NOAA Atlas 14 Rainfall Depths, NRCS Rainfall Distributions, and Dimensionless Unit Hydrographs

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NRCS STATE HYDRAULIC ENGINEER

Objectives

History

NOAA 14 Rainfall Depths

NRCS Rainfall Distributions

Dimensionless Unit Hydrographs

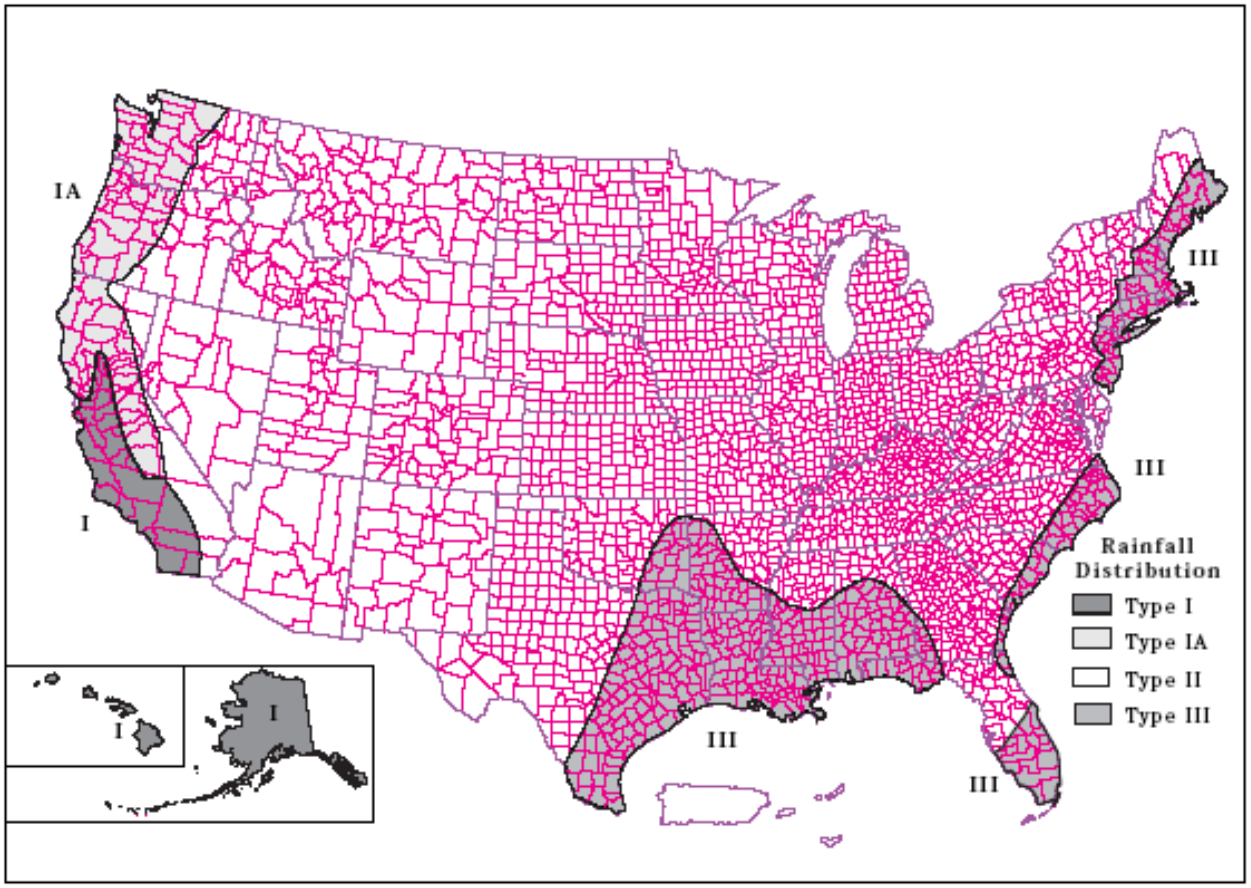
NRCS Hydrology Policy

History

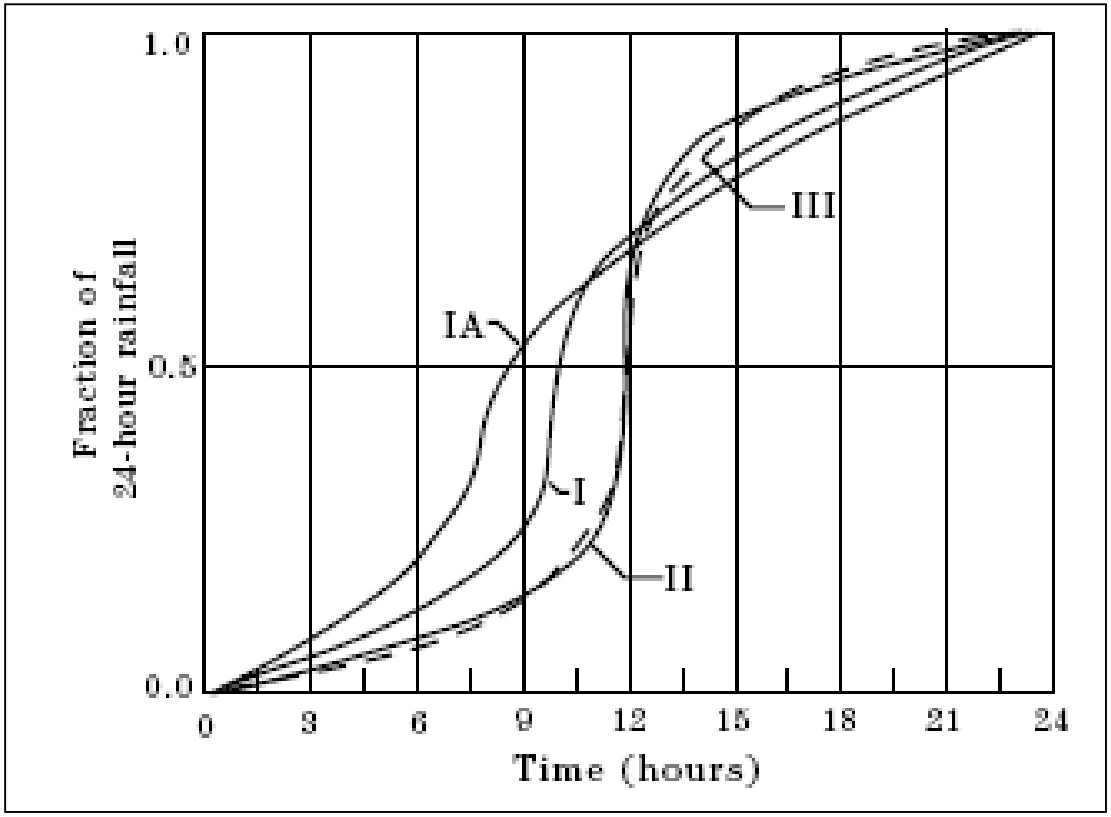
U.S. Weather Bureau Technical Paper 40

- Initial publication in 1961
- Rainfall durations: 30 min to 24 hour
- Rainfall frequency: 1 year to 100 year events
- Universally used and widely accepted
- Developed using available rainfall information from much fewer stations than what exists today

History


IA
I
III
III
III
III
I
I
Rainfall Distribution
Type I
Type IA
Type II
Type III

History


1.0
0.5
0.0
Fraction of
24-hour rainfall
IA
I
II
III
0
3
6
9
12
15
18
21
24
Time (hours)

NOAA Atlas 14

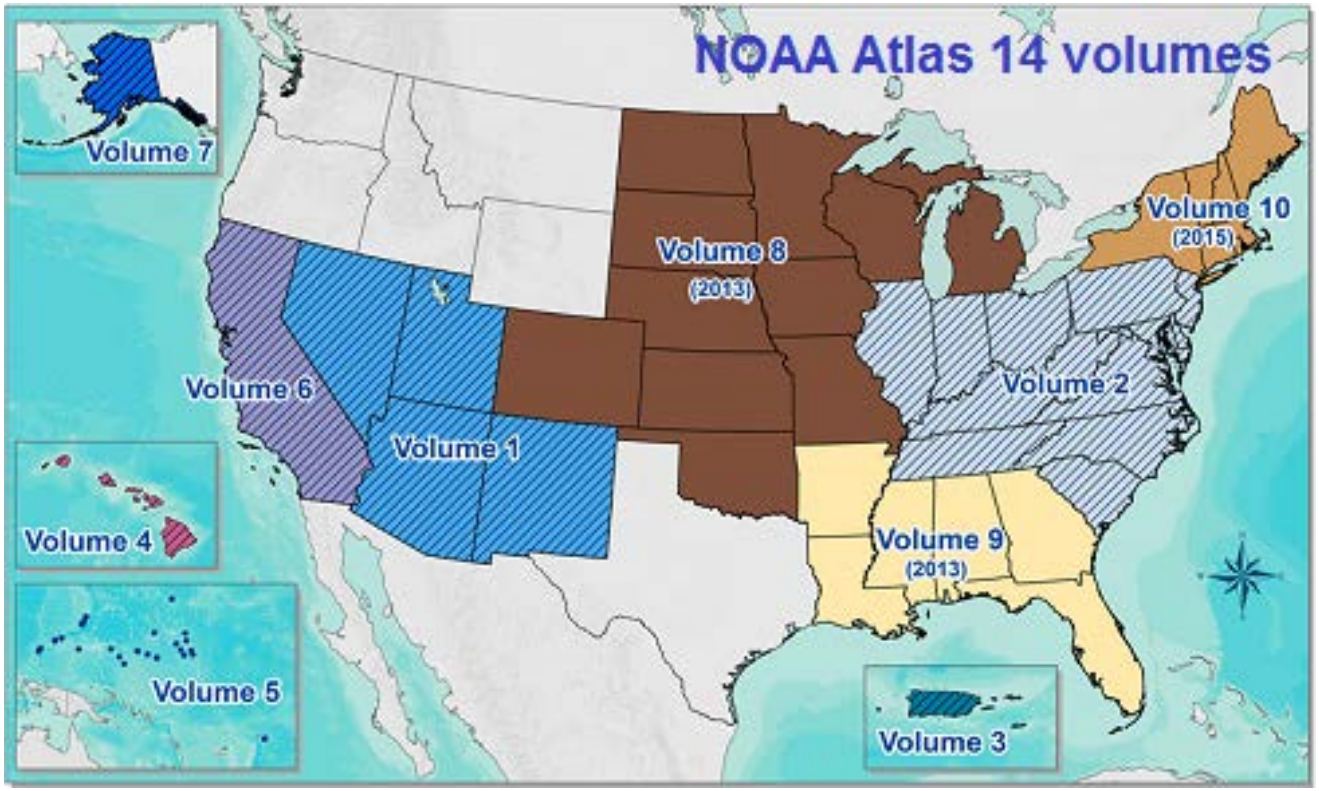
There was concern within the state that TP-40 was not representative of the precipitation of today

Worked through a FHWA pooled fund project to coordinate with 11 other states to fund the regional study completed by NOAA

Within Minnesota the project was funded by:

- MPCA
- MnDOT
- City State Aid

NOAA Atlas 14



NOAA Atlas 14

Volume 8 of NOAA Atlas 14 Precipitation-Frequency Atlas of the United States was released in 2013

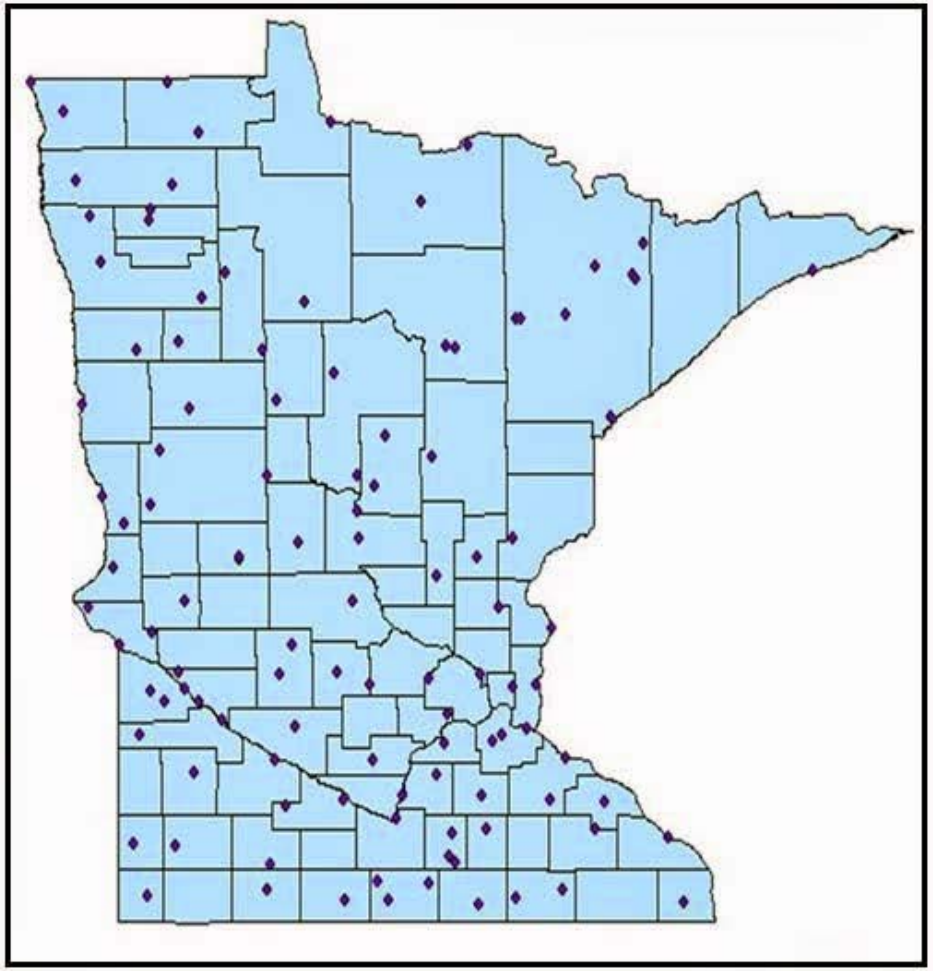
405 Data sets for MN were used in the analysis (vs. 140 in TP-40)

Average record length now over 50 years (more than double the record used in TP-40)

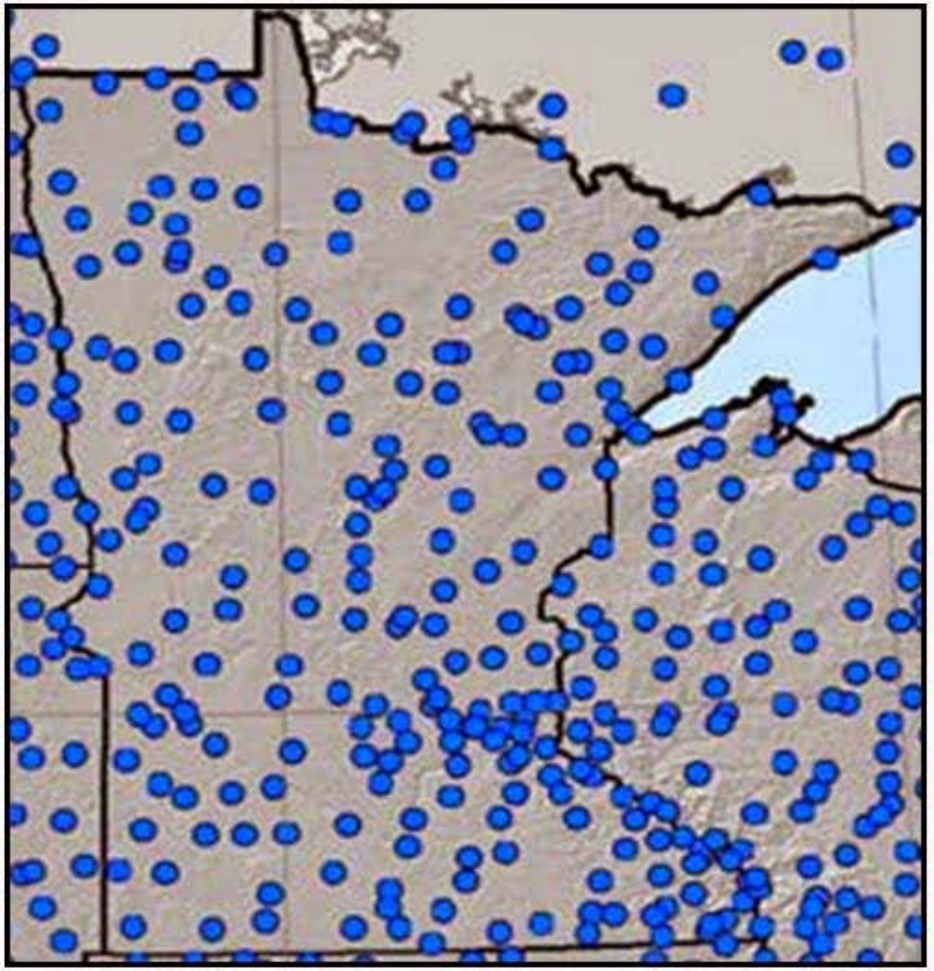
Rainfall durations: 5 min to 60 days

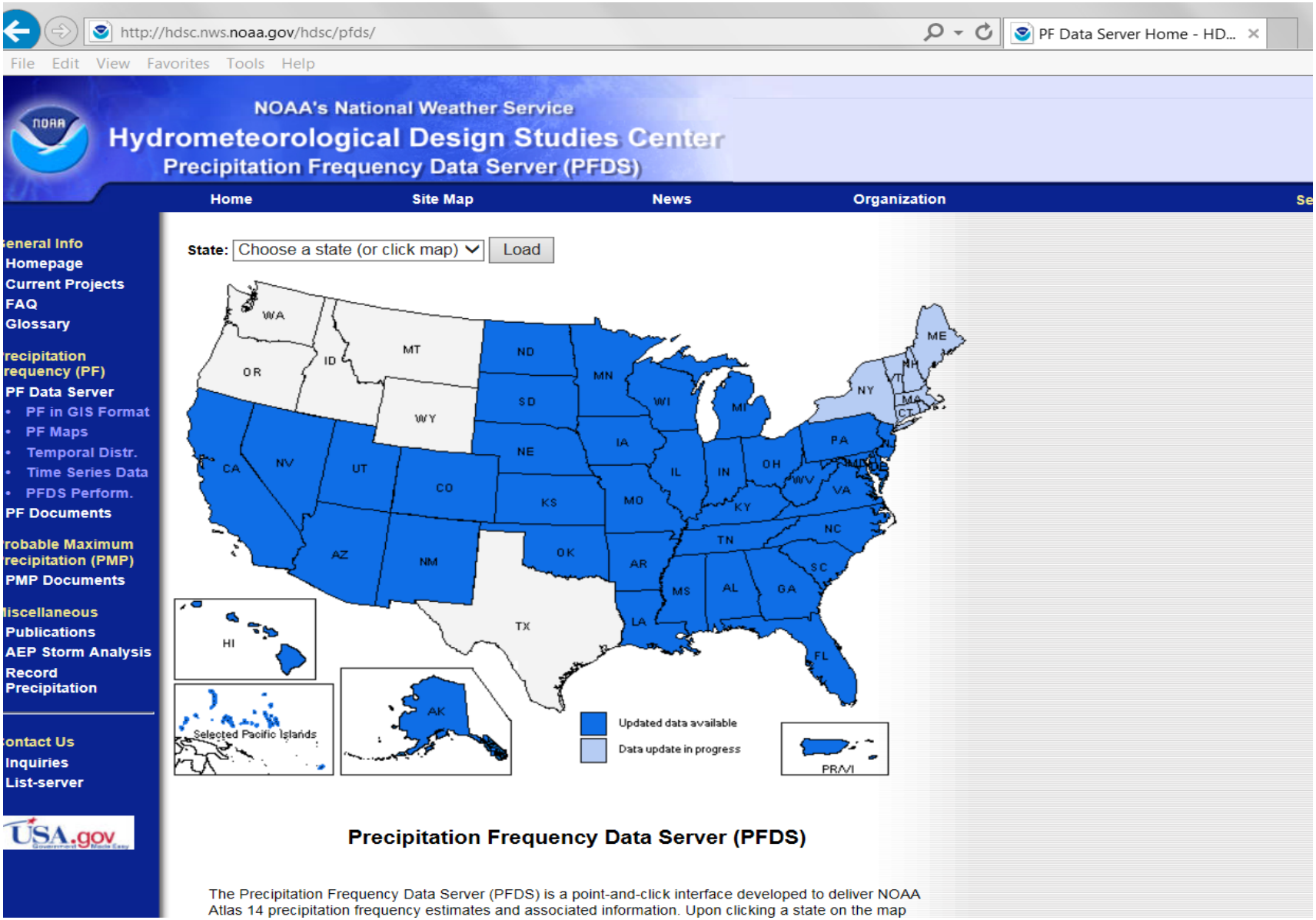
Rainfall frequency: 1 year to 1000 year events

TP-40 Daily Stations



NOAA Atlas 14 Daily Stations




http://hdsc.nws.noaa.gov/hdsc/pfds/
PF Data Server Home - HD...
File Edit View Favorites Tools Help
NOAA's National Weather Service
Hydrometeorological Design Studies Center
Precipitation Frequency Data Server (PFDS)
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FAQ
Glossary
Precipitation Frequency (PF)
PF Data Server
PF in GIS Format
PF Maps
Temporal Distr.
Time Series Data
PFDS Perform.
PF Documents
Probable Maximum Precipitation (PMP)
PMP Documents
Miscellaneous
Publications
AEP Storm Analysis
Record Precipitation
Contact Us
Inquiries
List-server
USA.gov
State: Choose a state (or click map)
Load
WA
OR
CA
ID
NV
MT
WY
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GA
FL
SC
NC
VA
PA
NY
ME
VT
NH
MA
CT
HI
Selected Pacific Islands
AK
Updated data available
Data update in progress
PR/VI
Precipitation Frequency Data Server (PFDS)
The Precipitation Frequency Data Server (PFDS) is a point-and-click interface developed to deliver NOAA Atlas 14 precipitation frequency estimates and associated information. Upon clicking a state on the map

http://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=mn

PF Data Server Home - HDSC/... | PFDS: Contiguous US

File Edit View Favorites Tools Help

recipitation
requency (PF)
PF Data Server
PF in GIS Format
PF Maps
Temporal Distr.
Time Series Data
PFDS Perform.
PF Documents

robable Maximum
recipitation (PMP)
PMP Documents

iscellaneous
Publications
AEP Storm Analysis
Record
Precipitation

ontact Us
Inquiries
List-server

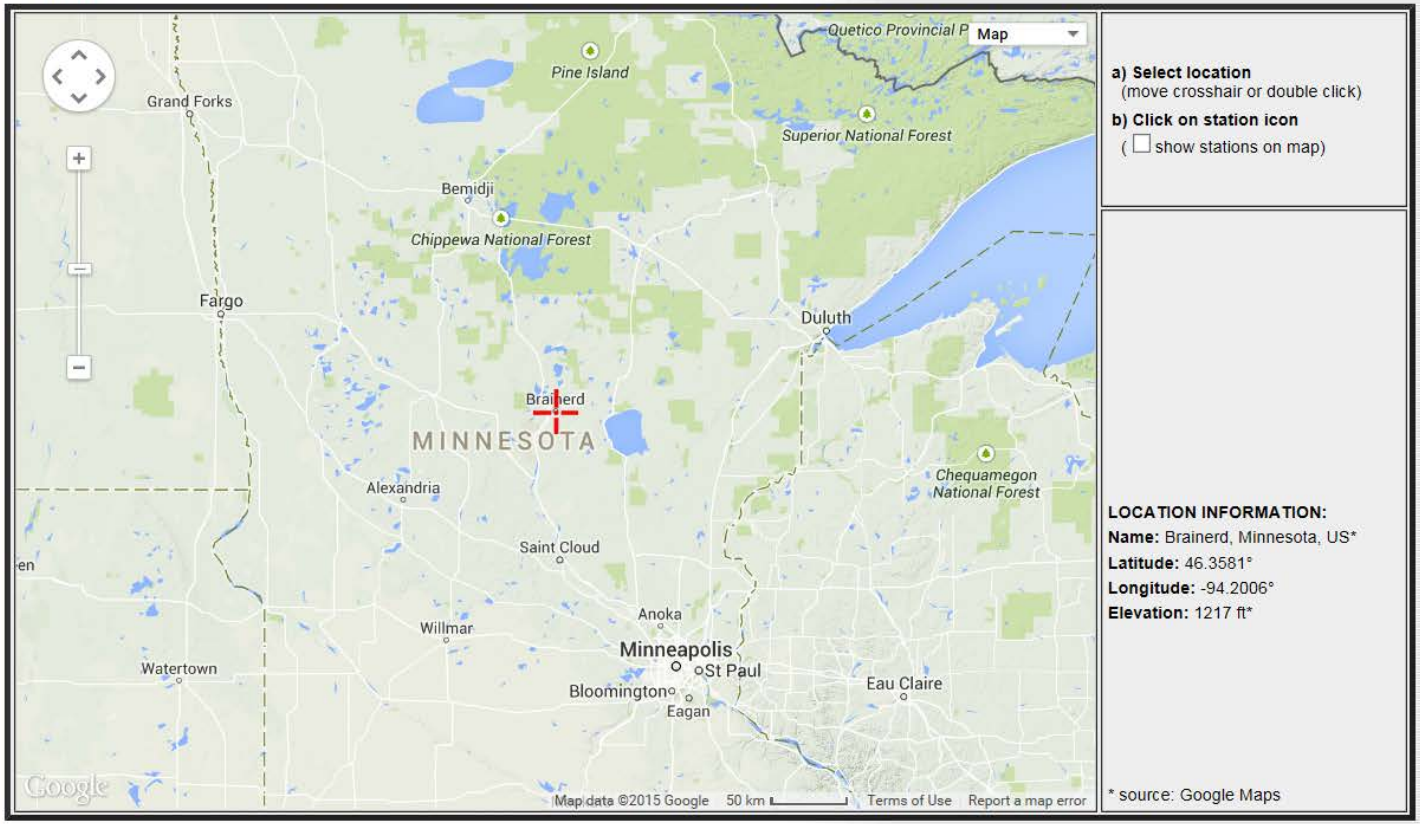
SELECT LOCATION

1. Manually:

a) Enter location (decimal degrees, use "-" for S and W): latitude: longitude: submit

b) Select station (click here for a list of stations used in frequency analysis for MN): select station

2. Use map:



a) Select location
(move crosshair or double click)

b) Click on station icon
(☐ show stations on map)

LOCATION INFORMATION:
Name: Brainerd, Minnesota, US*
Latitude: 46.3581°
Longitude: -94.2006°
Elevation: 1217 ft*

* source: Google Maps

POINT PRECIPITATION FREQUENCY (PF) ESTIMATES

PF tabular | PF graphical | Supplementary information

Print Page

PDS-based precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.354 (0.277–0.455)	0.419 (0.327–0.539)	0.527 (0.410–0.679)	0.617 (0.477–0.797)	0.743 (0.556–0.985)	0.842 (0.616–1.13)	0.941 (0.667–1.28)	1.04 (0.711–1.45)	1.18 (0.774–1.68)	1.29 (0.822–1.85)
10-min	0.519 (0.405–0.666)	0.614 (0.479–0.789)	0.771 (0.600–0.994)	0.904 (0.699–1.17)	1.09 (0.815–1.44)	1.23 (0.902–1.65)	1.38 (0.977–1.88)	1.53 (1.04–2.13)	1.73 (1.13–2.46)	1.88 (1.20–2.71)
15-min	0.633 (0.494–0.813)	0.749 (0.584–0.962)	0.941 (0.732–1.21)	1.10 (0.852–1.42)	1.33 (0.994–1.76)	1.50 (1.10–2.01)	1.68 (1.19–2.29)	1.86 (1.27–2.59)	2.11 (1.38–3.00)	2.30 (1.47–3.30)
30-min	0.868 (0.678–1.12)	1.03 (0.805–1.33)	1.30 (1.01–1.68)	1.53 (1.18–1.97)	1.84 (1.38–2.44)	2.09 (1.53–2.79)	2.33 (1.65–3.18)	2.58 (1.76–3.60)	2.92 (1.92–4.15)	3.18 (2.03–4.58)
60-min	1.09 (0.853–1.40)	1.32 (1.03–1.70)	1.69 (1.32–2.18)	2.00 (1.55–2.59)	2.43 (1.82–3.22)	2.77 (2.03–3.71)	3.11 (2.20–4.24)	3.45 (2.35–4.80)	3.91 (2.56–5.56)	4.26 (2.73–6.13)
2-hr	1.32 (1.04–1.67)	1.61 (1.27–2.04)	2.08 (1.64–2.65)	2.48 (1.94–3.16)	3.03 (2.29–3.96)	3.45 (2.55–4.57)	3.88 (2.78–5.23)	4.32 (2.97–5.94)	4.90 (3.24–6.89)	5.34 (3.45–7.60)
3-hr	1.45 (1.15–1.83)	1.78 (1.41–2.24)	2.32 (1.84–2.93)	2.77 (2.18–3.51)	3.40 (2.59–4.43)	3.90 (2.90–5.12)	4.39 (3.17–5.89)	4.90 (3.39–6.71)	5.58 (3.72–7.80)	6.10 (3.97–8.64)
6-hr	1.71 (1.38–2.13)	2.07 (1.66–2.57)	2.67 (2.14–3.33)	3.19 (2.54–3.99)	3.93 (3.04–5.07)	4.52 (3.41–5.89)	5.13 (3.74–6.81)	5.76 (4.04–7.82)	6.63 (4.48–9.19)	7.31 (4.81–10.2)
12-hr	2.01 (1.64–2.47)	2.35 (1.91–2.89)	2.95 (2.39–3.63)	3.49 (2.81–4.31)	4.28 (3.37–5.49)	4.94 (3.79–6.39)	5.64 (4.18–7.44)	6.40 (4.55–8.61)	7.46 (5.10–10.3)	8.31 (5.52–11.5)
24-hr	2.29 (1.89–2.78)	2.65 (2.18–3.22)	3.30 (2.70–4.01)	3.88 (3.16–4.73)	4.75 (3.78–6.03)	5.48 (4.25–7.01)	6.26 (4.69–8.17)	7.11 (5.11–9.47)	8.30 (5.74–11.3)	9.27 (6.22–12.7)
2-day	2.54 (2.12–3.04)	3.01 (2.51–3.60)	3.81 (3.16–4.57)	4.51 (3.72–5.44)	5.53 (4.44–6.90)	6.36 (4.98–8.01)	7.23 (5.47–9.28)	8.15 (5.91–10.7)	9.42 (6.57–12.6)	10.4 (7.08–14.1)
3-day	2.79 (2.34–3.32)	3.28 (2.75–3.90)	4.13 (3.45–4.92)	4.88 (4.05–5.83)	5.97 (4.82–7.39)	6.86 (5.40–8.57)	7.79 (5.93–9.93)	8.78 (6.41–11.4)	10.2 (7.14–13.5)	11.3 (7.68–15.1)
4-day	3.03 (2.55–3.58)	3.52 (2.96–4.16)	4.37 (3.67–5.18)	5.14 (4.29–6.10)	6.26 (5.09–7.71)	7.18 (5.69–8.93)	8.15 (6.24–10.3)	9.19 (6.75–11.9)	10.6 (7.52–14.1)	11.8 (8.10–15.8)
7-day	3.64 (3.10–4.25)	4.12 (3.50–4.82)	4.97 (4.22–5.83)	5.74 (4.84–6.75)	6.89 (5.66–8.41)	7.84 (6.28–9.66)	8.86 (6.85–11.1)	9.95 (7.38–12.8)	11.5 (8.19–15.1)	12.7 (8.81–16.9)
10-day	4.17 (3.58–4.84)	4.67 (4.00–5.43)	5.56 (4.74–6.47)	6.35 (5.39–7.42)	7.52 (6.21–9.10)	8.49 (6.84–10.4)	9.52 (7.40–11.9)	10.6 (7.92–13.6)	12.2 (8.72–15.9)	13.4 (9.33–17.7)
20-day	5.69 (4.94–6.52)	6.36 (5.52–7.29)	7.47 (6.46–8.58)	8.41 (7.23–9.70)	9.74 (8.10–11.5)	10.8 (8.76–12.9)	11.8 (9.29–14.5)	12.9 (9.73–16.2)	14.4 (10.4–18.5)	15.6 (11.0–20.3)
30-day	6.98 (6.10–7.92)	7.81 (6.83–8.88)	9.16 (7.98–10.4)	10.3 (8.89–11.7)	11.8 (9.81–13.7)	12.9 (10.5–15.3)	14.0 (11.0–16.9)	15.1 (11.4–18.7)	16.5 (12.0–21.0)	17.6 (12.5–22.7)
45-day	8.62 (7.60–9.71)	9.68 (8.52–10.9)	11.3 (9.95–12.8)	12.7 (11.0–14.3)	14.4 (12.0–16.6)	15.6 (12.8–18.3)	16.8 (13.3–20.1)	17.9 (13.6–22.0)	19.3 (14.1–24.3)	20.3 (14.5–26.1)
60-day	10.0 (8.89–11.2)	11.3 (9.98–12.6)	13.2 (11.6–14.8)	14.7 (12.9–16.6)	16.6 (14.0–19.0)	18.0 (14.8–20.9)	19.3 (15.3–22.9)	20.4 (15.6–24.9)	21.8 (16.0–27.3)	22.8 (16.3–29.1)

NOAA Atlas 14 Rainfall Depths

GIS was used to tabulate county wide average 24-hour rainfall depths by frequency for each county in MN

County	Rainfall Type	1-year	2-year	5-year	10-year	25-year	50-year	100-year
AITKIN	MSE 3 MN	2.30	2.67	3.32	3.90	4.76	5.48	6.25
ANOKA	MSE 3 MN	2.45	2.83	3.54	4.21	5.23	6.11	7.06
BECKER	MSE 3 MN	2.16	2.49	3.12	3.73	4.71	5.57	6.52
BELTRAMI	MSE 3 MN	2.12	2.46	3.09	3.66	4.54	5.28	6.09
BENTON	MSE 3 MN	2.32	2.69	3.35	3.93	4.81	5.53	6.30
BIG STONE	MSE 3 MN	2.19	2.54	3.14	3.68	4.48	5.13	5.82
BLUE EARTH	MSE 3 MN	2.51	2.92	3.68	4.38	5.47	6.40	7.41
BROWN	MSE 3 MN	2.39	2.75	3.42	4.05	5.01	5.84	6.74
CARLTON	MSE 3 MN	2.35	2.70	3.34	3.92	4.79	5.53	6.32
CARVER	MSE 3 MN	2.47	2.84	3.54	4.20	5.26	6.17	7.18
CASS	MSE 3 MN	2.23	2.59	3.25	3.84	4.72	5.46	6.24
CHIPPEWA	MSE 3 MN	2.31	2.65	3.27	3.88	4.83	5.65	6.56
CHISAGO	MSE 3 MN	2.42	2.80	3.49	4.11	5.03	5.80	6.63
CLAY	MSE 3 MN	2.10	2.47	3.14	3.77	4.75	5.58	6.49
CLEARWATER	MSE 3 MN	2.12	2.45	3.08	3.70	4.69	5.56	6.53
COOK	MSE 3 MN	2.09	2.42	3.01	3.52	4.28	4.91	5.57
COTTONWOOD	MSE 3 MN	2.41	2.80	3.51	4.18	5.21	6.09	7.04
CROW WING	MSE 3 MN	2.29	2.64	3.28	3.86	4.73	5.47	6.25
DAKOTA	MSE 3 MN	2.46	2.80	3.49	4.17	5.29	6.29	7.41

NOAA Atlas 14 Rainfall Depths

Some surprises with large changes over short distances:

- Difference in 100-yr, 24-hr rainfall depths:
  - Minneapolis, MN to St. Cloud, MN : 7.9” to 6.1” = 1.8” difference
  - Duluth Airport to Duluth Harbor: 6.65” to 6.0” = 0.65” difference

TP-40 vs. NOAA Atlas 14 Rainfall Depths

Some rainfall depths increased, some did not change, and some decreased. Depends on:

- Frequency
- Duration
- Location

TP-40 vs. NOAA Atlas14 Rainfall Depths

TP-40

10-year/24 hour

- Itasca County: 3.67”
- Pine County: 3.95”
- Isanti County: 4.05”

100-year/24 hour

- Itasca County: 5.25”
- Pine County: 5.5”
- Isanti County: 5.75”

NOAA 14

10-year/24 hour

- Itasca County: 3.79”
- Pine County: 4.06”
- Isanti County: 4.13”

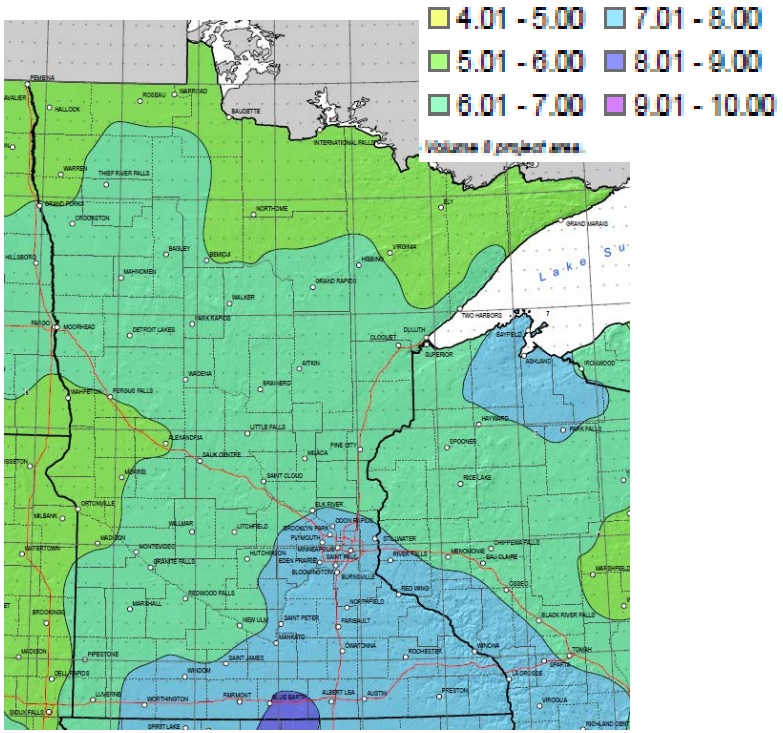
100-year/24 hour

- Itasca County: 6.05”
- Pine County: 6.49”
- Isanti County: 6.68”

TP-40 vs. NOAA Atlas 14 Rainfall Depths

TP-40 100 YR, 24 HR

NOAA 14 100 YR, 24 HR



What is a Rainfall Distribution?

Rainfall distributions are synthetic arrangements of a total rainfall amount over time such that it includes maximum rainfall duration intensities for the selected design frequency that is critical for producing peak runoff.

NOAA vs. NRCS Rainfall Distributions

NOAA Rainfall Distributions – Statistical Analysis of Individual Storms, Huff Distributions, etc.

NRCS Rainfall Distributions – Used for designs. Example: A 10-yr, 24 hr rainfall design storm needs to contain:

- 10-yr – 5 min intensity
- 10-yr – 30 min intensity
- 10-yr – 1 hr intensity
- 10-yr – 2 hr intensity
- Etc.
- Etc.
- 10-yr – 24 hr intensity

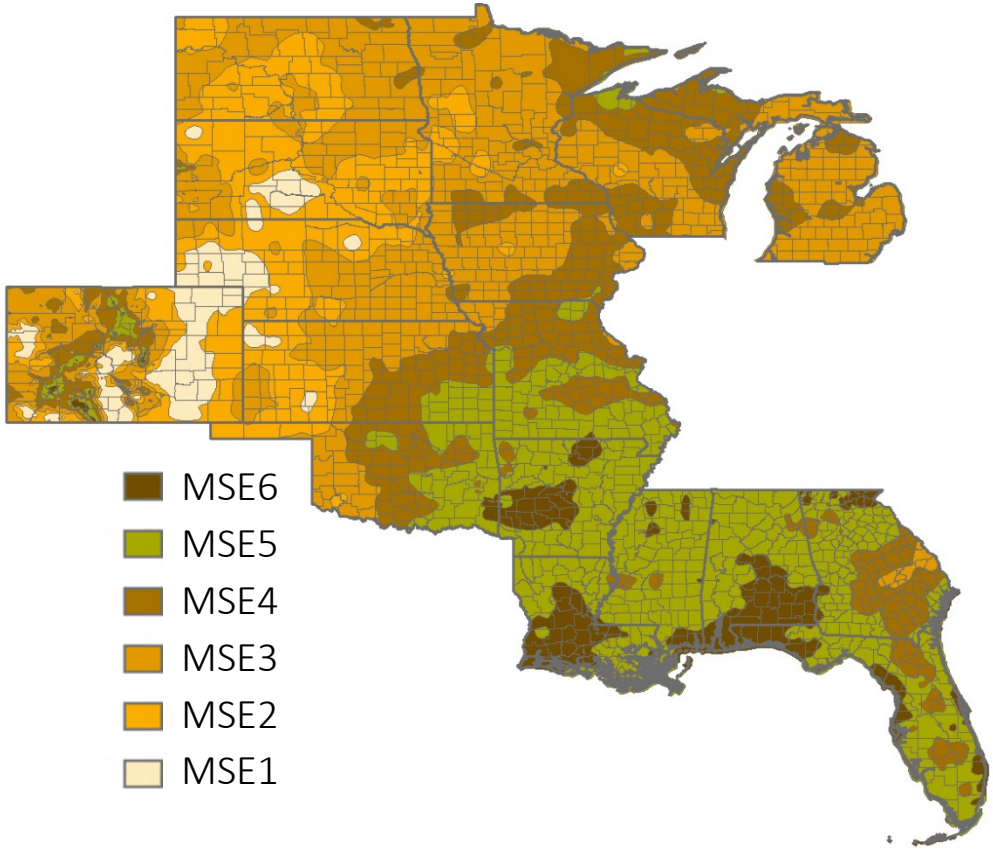
NRCS Rainfall Distributions

The NRCS Water Quality and Quantity Team developed temporal storm distribution regions for the Midwest and Southeast US (NOAA Atlas 14 volumes 7 and 8)

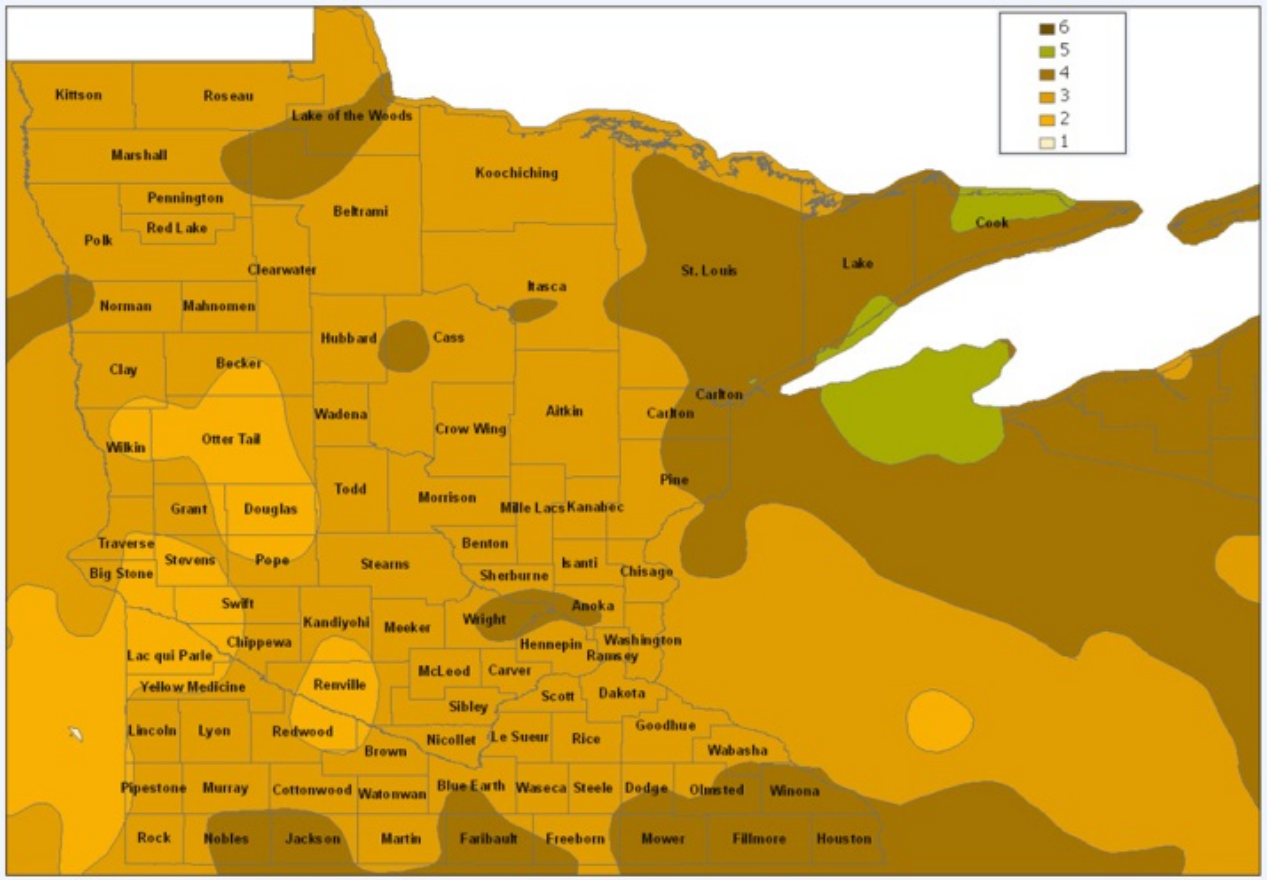
Distributions were based on ratios of the NOAA Atlas 14 (25-yr, 1-hr)/(25-yr, 24-hr) precipitation depths

Since these were developed for the Midwest and Southeast US, the distribution regions were titled MSE (MSE 1 through MSE 6)

NRCS Rainfall Distributions

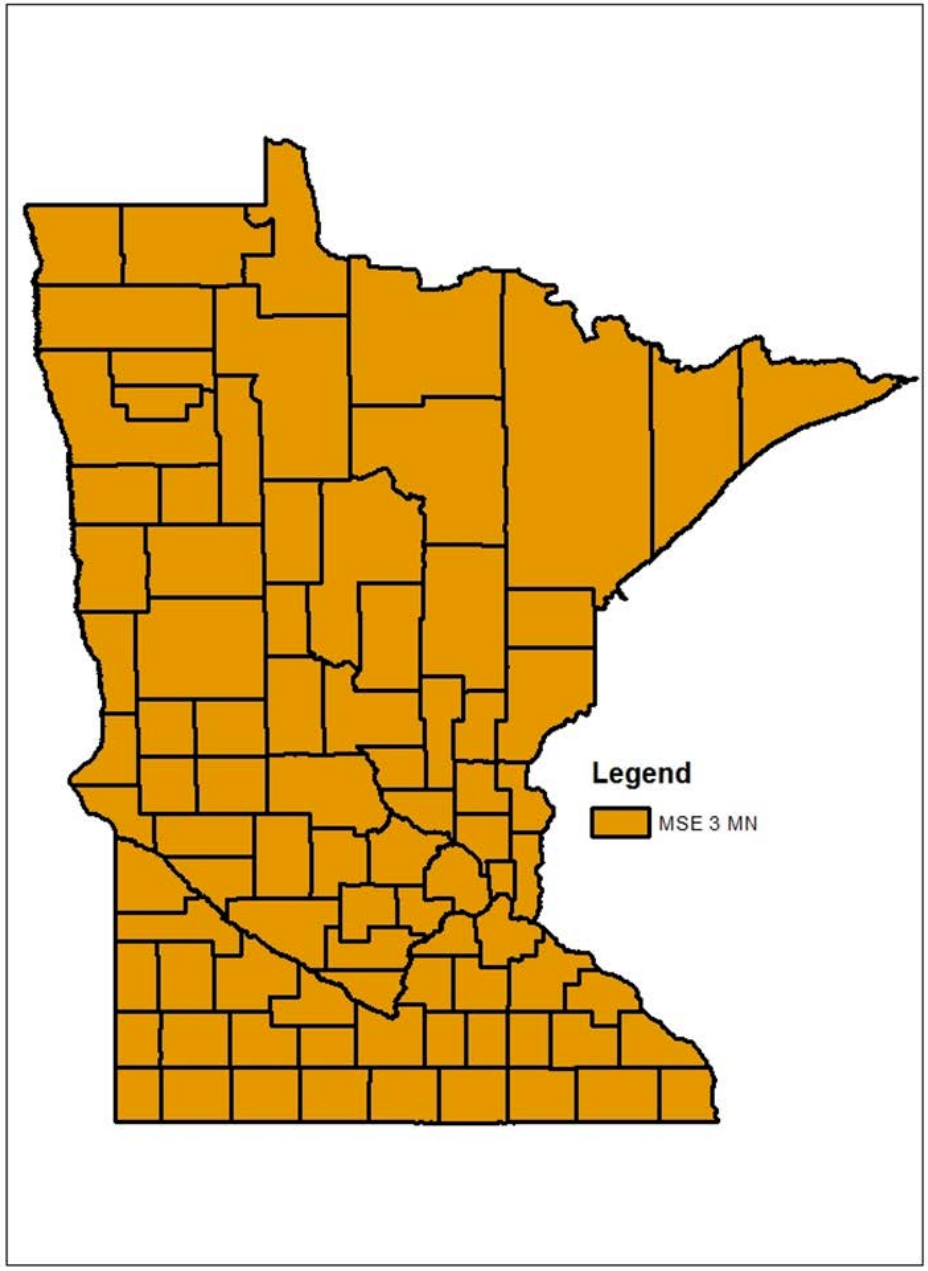


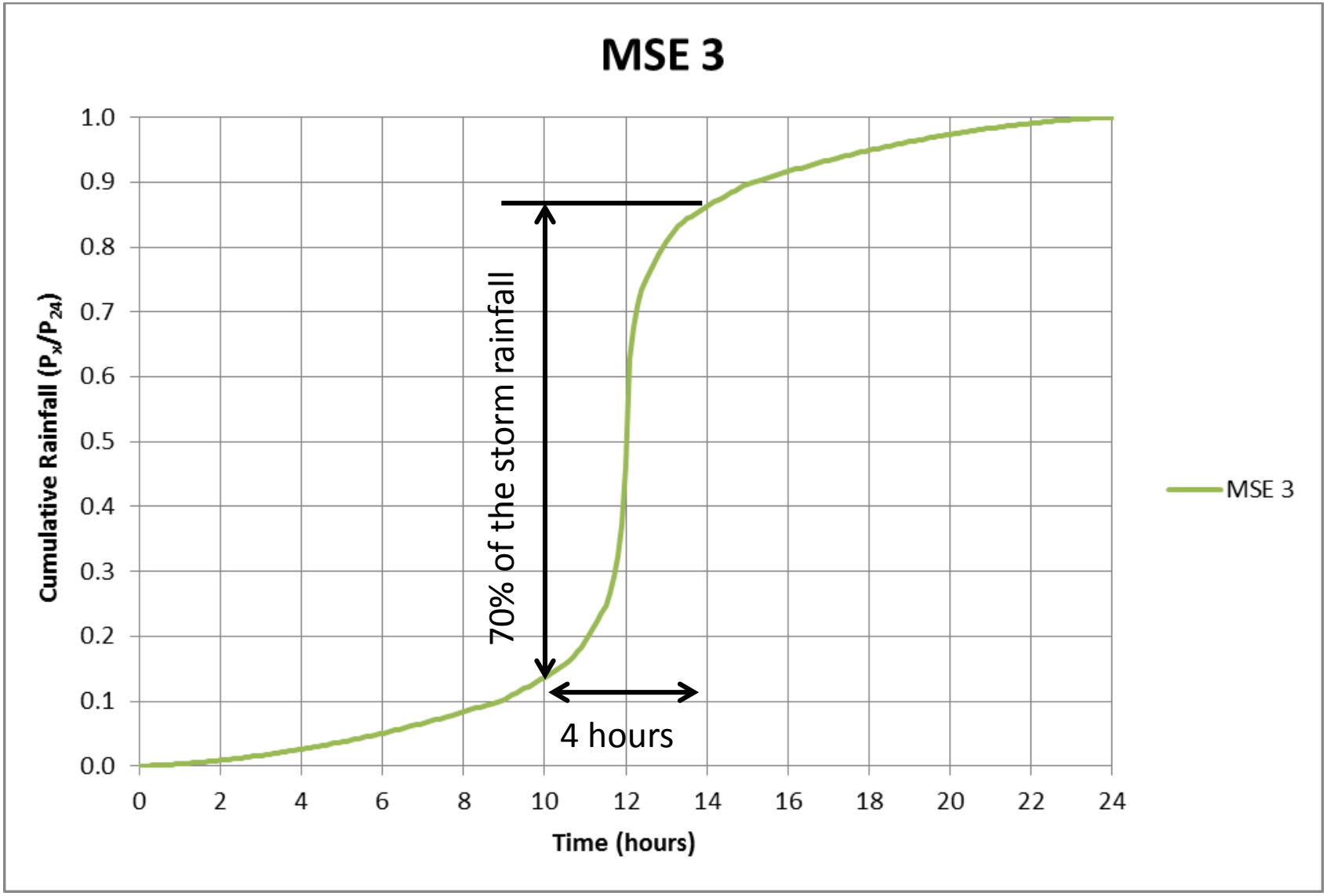
NRCS Rainfall Distributions



NRCS Rainfall Distributions

Minnesota NRCS will use MSE 3 for the entire state




MSE 3
Cumulative Rainfall (P_x/P_{24})
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)
70% of the storm rainfall
4 hours
MSE 3

Dimensionless Unit Hydrograph

What is a Dimensionless Unit Hydrograph?

From NEH, Part 630, Chapter 16 - a dimensionless unit hydrograph is a hydrograph developed to represent several unit hydrographs; plotted using the ratio of the basic units time to peak and peak rate.

What is a Unit Hydrograph?

Discharge hydrograph resulting from 1 inch of direct runoff distributed uniformly over the watershed resulting from a rainfall of a specified duration.

SCS Dimensionless Unit Hydrograph

What is SCS Dimensionless Unit Hydrograph?

Derived from many natural unit hydrographs from watershed varying widely in size and geographical locations.

Peak Rate Factor

What is Peak Rate Factor?

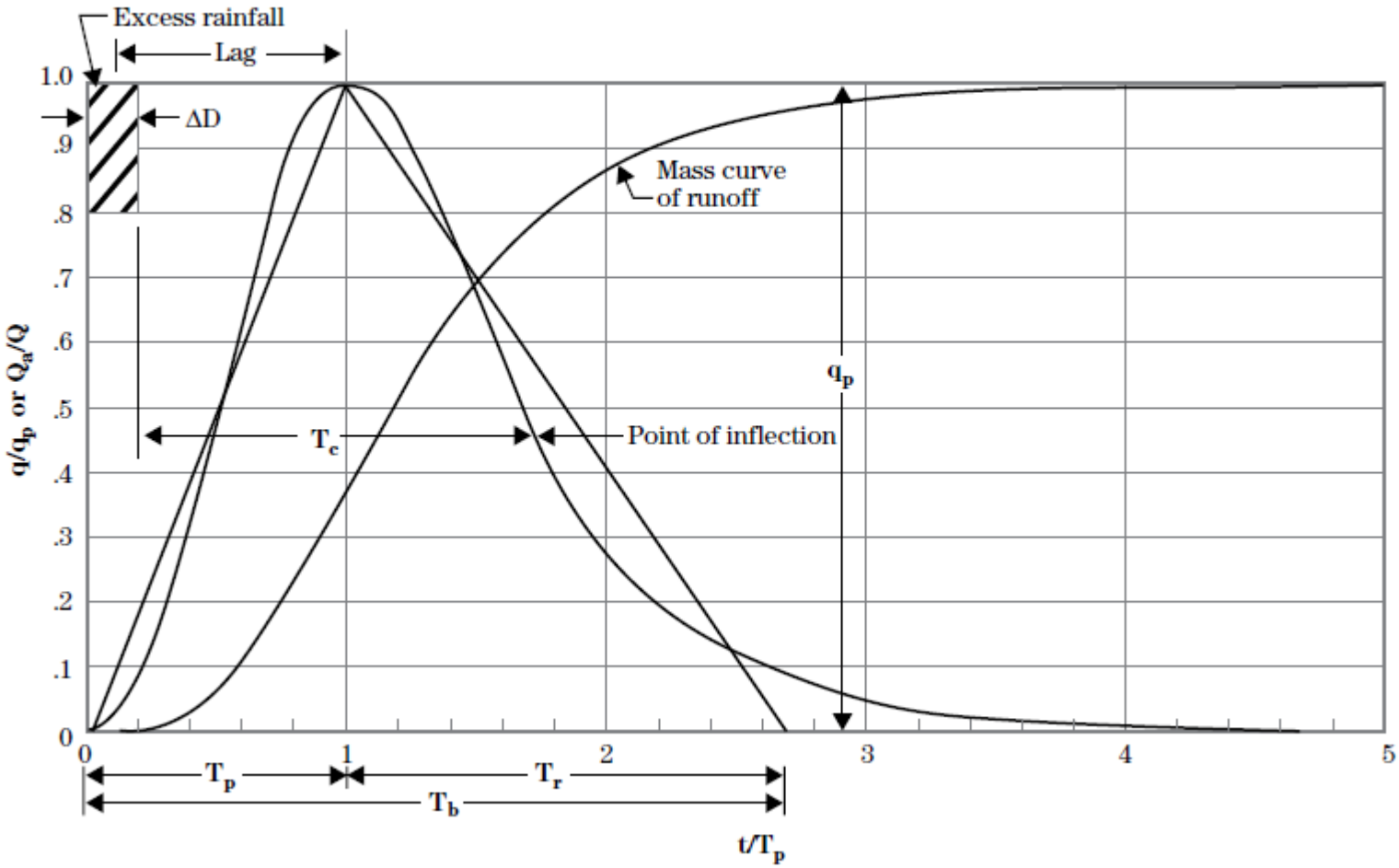
Essentially controls the volume of water on the rising and recession limbs of a dimensionless unit hydrograph.

The higher the peak rate factor the higher the peak discharge will be from the watershed.

The standard SCS dimensionless unit hydrograph has a peak rate factor of 484.

According to NEH 4, Part 630, Chapter 16, peak rate factors can range from below 100 to more than 600.

Figure 16A–1 Dimensionless curvilinear unit hydrograph and equivalent triangular hydrograph



Tr = time from the peak to the end of the triangular hydrograph
Tp = time from the beginning of the triangular hydrograph to its peak
Tc = time of concentration
qp = peak discharge

Peak Rate Factor = 100

Peak Rate Factor = 600

Figure 16B–11 Peak rate factor = 100

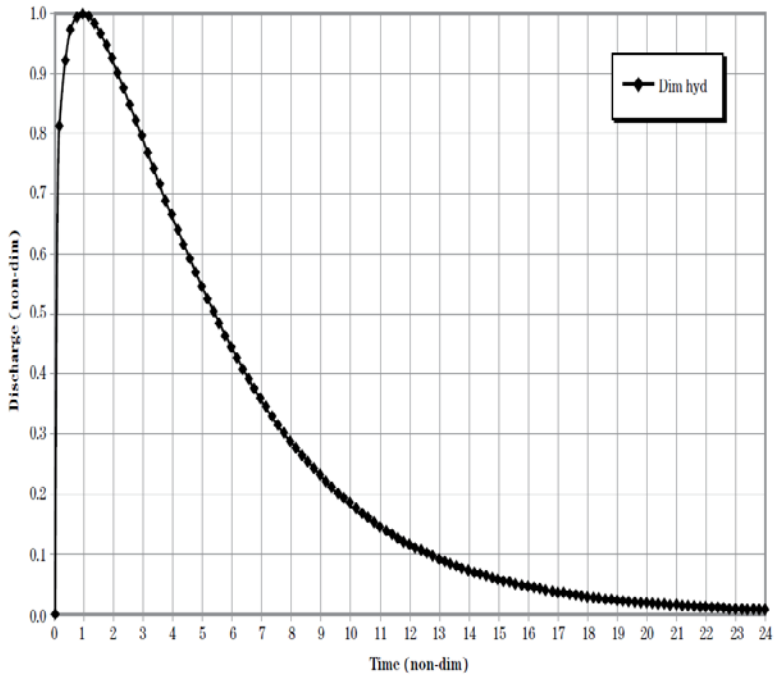
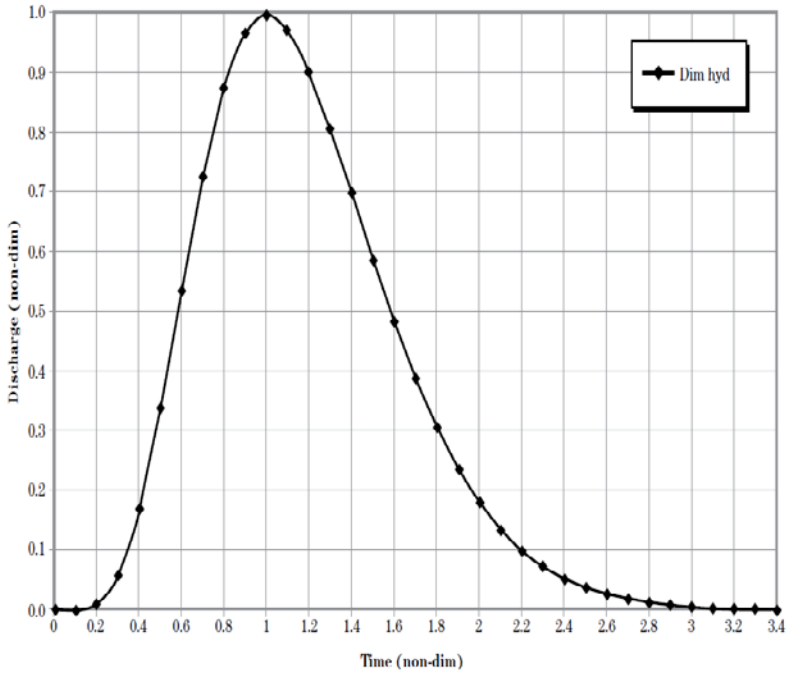


Figure 16B–1 Peak rate factor = 600



MN NRCS Hydrology Policy

Use NOAA Atlas 14 Rainfall Depths.

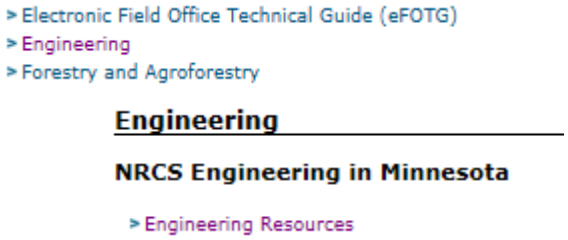
Use NRCS Rainfall Distribution MSE 3 for the entire state.

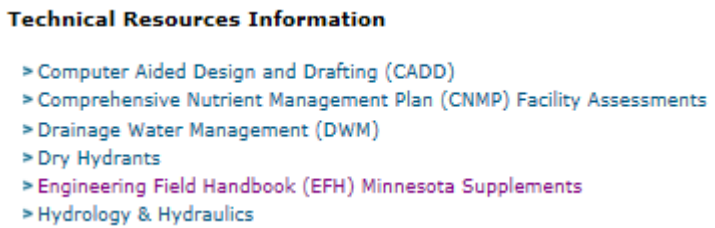
Use a dimensionless unit hydrograph with a peak rate factor of 400.

MN NRCS Hydrology Policy

MN NRCS Homepage – Topics – Technical Resources – Engineering – Engineering Resources – Engineering Field Handbook (EFH) Minnesota Supplements – Chapter 2

http://www.nrcs.usda.gov/wps/portal/nrcs/detail/mn/technical/engineering/?cid=nrcs142p2_023722





Google: MN NRCS EFH

How will this impact design?

GRASSED WATERWAY

Cass County

Background:

244 Acre Watershed, RCN = 72, Watershed Slope = 2.4%, Watershed Length = 5600’

Design:

Initial Design Rainfall (10 yr-24 hr) = 3.73” (TP-40 – Type II)

Peak Q = 83 cfs

Revised Design Rainfall = 3.84” (NOAA 14 – MSE 3 MN)

Peak Q = 83 cfs

How will this impact design?

GRADE STABILIZATION STRUCTURE

Benton County

Background:

264 Acre Watershed, RCN = 68, Watershed Slope = 2.8%, Watershed Length = 5900’

Design:

Initial Design Rainfall (50 yr-24 hr) = 5.13” (TP-40 – Type II)

Peak Q = 139.5 cfs

Revised Design Rainfall = 5.53” (NOAA 14 – MSE 3 MN)

Peak Q = 151 cfs

Questions??

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