## MN650.290 Purpose of Minnesota Supplement

The purpose of this supplement is to assist Area and Field staff in utilizing the most current rainfall data available, National Oceanic and Atmospheric Administration Atlas 14 (NOAA 14, Version 2, Volume 8), for the design of conservation practices. This supplement concerns use of rainfall data developed by the National Oceanic and Atmospheric Administration Atlas 14 (NOAA 14) and rainfall distributions based on the NOAA 14 data. These rainfall data and rainfall distributions will replace rainfall data from Weather Bureau Technical Paper 40 (TP-40) and the standard NRCS rainfall distribution Type II.

This supplement updates the rainfall depths, and rainfall distribution types to be used in estimating runoff and peak discharges as described in NEH Part 650, Engineering Field Handbook Chapter 2 (EFH-2). This supplement updates the rainfall database that is used by the computer program, EFH-2. This Supplement releases the statewide GIS shapefile for design rainfall data.

This supplement describes the implementation process, the technical background, and gives an example application of the rainfall data in the computer program, EFH-2. This Supplement is based on rural watersheds, please discuss urban watersheds with State Hydraulic Engineer.

## MN650.291 Implementation of Minnesota Supplement

Effective upon receipt, NRCS Area and Field staff are to use the updated rainfall depths and rainfall distribution type when estimating runoff and peak discharges described in NEH 650, Chapter 2. The implementation is in two parts, (1) updating NEH 650, Chapter 2 for Minnesota and (2) updating the databases for the EFH-2 computer program.

(1) The methods and data described in this supplement supersede any applicable methods and data from NEH 650, Chapter 2 for Minnesota. The design rainfall table in Appendix 2 supersedes all rainfall data in NEH 650, Chapter 2 for Minnesota. The design rainfall data in Appendix 2 will replace rainfall depths from Weather Bureau Technical Paper 40 (TP-40). The new rainfall distribution type (MSE 3 MN) in Appendix 2 will replace the standard NRCS rainfall type Type II.

(2) This supplement will be implemented by replacing the rainfall database (**COUNTY.MN**) and rainfall distribution types (**type.rf**) used with the EFH-2 computer program. An example application of the EFH-2 Computer Program in Minnesota specific example is included in Appendix 1. The procedure for loading the updated rainfall database is presented in Appendix 3.

## MN650.292 Technical Background

Rainfall data summarized by duration and return period are integral pieces of information used for hydrologic analyses within NRCS. In 2013, the National Oceanic and Atmospheric Administration (NOAA) released Volume 8 of NOAA Atlas 14 Precipitation-Frequency Atlas of the United States. This publication includes data for the states of Colorado, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Oklahoma, South Dakota, and Wisconsin. The link to a PDF version of this document can be accessed through NOAA's website http://www.nws.noaa.gov/oh/hdsc/currentpf.htm.

Using statistical analysis of precipitation data from over 16,000 climate stations in the region, this document provides precipitation depth-frequency estimates for durations of 5-minutes through 60-days at recurrence intervals of 1-, 2-, 5-, 10-, 25-, 50-, 100-, 200-, 500-, and 1000-years. This new data supersedes precipitation-frequency data found in the previously published documents U.S. Weather Bureau Technical Paper 40 (1961 - 30 min to 24 hour durations), U.S. Weather Bureau Technical Paper 49 (1961 – 2 day to 10 day durations) and NWS Hydro 35 (1977 - 5 min to 60 min durations).

NRCS uses this data for estimating peak discharges and runoff volumes which, in turn, are used for the sizing and design of several conservation practices such as waterways, water and sediment control basins, animal waste storage facilities, grade stabilization structures, ponds, etc. With the release of the new data, both rainfall depths and rainfall distributions will be changing and thus will impact conservation practice design. This supplement provides guidance recommendation for NRCS adoption of the new data.

### (a) Rainfall Depths

NOAA used periods of record for rainfall stations up through December 2012 to compute precipitation-duration-frequency values. This additional 54 years of data since TP-40 was published gives different frequency-duration rainfall values. These values have been updated in 2013 for Minnesota.

Two methods may be used to obtain rainfall design depths:

1. Representative county values that have been developed from the NOAA 14 study for use with EFH-2. GIS was used to tabulate county wide average 24-hour rainfall depths by frequency. These are the default values seen in the EFH-2 computer program when the updated rainfall database (county.MN) is loaded. The data is also included in Appendix 2 of this Supplement. The county data are good reprensentative values when using a model and there are only minor variations of rainfall depths over a typical Minnesota county. If a more precise rainfall estimate is desired, data may be obtained as described in the site specific method that follows.
2. Site specific NOAA 14 rainfall values for EFH-2 and other hydrology programs are available using the NOAA website. Below are the steps for using NOAA's online application:

    1. Browse to http://hdsc.nws.noaa.gov/hdsc/pfds/ in a web browser.
    2. Click on Minnesota on the national map.
    3. In the map, drag the red cross hair icon to the project site location. Other options for selecting a location are to enter a latitude and longitude (from a GPS, for example) or select a rainfall station from a pull-down list. Typically choose the centroid of your drainage area.
    4. Scroll down on the screen below the map. A table of precipitation-frequency data is shown for the selected location.

5. Scroll to the bottom of the screen. There is an option to save the data in a comma-separated-variable (csv) format.
6. Replace the default rainfall values on the EFH-2 Rainfall/Discharge data tab with the 24-hour duration NOAA values from the table.

## (b) Rainfall Distribution Types

A new rainfall distribution type (MSE 3 MN) was developed from the NOAA 14 data for a dimensionless unit hydrograph with peak rate factor of 400. See section (c) Dimensionless Unit Hydrograph below for discussion of peak rate facor.

The new rainfall type will replace the NRCS Type II in EFH-2 for Minnesota. The Type II should no longer be used unless an old model needs to be recreated. Figure 1 displays appropriate rainfall distribution types to use per county. The rainfall distribution type for each county is presented in the table in Appendix 1. The rainfall distribution type is developed for use with the EFH-2 computer program (**type.rf**).

EFH-2 uses equations to produce the unit peak discharge (cubic feet per second per inch of runoff per square mile of drainage area) from the time of concentration and excess runoff volume. The coefficients for these equations were developed for the new rainfall type (MSE 3 MN) from the NOAA 14 data. The equations, coefficients and plots for the NOAA 14 rainfall distribution type is included in the **type.RF** file and described in this Supplement, Appendix 4.

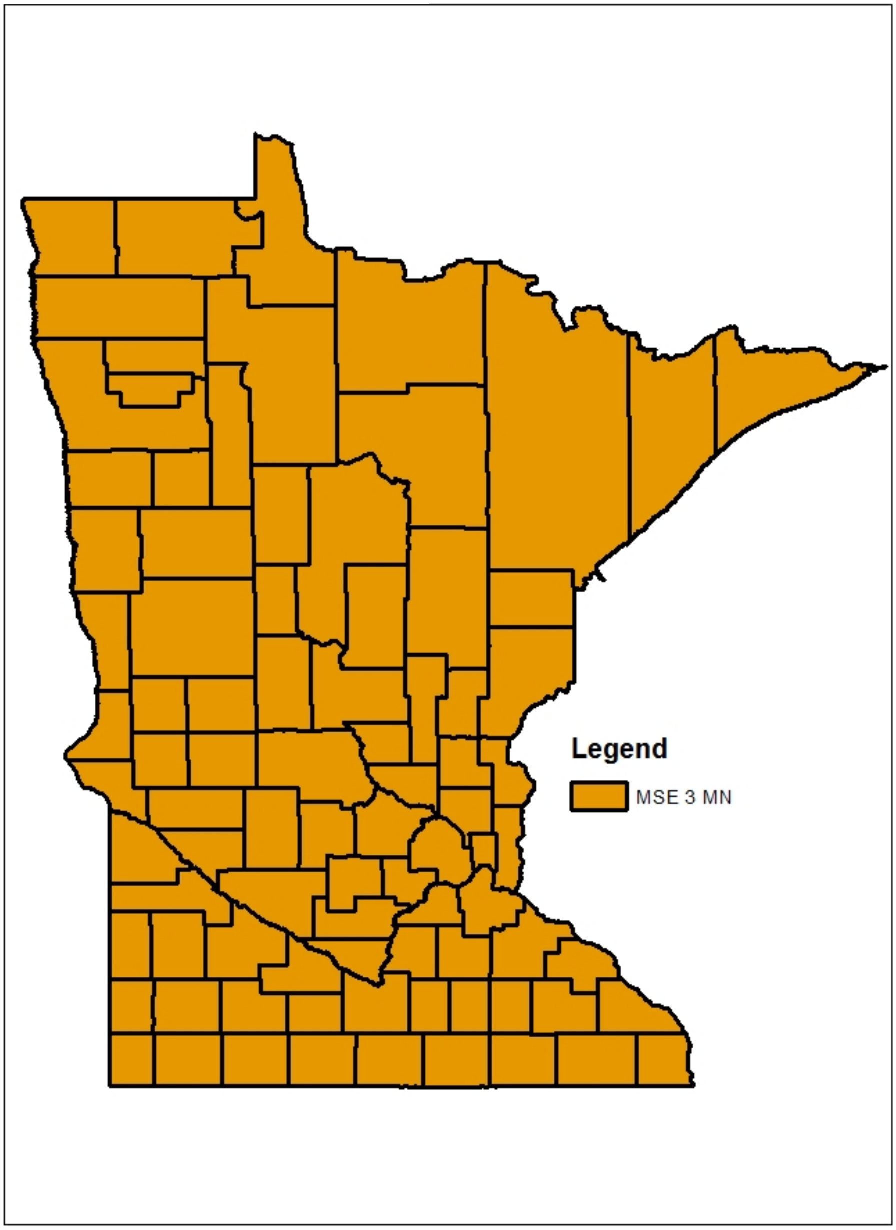



**Figure MN2-1: EFH-2 Rainfall Distribution Types for Minnesota**

### (c) Dimensionless Unit Hydrograph

The standard SCS dimensionless unit hyrdrograph has a peak rate factor of 484. For 2-year to 100-year 24 hour storms for various counties, drainage areas, and watershed slopes it was found that using a peak rate factor of 484 with the new rainfall distribution type (MSE 3) gave higher peak discharges than the previous discharge values (TP-40, Type I & Type II). Using the new rainfall distribution type (MSE 3) from the NOAA 14 data with a dimensionless unit hydrograph with peak rate factor of 400 (not the standard SCS dimensionless unit hydrograph) gave more applicable discharges for the 2-year to 100-year 24 hour storms. Figure 2 shows a dimensionless unit hydrograph with peak rate factor of 400. This modified version of the MSE 3, which simulates the impact of using a dimensionless unit hydrograph with peak rate factor of 400, is named MSE 3 MN to distinguish it from the unmodified MSE 3 distribution. Minnesota will use the new distribution type (MSE 3 MN) for all rural NRCS hydrology applications in the state.

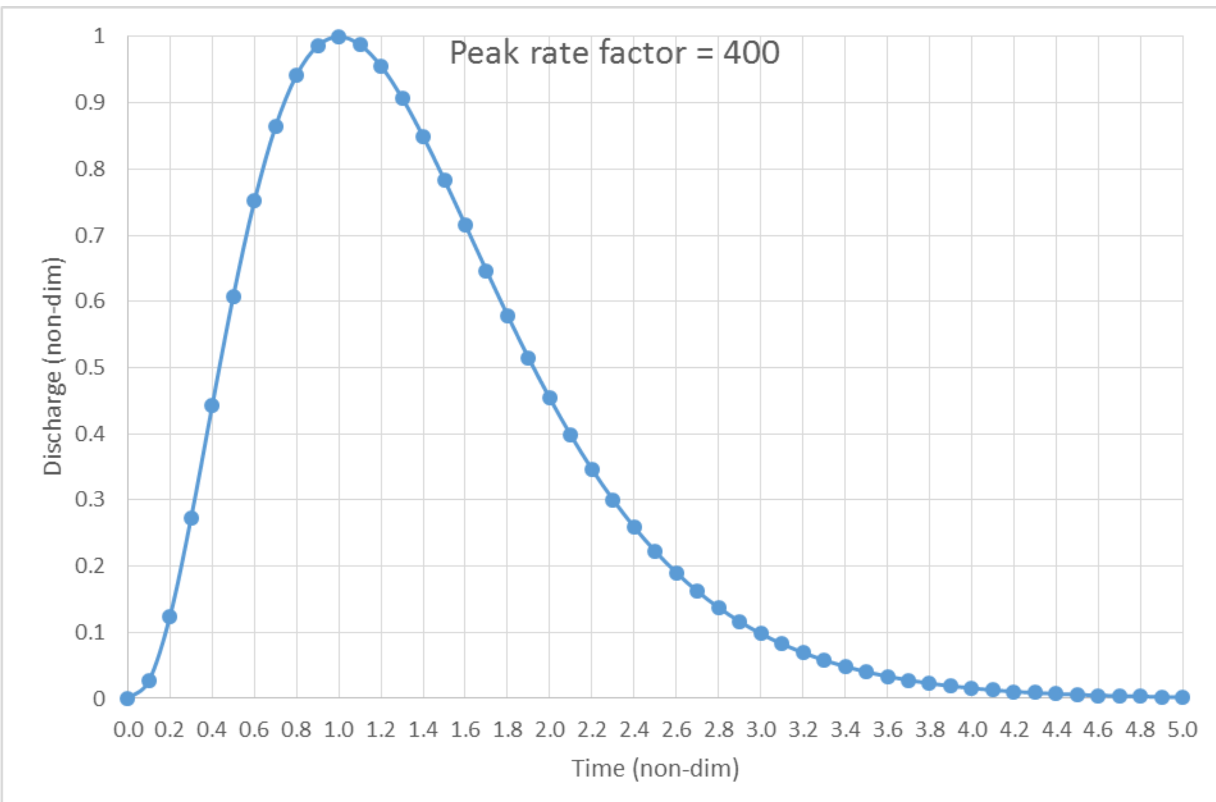



**Figure MN2-2: Dimensionless Unit Hydrograph with Peak rate factor = 400**

### (d) Time of Concentration (210-VI-EFH, Amend. MN14, March 2010)

Time of concentration (Tc) may be determined by the method in Engineering Field Handbook, Chapter 2 (EFH2), by methods in Chapter 15 of NEH Part 630-Hydrology, or by applying the Folmar & Miller (F&M) equation (reference: Folmar, Norman D. and Arthur C. Miller, “Development of an Empirical Lag Time Equation”, Journal of Irrigation and Drainage Engineering – American Society of Civil Engineers, July/August 2008, pages 501 to 506.) The F&M Tc formula is:

**$Tc = (LHL)^{0.65}/108.3$**

Longest Hydraulic Length (LHL) is in units of feet and Tc results are in units of hours.

Testing has shown that the EFH-2 method is conservative for typical watersheds in Minnesota where storage in microtopography is present. When the F&M equation for Tc is utilized with the EFH-2 method, peak discharges are much closer to observed values. It is recommended that the F&M Tc be used with the EFH-2 method for typical Minnesota watersheds with some storage present.

The F&M Tc formula was not developed using any urban watersheds so its use is limited to rural watersheds. The watersheds examined in their analysis had watershed slopes of 2.9% and greater so this does not apply in watersheds with less than 1% slope, and with watersheds between 1% and 2% slope, the procedure should be used with caution. For watersheds less than 2% it is recommended to increase the EFH-2 Tc by a factor of 1.65 in order to obtain peak discharges in line with observed values. Another option for flat watersheds that are large or contain considerable storage would be to model them with software such as WinTR-55, WinTR-20, or HEC-HMS.

Watersheds exceeding 1500 acres in size need to be broken into appropriate subareas and modeled in software such as WinTR-55, WinTR-20, or HEC-HMS to obtain a realistic discharge. For watersheds less than 1500 acres, modeling can also be used where storage exists behind roads or in natural or constructed depressions to reduce design discharges.

Non-contributing portions of a watershed may be removed from the total drainage area where appropriate. A clear explanation must be given in project documentation for why the area is non-contributing.

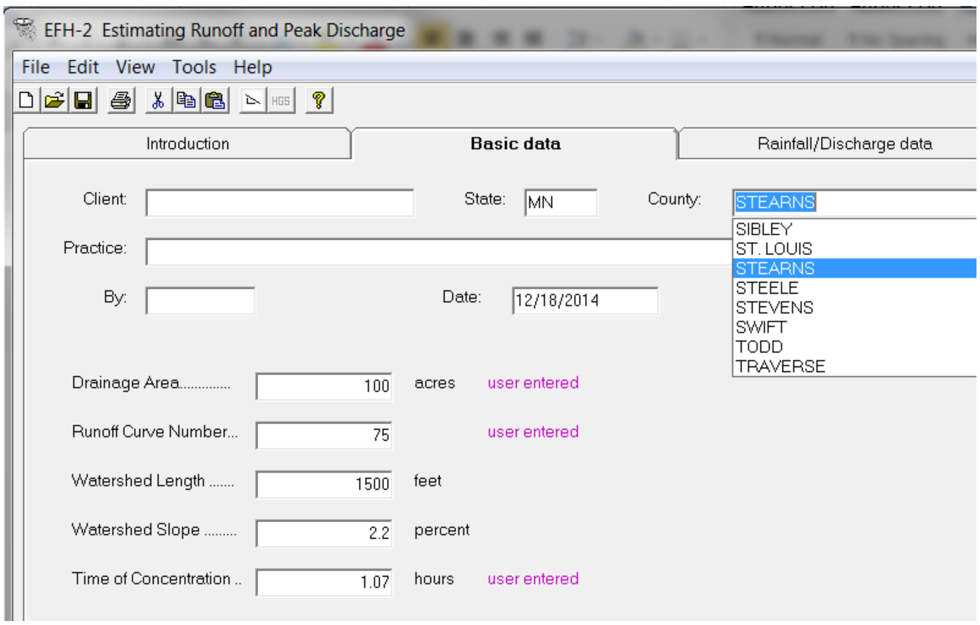
Watersheds with potential storage locations will be modeled using such programs as Win TR-55, WinTR-20, and HEC-HMS in order to account for the storage. Generally if at least 10% of the runoff volume has the potential to be impacted by storage in the watershed, the watershed should be modeled to determine peak discharge. If storage is ignored a conservative peak discharge will be computed.

See Appendix 5 for the Minnesota Hydrology Flowchart.

## Appendix MN650.29-1. Example Application of the EFH-2 Computer Program in Minnesota

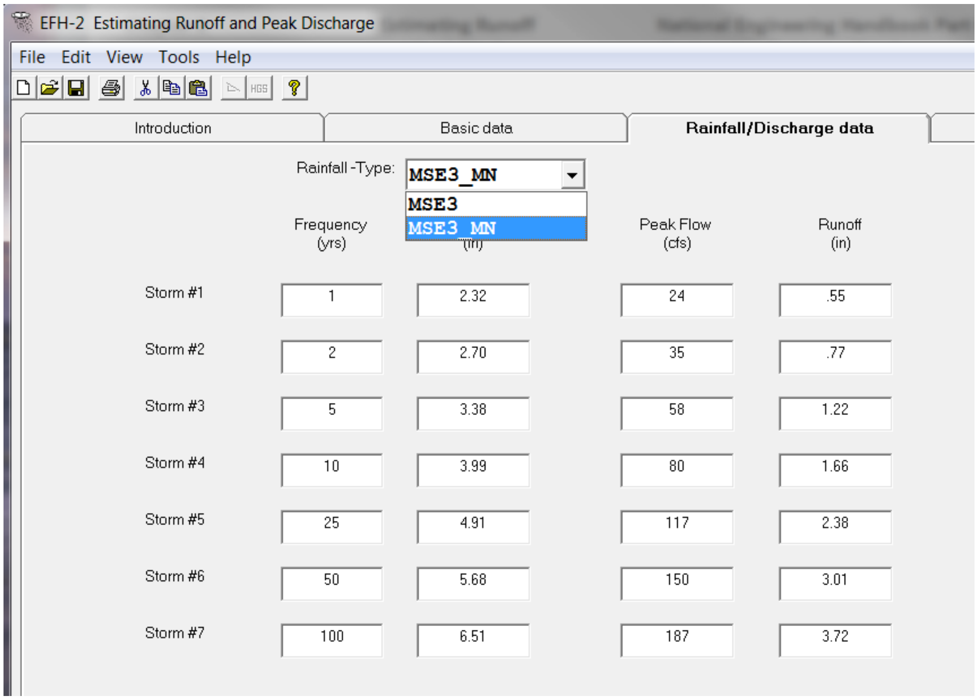
For this example, a small watershed in Stearns County was selected. The drainage area is 100 acres, the curve number is 75, watershed length is 1500 feet, and average watershed slope is 2.2 percent. From the rainfall distribution map above, the rainfall distribution region is MSE 3 MN.

1. Open the EFH-2 computer program and open the Basic Data tab. Enter State "MN" and use the pull-down menu to select "Stearns" county.




2. Enter the remaining data on this window. The Drainage Area and Runoff Curve Number could alternatively have been entered by opening the RCN tab (far right side of Basic data window).
3. Since this is a rural site with a drainage area greater then 30 acres and a watershed slope greater than to 2%; the Time of concentration (Tc) will have to be adjusted and manually entered. Tc = Watershed Length $^{0.65}$/108.3 ( Tc = 1500 $^{0.65}$/108.3 = 1.07).
4. Open the Rainfall/Discharge data tab.
5. The 24-hour rainfall data for Stearns County has automatically been entered. At this point you may replace these county values with site specific data from http://hdsc.nws.noaa.gov/hdsc/pfds/ if desired.

6. Use the Rainfall Type pull-down menu to select MSE3 MN.




7. Upon choosing the rainfall type, the peak discharges and runoff depths are calculated.
8. To complete the project, click File and Save. Print output if desired. Close EFH-2.

## Appendix MN650.29-2. County Rainfall Database (COUNTY.MN)

Notes: Rainfall distribution for each county and zone are shown with the county name (MSE 3 MN). The 24-hour rainfall duration values are in units of inches.

**Table MN A2-1 NRCS Rainfall Values for Minnesota Counties**

| 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 |
| DODGE | MSE 3 MN | 2.50 | 2.93 | 3.73 | 4.49 | 5.68 | 6.71 | 7.83 |
| DOUGLAS | MSE 3 MN | 2.23 | 2.57 | 3.17 | 3.73 | 4.56 | 5.26 | 6.01 |
| FARIBAULT | MSE 3 MN | 2.62 | 3.06 | 3.87 | 4.65 | 5.83 | 6.86 | 7.99 |
| FILLMORE | MSE 3 MN | 2.60 | 3.02 | 3.81 | 4.56 | 5.72 | 6.73 | 7.83 |
| FREEBORN | MSE 3 MN | 2.56 | 3.00 | 3.81 | 4.57 | 5.75 | 6.75 | 7.84 |
| GOODHUE | MSE 3 MN | 2.50 | 2.89 | 3.64 | 4.37 | 5.53 | 6.55 | 7.68 |
| GRANT | MSE 3 MN | 2.20 | 2.56 | 3.18 | 3.74 | 4.55 | 5.23 | 5.94 |
| HENNEPIN | MSE 3 MN | 2.48 | 2.86 | 3.57 | 4.26 | 5.34 | 6.29 | 7.32 |
| HOUSTON | MSE 3 MN | 2.62 | 23.04 | 3.82 | 4.56 | 5.72 | 6.72 | 7.81 |
| HUBBARD | MSE 3 MN | 2.10 | 2.54 | 3.19 | 3.81 | 4.76 | 5.58 | 6.48 |
| ISANTI | MSE 3 MN | 2.40 | 2.79 | 3.50 | 4.13 | 5.07 | 5.85 | 6.68 |
| ITASCA | MSE 3 MN | 2.18 | 2.56 | 3.21 | 3.79 | 4.63 | 5.32 | 6.05 |
| JACKSON | MSE 3 MN | 2.48 | 2.90 | 3.66 | 4.38 | 5.47 | 6.41 | 7.43 |
| KANABEC | MSE 3 MN | 2.33 | 2.70 | 3.35 | 3.94 | 4.83 | 5.57 | 6.35 |
| KANDIYOHI | MSE 3 MN | 2.42 | 2.75 | 3.38 | 3.98 | 4.93 | 5.76 | 6.67 |
| KITTSON | MSE 3 MN | 1.93 | 2.27 | 2.88 | 3.43 | 4.26 | 4.96 | 5.71 |
| KOOCHICHING | MSE 3 MN | 2.09 | 2.42 | 2.99 | 3.49 | 4.22 | 4.81 | 5.44 |

| County | Rainfall Type | 1-year | 2-year | 5-year | 10-year | 25-year | 50-year | 100-year |
|---|---|---|---|---|---|---|---|---|
| LAC QUI PARLE | MSE 3 MN | 2.23 | 2.56 | 3.16 | 3.71 | 4.55 | 5.26 | 6.02 |
| LAKE | MSE 3 MN | 2.15 | 2.48 | 3.06 | 3.59 | 4.40 | 5.07 | 5.79 |
| LAKE OF THE WOODS | MSE 3 MN | 2.03 | 2.35 | 2.92 | 3.47 | 4.31 | 5.03 | 5.82 |
| LE SUEUR | MSE 3 MN | 2.47 | 2.86 | 3.58 | 4.26 | 5.30 | 6.19 | 7.16 |
| LINCOLN | MSE 3 MN | 2.31 | 2.69 | 3.37 | 3.99 | 4.91 | 5.68 | 6.50 |
| LYON | MSE 3 MN | 2.33 | 2.70 | 3.38 | 4.01 | 4.99 | 5.83 | 6.74 |
| MAHNOMEN | MSE 3 MN | 2.16 | 2.49 | 3.13 | 3.78 | 4.83 | 5.76 | 6.81 |
| MARSHALL | MSE 3 MN | 2.01 | 2.37 | 3.01 | 3.61 | 4.51 | 5.27 | 6.09 |
| MARTIN | MSE 3 MN | 2.53 | 2.90 | 3.63 | 4.33 | 5.44 | 6.41 | 7.48 |
| MCLEOD | MSE 3 MN | 2.41 | 2.79 | 3.48 | 4.13 | 5.14 | 6.00 | 6.95 |
| MEEKER | MSE 3 MN | 2.40 | 2.76 | 3.42 | 4.04 | 5.02 | 5.86 | 6.78 |
| MILLE LACS | MSE 3 MN | 2.34 | 2.72 | 3.38 | 3.98 | 4.86 | 5.59 | 6.37 |
| MORRISON | MSE 3 MN | 2.28 | 2.65 | 3.31 | 3.91 | 4.79 | 5.53 | 6.31 |
| MOWER | MSE 3 MN | 2.55 | 2.99 | 3.80 | 4.55 | 5.72 | 6.71 | 7.80 |
| MURRAY | MSE 3 MN | 2.40 | 2.79 | 3.51 | 4.16 | 5.14 | 5.96 | 6.85 |
| NICOLLET | MSE 3 MN | 2.43 | 2.82 | 3.52 | 4.18 | 5.18 | 6.03 | 6.95 |
| NOBLES | MSE 3 MN | 2.45 | 2.88 | 3.66 | 4.35 | 5.39 | 6.25 | 7.16 |
| NORMAN | MSE 3 MN | 2.11 | 2.47 | 3.14 | 3.78 | 4.79 | 5.66 | 6.63 |
| OLMSTED | MSE 3 MN | 2.54 | 2.95 | 3.74 | 4.50 | 5.69 | 6.72 | 7.86 |
| OTTER TAIL | MSE 3 MN | 2.20 | 2.55 | 3.17 | 3.74 | 4.61 | 5.35 | 6.15 |
| PENNINGTON | MSE 3 MN | 2.10 | 2.46 | 3.11 | 3.72 | 4.67 | 5.47 | 6.34 |
| PINE | MSE 3 MN | 2.40 | 2.78 | 3.46 | 4.06 | 4.96 | 5.70 | 6.49 |
| PIPESTONE | MSE 3 MN | 2.32 | 2.71 | 3.39 | 3.99 | 4.87 | 5.59 | 6.35 |
| POLK | MSE 3 MN | 2.07 | 2.41 | 3.05 | 3.66 | 4.61 | 5.43 | 6.33 |
| POPE | MSE 3 MN | 2.29 | 2.64 | 3.27 | 3.85 | 4.73 | 5.47 | 6.27 |
| RAMSEY | MSE 3 MN | 2.45 | 2.81 | 3.50 | 4.19 | 5.29 | 6.27 | 7.36 |
| RED LAKE | MSE 3 MN | 2.11 | 2.45 | 3.09 | 3.69 | 4.64 | 5.47 | 6.37 |
| REDWOOD | MSE 3 MN | 2.35 | 2.70 | 3.34 | 3.95 | 4.90 | 5.72 | 6.61 |
| RENVILLE | MSE 3 MN | 2.37 | 2.69 | 3.31 | 3.90 | 4.84 | 5.65 | 6.56 |
| RICE | MSE 3 MN | 2.46 | 2.84 | 3.55 | 4.24 | 5.32 | 6.26 | 7.29 |
| ROCK | MSE 3 MN | 2.36 | 2.77 | 3.47 | 4.09 | 4.97 | 5.69 | 6.44 |
| ROSEAU | MSE 3 MN | 1.98 | 2.28 | 2.86 | 3.41 | 4.27 | 5.02 | 5.85 |
| SCOTT | MSE 3 MN | 2.48 | 2.85 | 3.54 | 4.22 | 5.30 | 6.25 | 7.29 |
| SHERBURNE | MSE 3 MN | 2.39 | 2.79 | 3.48 | 4.11 | 5.04 | 5.81 | 6.63 |
| SIBLEY | MSE 3 MN | 2.43 | 2.82 | 3.52 | 4.17 | 5.17 | 6.03 | 6.95 |
| ST. LOUIS | MSE 3 MN | 2.12 | 2.47 | 3.08 | 3.63 | 4.46 | 5.14 | 5.87 |
| STEARNS | MSE 3 MN | 2.32 | 2.70 | 3.38 | 3.99 | 4.91 | 5.68 | 6.51 |
| STEELE | MSE 3 MN | 2.48 | 2.91 | 3.70 | 4.44 | 5.57 | 6.55 | 7.61 |
| STEVENS | MSE 3 MN | 2.22 | 2.56 | 3.17 | 3.72 | 4.53 | 5.21 | 5.93 |
| SWIFT | MSE 3 MN | 2.30 | 2.64 | 3.28 | 3.86 | 4.76 | 5.52 | 6.34 |
| TODD | MSE 3 MN | 2.27 | 2.65 | 3.33 | 3.94 | 4.85 | 5.61 | 6.41 |
| TRAVERSE | MSE 3 MN | 2.17 | 2.83 | 3.16 | 3.72 | 4.53 | 5.20 | 5.90 |

| County | Rainfall Type | 1-year | 2-year | 5-year | 10-year | 25-year | 50-year | 100-year |
|---|---|---|---|---|---|---|---|---|
| WABASHA | MSE 3 MN | 2.55 | 2.95 | 3.72 | 4.47 | 5.65 | 6.68 | 7.81 |
| WADENA | MSE 3 MN | 2.23 | 2.58 | 3.24 | 3.85 | 4.81 | 5.63 | 6.52 |
| WASECA | MSE 3 MN | 2.50 | 2.92 | 3.69 | 4.41 | 5.52 | 6.46 | 7.49 |
| WASHINGTON | MSE 3 MN | 2.44 | 2.80 | 3.49 | 4.16 | 5.23 | 6.16 | 7.20 |
| WATONWAN | MSE 3 MN | 2.46 | 2.84 | 3.55 | 4.22 | 5.26 | 6.16 | 7.15 |
| WILKIN | MSE 3 MN | 2.12 | 2.48 | 3.12 | 3.69 | 4.54 | 5.25 | 6.01 |
| WINONA | MSE 3 MN | 2.54 | 2.94 | 3.68 | 4.40 | 5.53 | 6.51 | 7.59 |
| WRIGHT | MSE 3 MN | 2.42 | 2.81 | 3.53 | 4.18 | 5.18 | 6.02 | 6.93 |
| YELLOW MEDICINE | MSE 3 MN | 2.30 | 2.65 | 3.30 | 3.92 | 4.88 | 5.70 | 6.60 |

## Appendix MN650.29-3. Instructions for Incorporating Updated Rainfall into EFH-2 Computer Program in Minnesota

EFH-2 Runoff and Peak Discharge software requires a rainfall database (**COUNTY.MN**) and rainfall distribution types (**type.rf**). These databases are available on the Minnesota NRCS Engineering site and will replace the TP-40 based databases. The following describes the steps to use the current databases with the EFH-2 computer program.

1. Navigate to the Hydrology & Hydraulics section of the Minnesota NRCS Engineering site. (Topics > Technical Resources > Engineering > Engineering Resources > Hydrology & Hydraulics)

2. Individually, save "**COUNTY.MN"** and " **type.rf"** into C:\Program Files(x86)\USDA\EFH2 on your computer. Show hidden files will need to be activated in order to view these folders. This will replace the existing TP40 based data file. The EFH-2 software now has the NOAA 14 rainfall depths and rainfall distribution types database for Minnesota.

3. Within the EFH-2 computer program, type "MN" for the state under the Basic Data tab to see every county and rainfall zone in Minnesota. Appendix 1 provides an example application of the Minnesota rainfall data in EFH-2 software.

## Appendix MN650.29-4. Rainfall Distribution Type Equations, Peak Discharge Curves and Peak Discharge Equation Coefficients

The EFH-2 computer program estimates peak discharges using equations that simulate results from other more detailed rainfall/runoff models such as WinTR-20. Since it was found that a new dimensionless unit hydrograph was needed with the NOAA 14 data to produce reasonable results, new peak flow coefficients for the peak discharge equations were created.

<u>Peak Equation Coefficients</u>

Rainfall distributions were created for each region and used in WinTR-20 models to develop peak flow equation coefficients for use in EFH-2 computer program. To simplify the estimation of peak discharge, WinTR-20 was run for times of concentration of 0.1 to 10.0 hours and $I_a/P$ ratios of 0.1, 0.25, 0.3, 0.4 and 0.5. $I_a$ is initial abstraction in units of inches. Initial abstraction includes all losses before runoff begins (interception, depression storage, early storm infiltration, etc). P is the storm rainfall with units of inches and CN = NRCS runoff curve number.

$$I_a = 0.2 * ((1000 / CN) – 10) \quad \text{Eq. 1}$$

Equations to relate time of concentration to unit peak discharge were then developed. The equation used to compute the unit peak discharge (q) for the EFH-2 computer program is:

$$q = 10 \wedge (Coeff\_1 + Coeff\_2 * LOG(T_c) + Coeff\_3 * (LOG(T_c))\wedge 2) \quad \text{Eq. 2}$$

The coefficients to be used with each rainfall distribution are tabulated below. For example, the equation applicable to the MSE 3 MN rainfall distribution region of Minnesota and $I_a/P$ ratio of 0.1 is:

$$q = 10 \wedge (2.5287 – 0.6729 * LOG(T_c) – 0.1275 * (LOG(T_c))^2) \quad \text{Eq. 3}$$

For a time of concentration of 0.5 hours and $I_a/P$ ratio of 0.1, the unit peak discharge is q = 524.46 cfs / inch / sq mile. If the drainage area is 200 acres (0.31 square miles) and there is 1.5 inches of runoff, the peak discharge, Q, is:

$$Q = 524.46 * 0.31 * 1.5 = 244 \text{ cfs} \quad \text{Eq. 4}$$

The peak discharge equations included in the type.rf file have drainage area units in square miles. The customary units used in EFH-2 are acres. The following figure show plots of the unit peak discharge curves with drainage area in acres. These curves may be used for hand calculation of peak discharge.

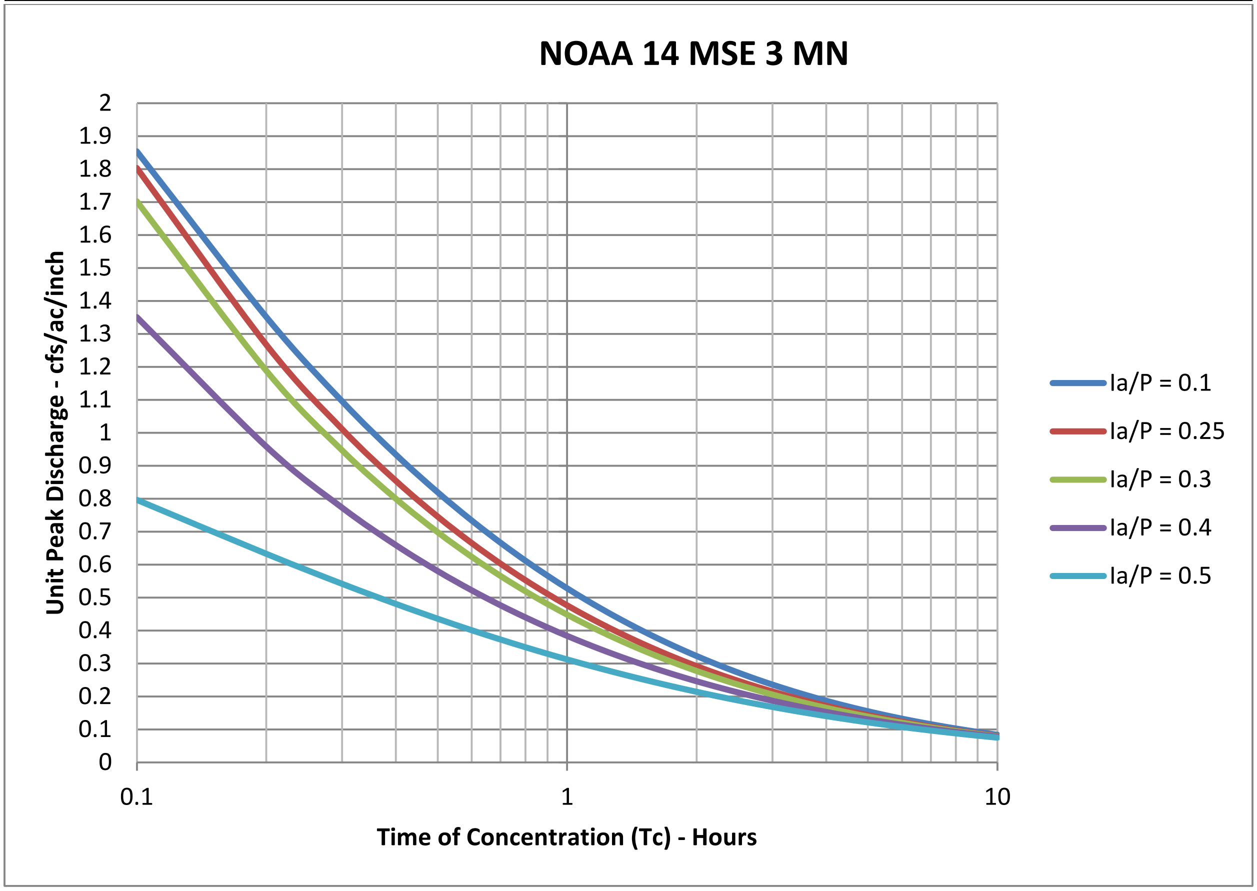



**Figure A4-1, EFH-2 Peak Discharge Curves for MSE 3 MN**

**Table A4-1, EFH-2 Peak Discharge Equation Coefficients for MSE 3 MN**

| $I_a/P$ | Coeff_1 | Coeff_2 | Coeff_3 |
|---|---|---|---|
| 0.1 | 2.5287 | -0.6729 | -0.1275 |
| 0.25 | 2.4842 | -0.6764 | -0.0984 |
| 0.3 | 2.4578 | -0.6663 | -0.0869 |
| 0.4 | 2.3902 | -0.6195 | -0.0729 |
| 0.5 | 2.3005 | -0.5131 | -0.1065 |

The following plot is for use with 24-hour design storms. It represents the accumulated rainfall during the 24-hour storm duration on a non-dimensional basis. The maximum accumulated rainfall in the plot is 1.0 which represents the total storm 24-hour rainfall. The rainfall distribution is represented in WinTR-20 in tabular format at a time interval of 0.1 hour.

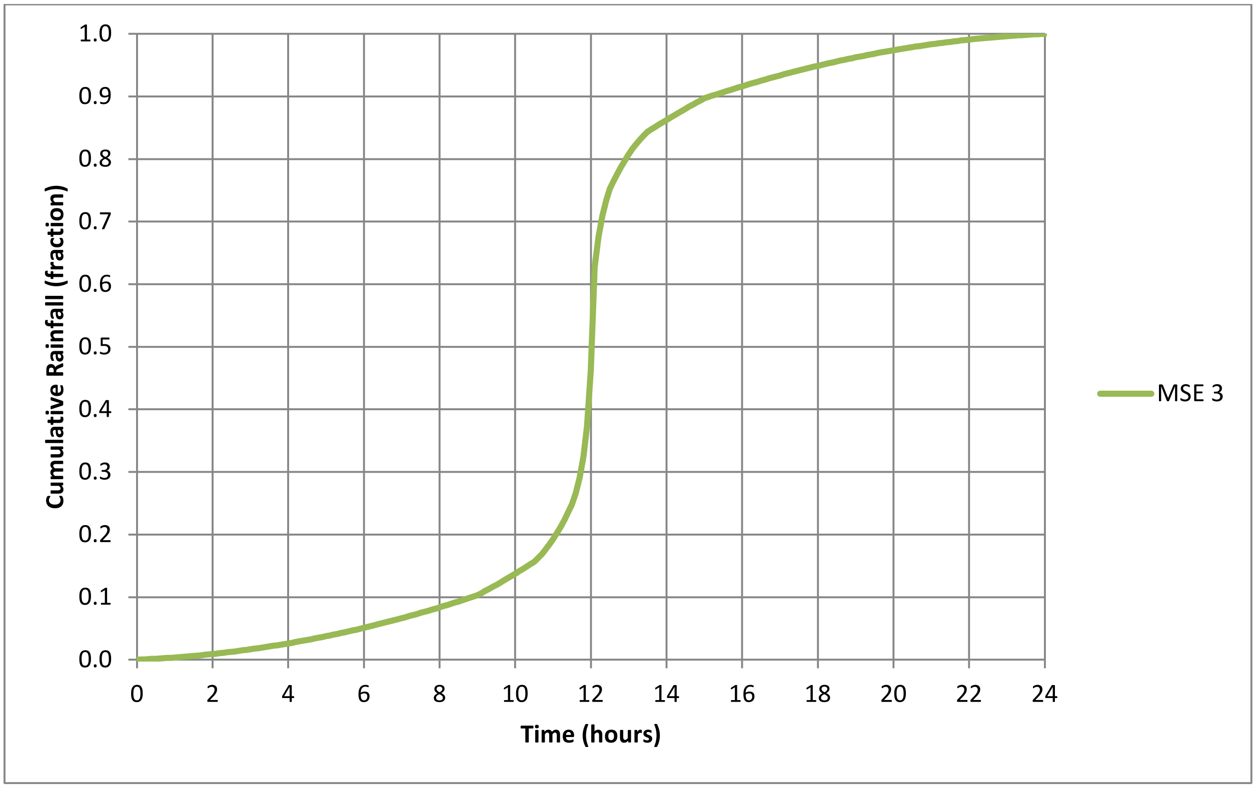



**Figure A4-2, Plot of the MSE 3 rainfall distribution.**

## Appendix MN650.29-5. Minnesota Hydrology Flowchart

# Minnesota Hydrology Flowchart

DA = Drainage Area

Tc = Time of Concentration in hours

F&M = Folmar & Miller equation Tc = $(LHL^{0.65})/108.3$

LHL = Longest Hydraulic Length in feet

Model = WinTR-20, HEC-HMS or WinTR-55

Note: If storage in the watershed effects more than 10% of the runoff, modeling is recommended to account for storage.