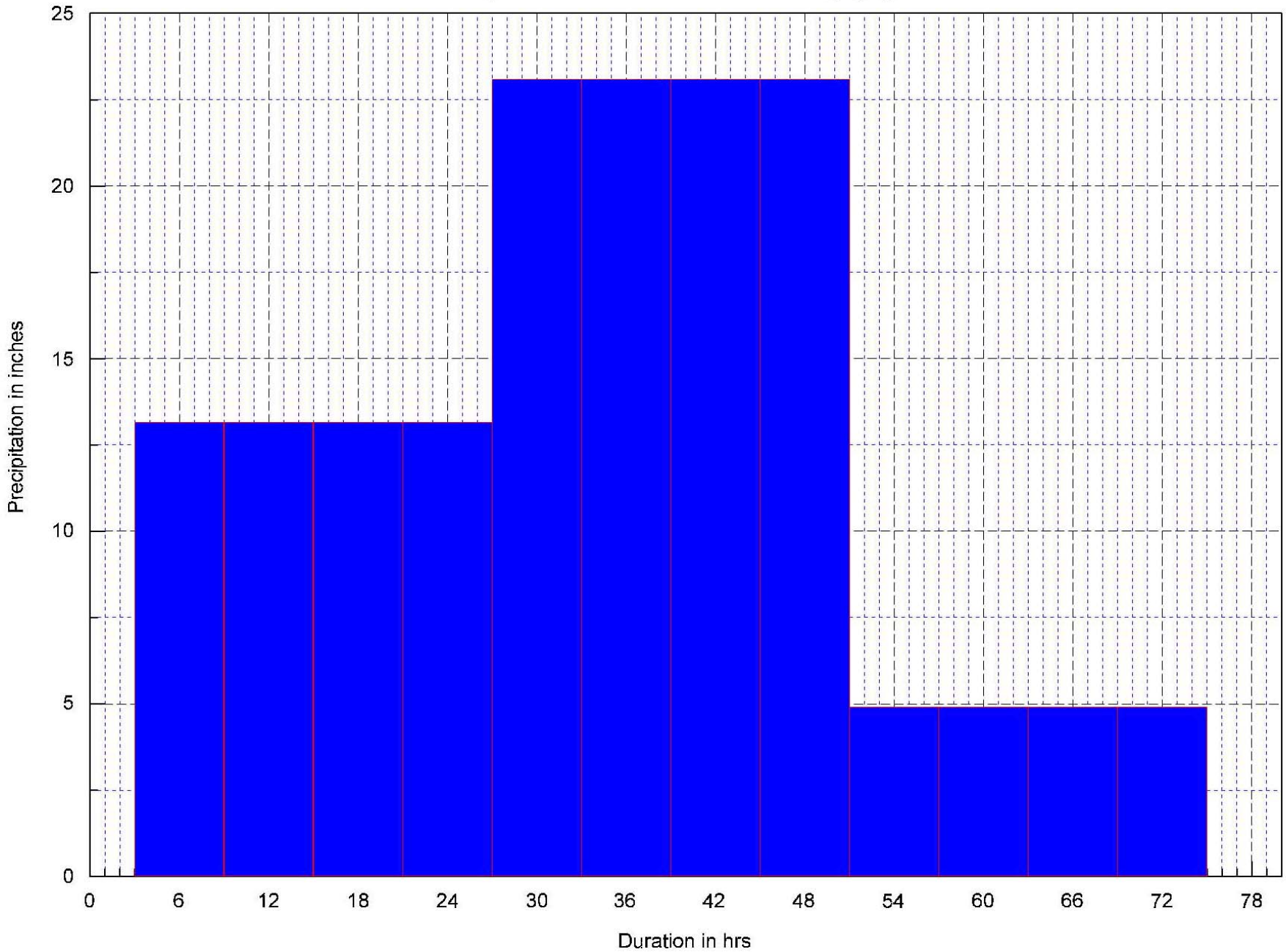
Meteorologically Correct PMP Time Distribution

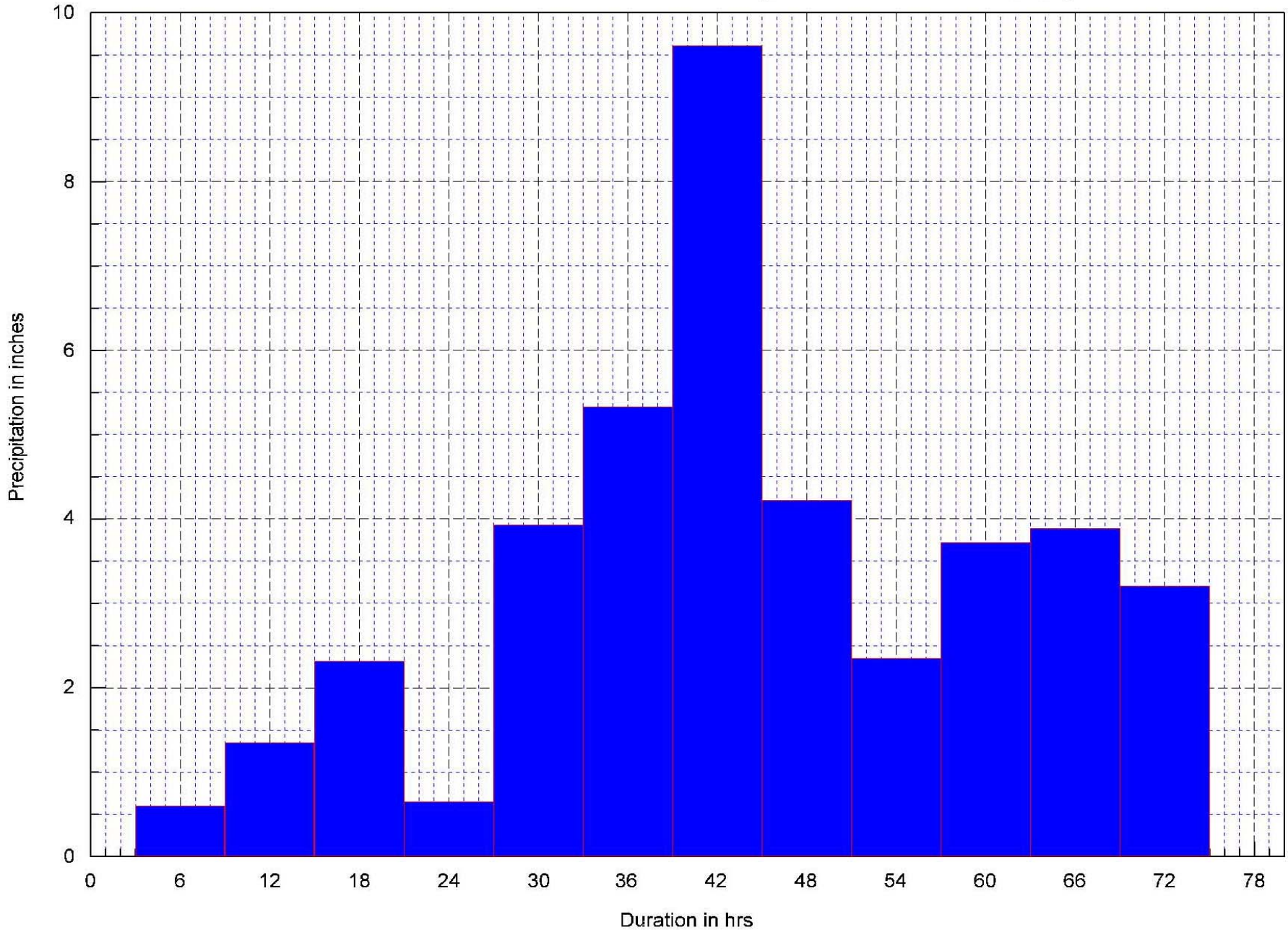
- Corps of Engineers divides the 72-hr PMP into three days.
- HMR 52 recommends dividing the 72-hr PMP into three days with the smallest 24-hr at the beginning of the storm.
- HMR 57, HMR 58/59 (HMR 36) recommends dividing the 72-hr PMP into three days.

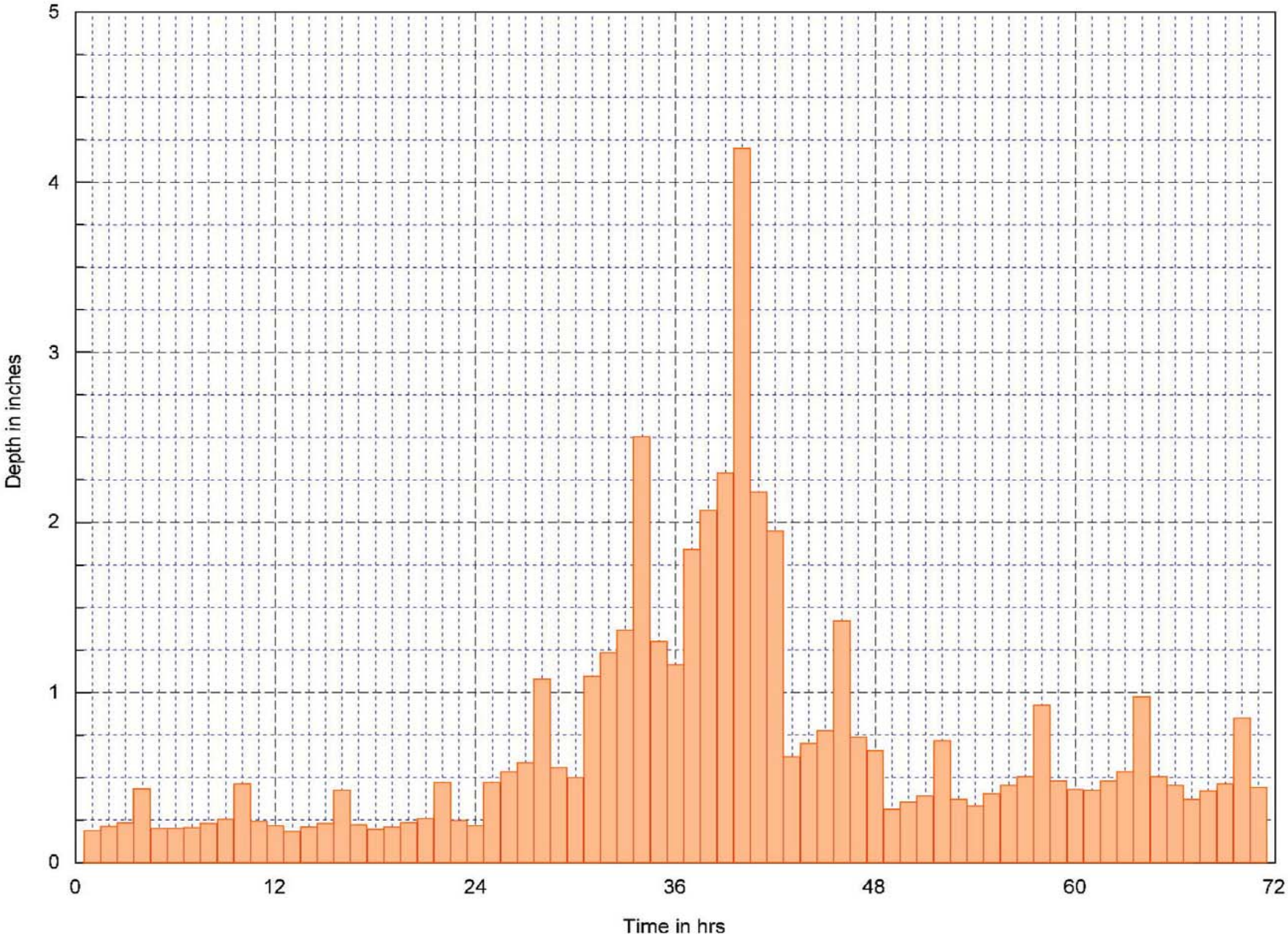
Description of PMP Time Distribution From HMR 36 & 57

- Group the four heaviest 6-hour increments of the 72-hour PMP in a 24-hour sequence, the middle four increments in a 24-hour sequence, and the smallest four increments in a 24-hour sequence.
- Within each of these 24-hour sequences arrange the four increments in accordance with the sequential requirements. That is, the second highest next to the highest, the third highest adjacent to these, and the fourth highest at either end.
- Arrange the three 24-hour sequences in accordance with the sequential requirement, that is, the second highest 24-hour period next to the highest with the third at either end. Any of the possible combinations to the three 24-hour periods is acceptable with the exception of placing the lightest 24-hour period in the middle.


Daily PMP Distribution (1).pdw
Precipitation in inches
25
20
15
10
5
0
0
6
12
18
24
30
36
42
48
54
60
66
72
78
Duration in hrs


Daily PMP Distribution (2).pdw
Precipitation in inches
25
20
15
10
5
0
0
6
12
18
24
30
36
42
48
54
60
66
72
78
Duration in hrs


6-hr Distribution based on Daily Distribution (1).pdw
Precipitation in inches
Duration in hrs
0
2
4
6
8
10
0
6
12
18
24
30
36
42
48
54
60
66
72
78



HOURLY TIME DISTRIBUTION BASED ON DAILY DISTRIBUTION (1)

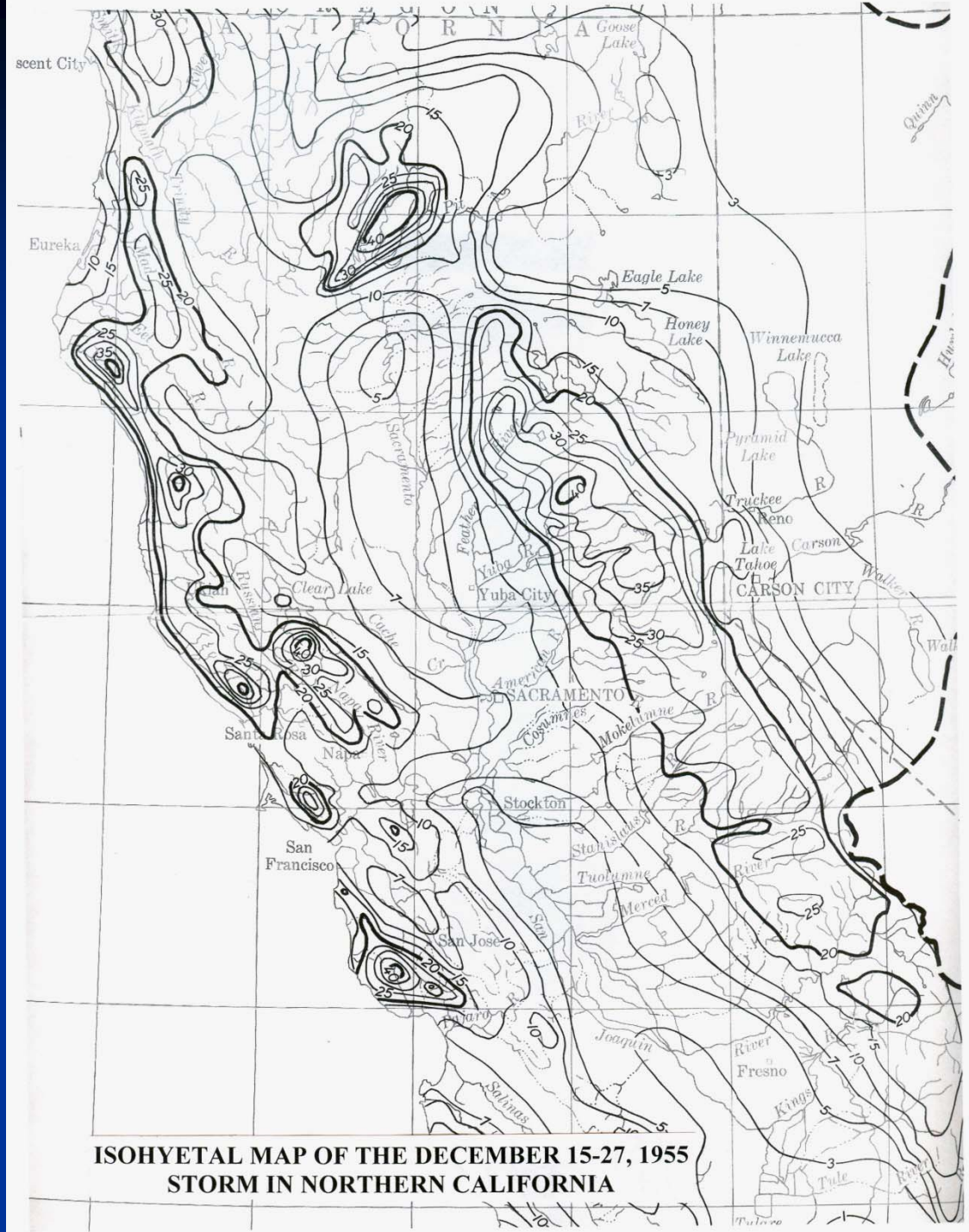
Spatial Distribution

- The computation of PMP gives a basin-average value, which implies even distribution over the entire basin. It is meteorologically unlikely that a storm will provide even distribution of precipitation over any but the smallest area. Various methods for areal distribution of general storm PMP have been developed over the years. For non-orographic regions of the United States east of the Continental Divide, the spatial distribution criteria is obtained from HMR 52.

For Orographic Areas (HMR 57, HMR 58/59)

Two methods are available that would enable the hydrologist to center the PMP storm at the critical sub-basin in a multiple basin under study. These are:

- A historical isohyetal map of a major storm in the area which can be moved around in a critical way.
- The Bureau of Reclamation method of "successive subtraction of PMP volumes."
- For any but the smallest basins, it is meteorologically and hydrologically reasonable to expect PMP for one sub-basin of the total basin and something less than the PMP for the other sub-basins.



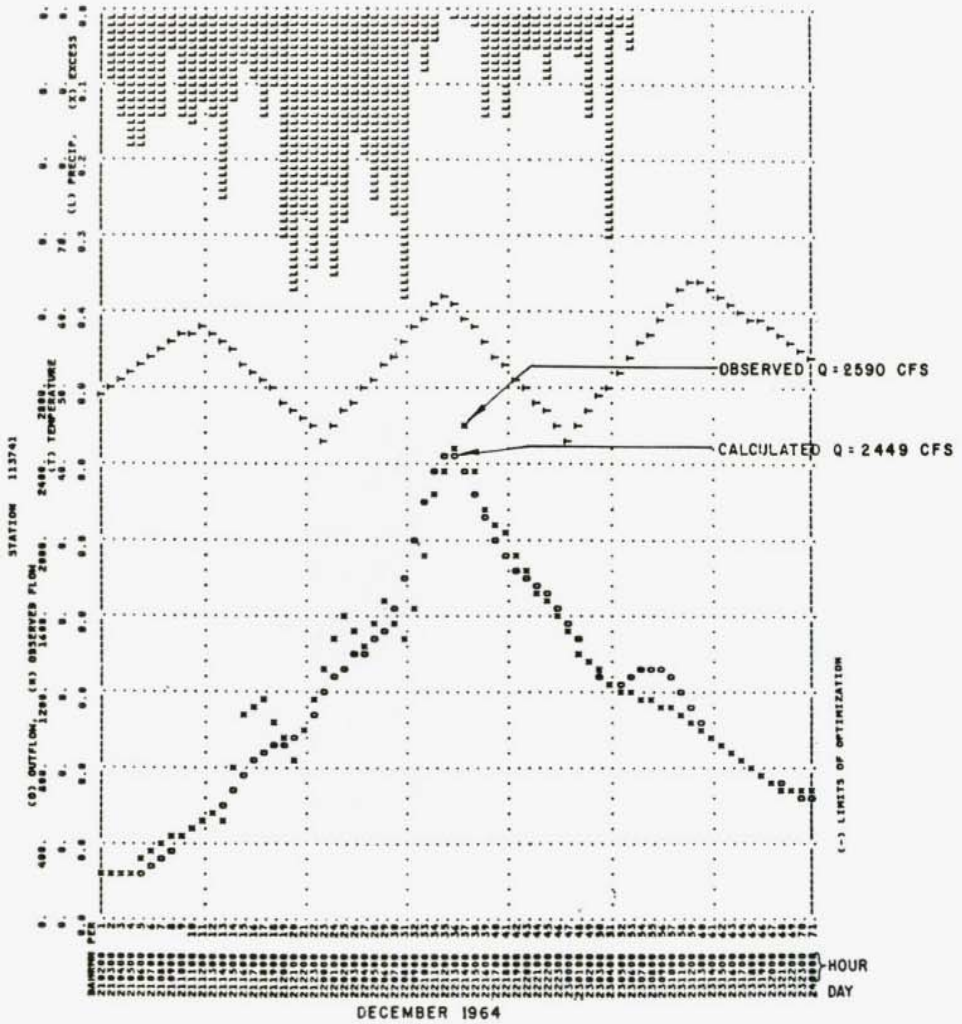
ISOHYETAL MAP OF THE DECEMBER 15-27, 1955 STORM IN NORTHERN CALIFORNIA

Unit Hydrograph
Definition Of The Unit Hydrograph

- The unit hydrograph is defined as the hydrograph of storm runoff at a given point that will result from an isolated event of rainfall excess occurring within a unit of time and spread in an average pattern over the contributing area. Rainfall excess is that portion of the rainfall that enters the stream channel as storm runoff.

Conservatism in Unit Hydrograph

- All synthetic unit hydrographs are conservative especially the SCS triangular unit hydrograph.
- By definition, the unit hydrograph is supposed to represent the runoff from rainfall. However, in California, all unit hydrographs derived by the author from the storms/floods of 1950, 1955/56, 1963, 1964, 1969, 1978, 1982, 1986 and 1997 included runoff from snowmelt. (This represents from 300-500 flood reconstitution using the HEC-1, *Unit Hydrograph & Loss Rate Optimization*.)



INFLOW, OUTFLOW, AND OBSERVED FLOW IN
CUBIC FEET PER SECOND (CFS)
TEMPERATURE IN DEGREES FAHRENHEIT (°F)
PRECIPITATION IN INCHES (IN.)

DRAINAGE AREA. . . . . 75.6 SQUARE MILES
SNOWMELT . . . . . 1.24 INCHES
SNOW EXCESS . . . . . 0.24 INCHES
RAIN . . . . . 6.18 INCHES
RAIN EXCESS . . . . . 1.46 INCHES

BASIN MEAN ANNUAL PRECIPITATION = 43.02 INCHES
PRECIPITATION PATTERN STATION(S) = 7292 RED BLUFF
7295 REDDING ISE
8135 SHASTA, 9390 VOLTA P.H.
TEMPERATURE PATTERN STATION(S) = 9390 VOLTA P.H.

NOTE:

RECONSTITUTION OF FLOOD PERFORMED WITH THE AID OF THE U.S. ARMY CORPS OF ENGINEERS, "HEC-1 FLOOD HYDROGRAPH PACKAGE," COMPUTER PROGRAM 723-X6-2010, THE HYDROLOGIC ENGINEERING CENTER, DAVIS, CALIFORNIA, SEPTEMBER 1981, REVISED JANUARY 1985.

SHASTA DIVISION

NO.	DATE	DESCRIPTION	GM	DWN.	CHKD.	SUPV.	APVD.
1	12-15-86	ISSUED	—	[illegible]	AYL	[illegible]	[illegible]

REVISIONS

APPROVED BY [illegible]

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SUPV. G. SINGH
DSGN. K. TSAY
DWN. Y.S. GEE
CHKD. B 4 Lu
O.K. [illegible]
DATE 12-15-86
SCALES AS NOTED

CIVIL
FLOOD HYDROGRAPH RECONSTITUTION
DECEMBER 21-24, 1964
113741 BEAR CREEK NEAR MILLVILLE
DEPARTMENT OF ENGINEERING
PACIFIC GAS AND ELECTRIC COMPANY
SAN FRANCISCO, CALIFORNIA

MICROFILM
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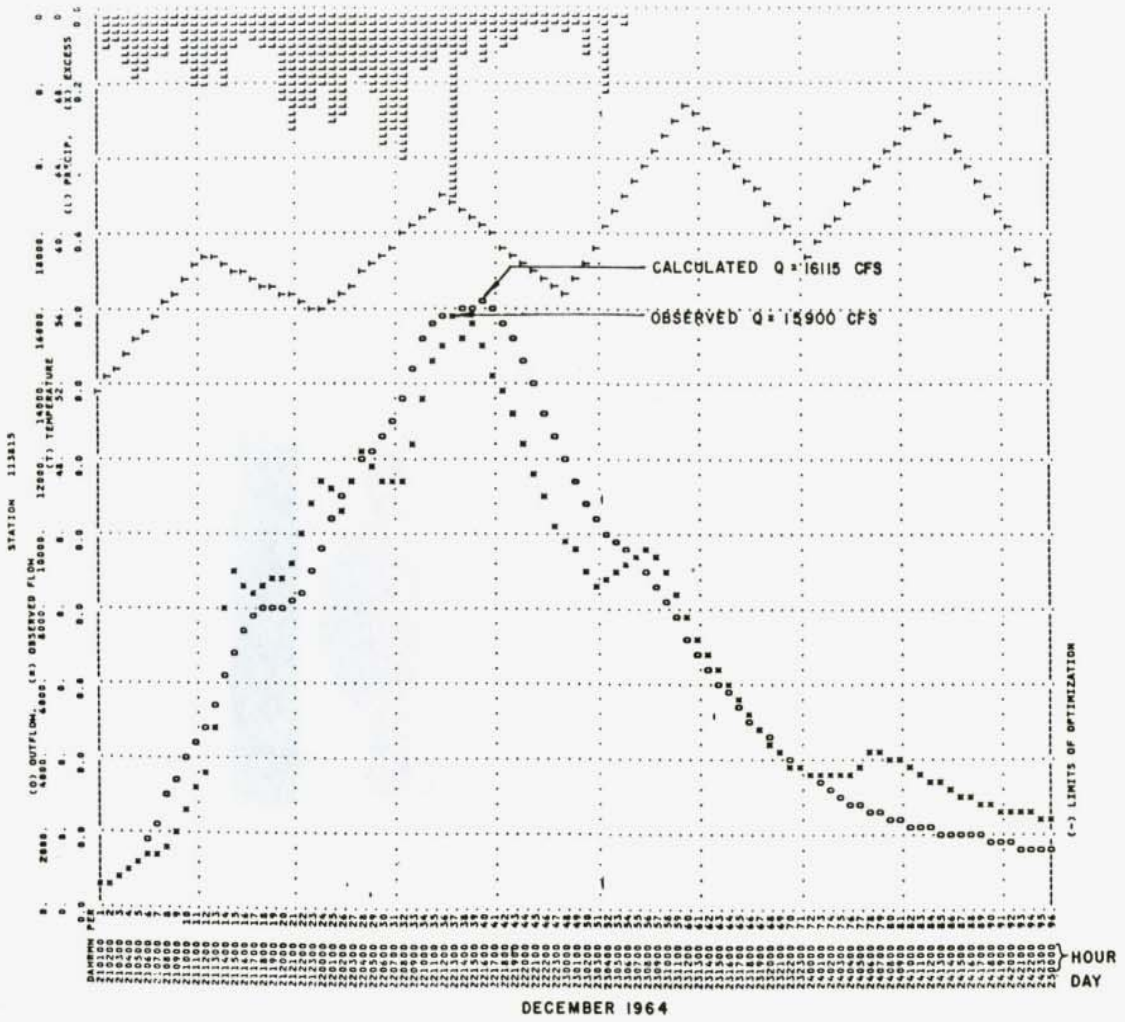

INFLOW, OUTFLOW, AND OBSERVED FLOW IN
CUBIC FEET PER SECOND (CFS)
TEMPERATURE IN DEGREES FAHRENHEIT (°F)
PRECIPITATION IN INCHES (IN.)

DRAINAGE AREA	131.0 SQUARE MILES
SNOWMELT	1.87 INCHES
SNOW EXCESS	1.68 INCHES
RAIN	7.44 INCHES
RAIN EXCESS	6.37 INCHES

BASIN MEAN ANNUAL PRECIPITATION = 45.64 INCHES
PRECIPITATION PATTERN STATION(S) = 7295 REDDING, 7292 RED BLUFF
8135 SHASTA & 9390 VOLTA PH.
TEMPERATURE PATTERN STATION(S) = 7292 RED BLUFF

NOTE:

RECONSTITUTION OF FLOOD PERFORMED WITH THE AID OF THE U.S. ARMY CORPS OF ENGINEERS, "HEC-1 FLOOD HYDROGRAPH PACKAGE," COMPUTER PROGRAM 723-X6-2010, THE HYDROLOGIC ENGINEERING CENTER, DAVIS, CALIFORNIA, SEPTEMBER 1981, REVISED JANUARY 1985.

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1	12-15-86	ISSUED	—	[illegible]	BYL	[illegible]	[illegible]

REVISIONS

APPROVED BY [illegible]

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SUPV. G.SINGH
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DWN. S.C.TIGBAO
CHKD. [illegible]
O.K. [illegible]
DATE 12-15-86
SCALES AS NOTED

CIVIL
FLOOD HYDROGRAPH RECONSTITUTION
DECEMBER 21-25,1964
113815 MILL CREEK NEAR LOS MOLINOS
DEPARTMENT OF ENGINEERING
PACIFIC GAS AND ELECTRIC COMPANY
SAN FRANCISCO, CALIFORNIA

SHASTA DIVISION

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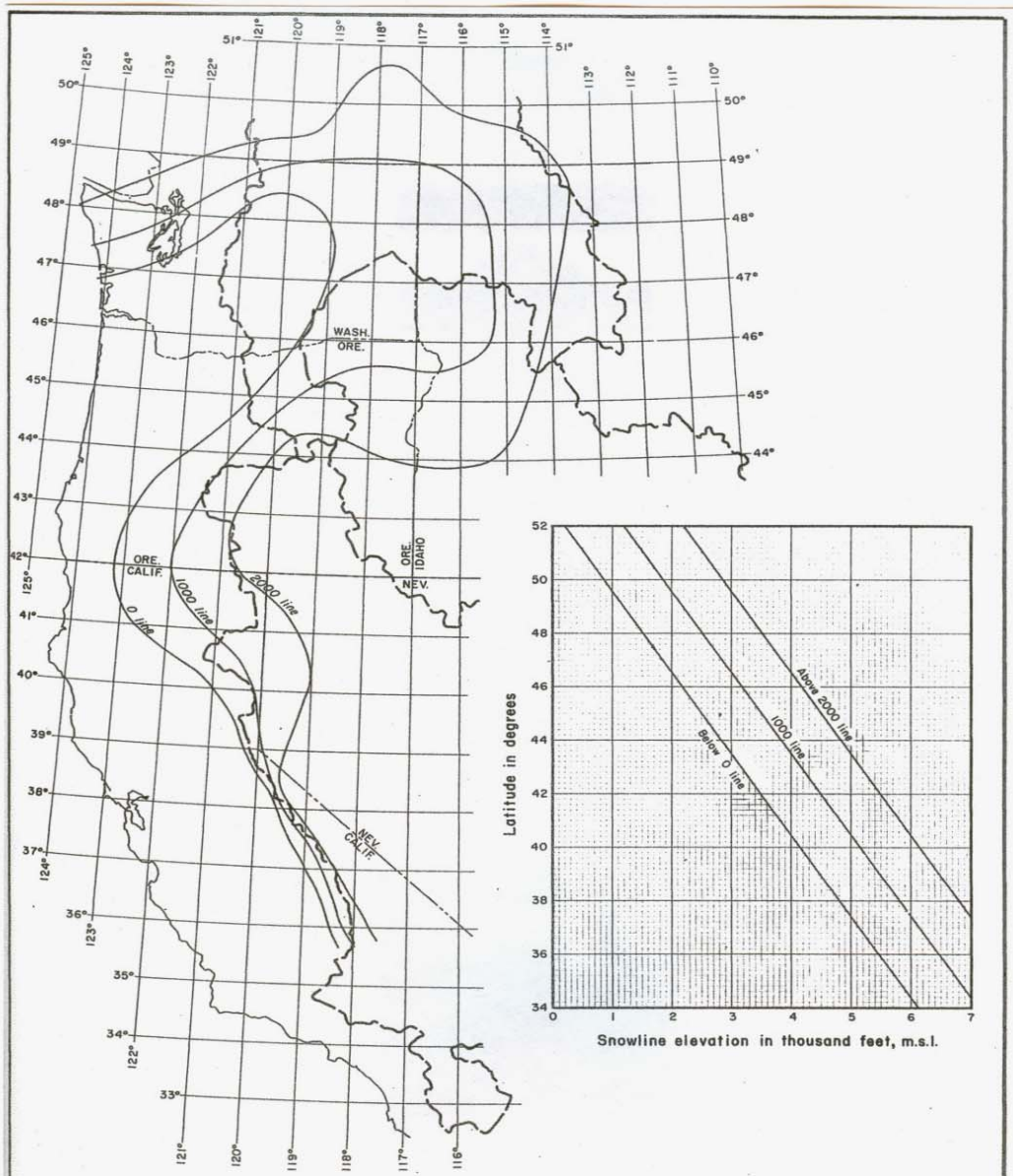
Snowpack and Snowmelt

- If the PMP is distributed in a reasonable and meteorologically correct sequence, snowmelt during the PMP is not a significant factor in developing the peak flows.

Equations used for Snowmelt

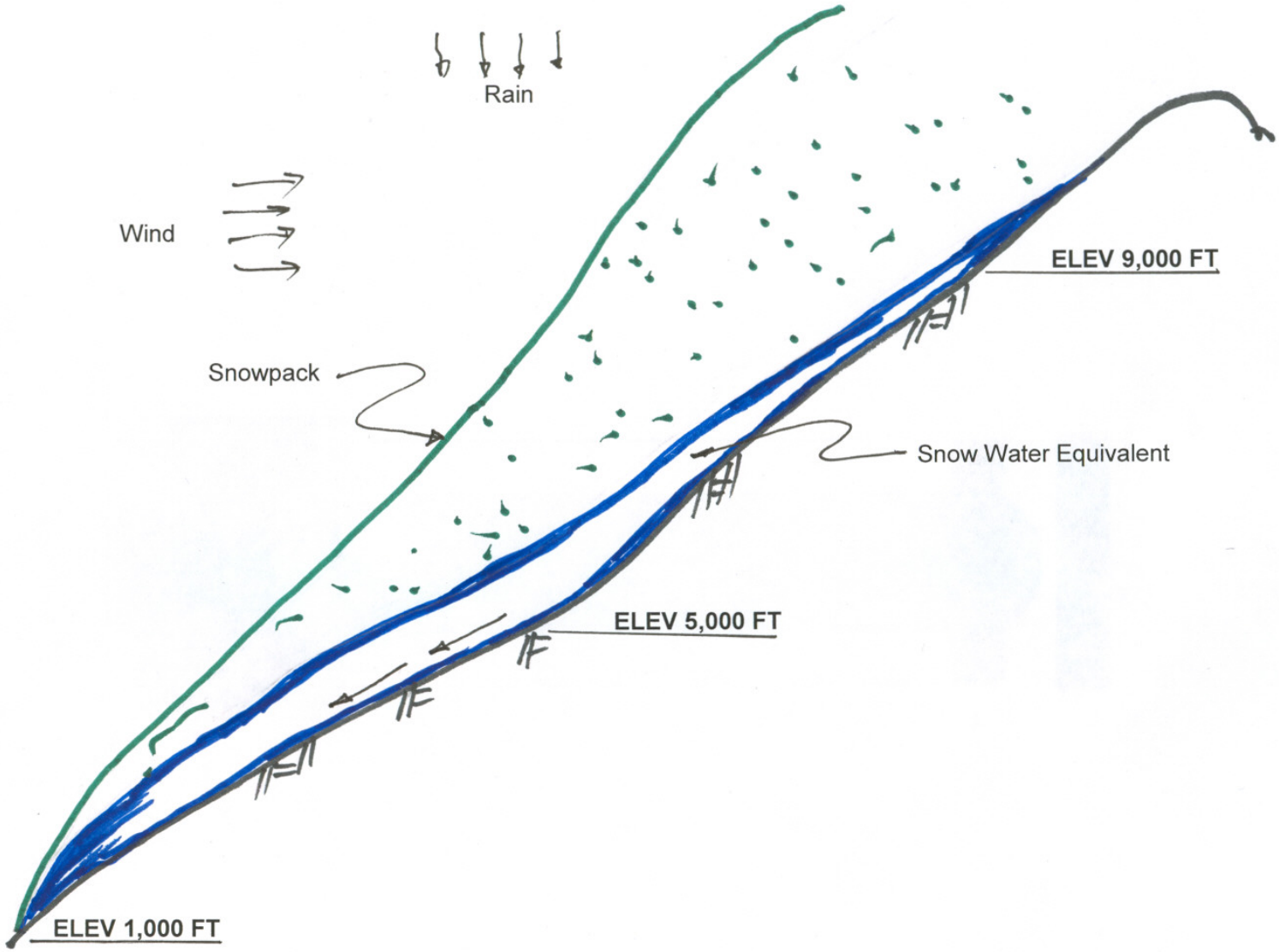
- One is the "degree-day" method. (Uses temperature only to melt the snowpack.)
- The other is the "Energy Budget Method. (Uses temperature, wind and rain to melt snowpack.)

Both equations assume that snowpack is ripe for melt and runoff.



AVERAGE 1 APRIL SNOWLINE ELEVATION

CHART 6



PROFILE OF SNOWPACK

THANK YOU