

Engineering Field Handbook Chapter 2: Estimating Runoff and Peak Discharges**Massachusetts EFH-2 Supplement Number: MA-EFH2****MA Supplement Background**

The purpose of this supplement is to assist Field staff in utilizing the most current rainfall data and rainfall distribution available for the design of conservation practices. These rainfall data were developed by the Northeast Regional Climate Center (NRCC) and will replace rainfall data from Weather Bureau Technical Paper 40 (TP-40). Rainfall distributions were developed by the NRCS Water Quality and Quantity Technology Development Team and replace the standard NRCS rainfall distributions Type II and Type III.

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 includes information on the MA rainfall counties and sub-county areas and provides an example application of the computer program, EFH-2. Appendices include additional information on the twenty MA precipitation areas, procedures to update the EFH-2 rainfall amount data files, background information on the four NRCC rainfall distribution types, and an example application of peak discharge calculation using a chart.

Effective upon receipt, NRCS MA staff are to use these updated rainfall depths and rainfall distribution types 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 Massachusetts and (2) updating the data files for the EFH-2 computer program by replacing the county rainfall (county.MA) and rainfall distribution types (type.rf) files.

The EFH-2 computer program User Guide contains information, guidance, and examples concerning runoff curve number, average watershed slope, watershed length, input/output operations, and limitations. Additional technical information is available from the NRCC web site (www.precip.net) and NRCS technical directives such as National Engineering Handbook Part 630 – Hydrology, Chapter 4, Storm Rainfall Depth and Distribution.

Rainfall Data

The NRCC has completed a rainfall-frequency analysis for data through December 31, 2008. This is the first comprehensive rainfall-frequency analysis for the northeast states since 1961, when TP-40 was completed. Data are available for specific locations from an interactive web site (www.precip.net). Alternatively, data for representative locations in Massachusetts counties are included in a rainfall amount data file (county.MA) for use with the EFH-2 computer program. The data contained in the database are included in Appendix 1 of this Supplement.

Rainfall Distributions

Four rainfall distributions have been developed for the northeast states (CT, MA, ME, NH, NY, RI, and VT). These rainfall distributions were developed based on the NRCC data. The state of Massachusetts is characterized by three rainfall distributions as indicated below in Figures 1 and 2. Appendix 1 includes detailed maps of all towns in each county or sub-county rainfall area.

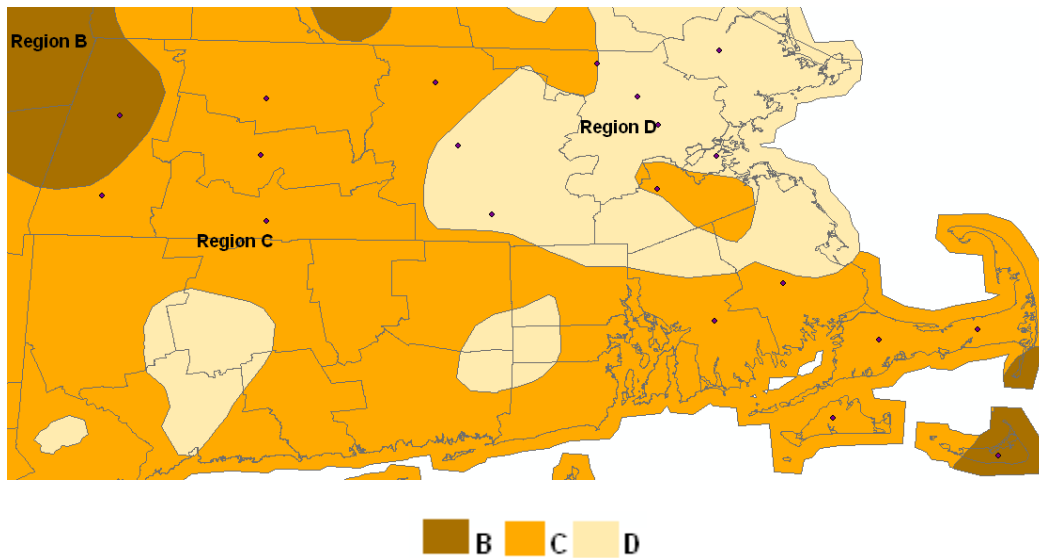


Figure 1 - Location of types B, C, and D rainfall distributions

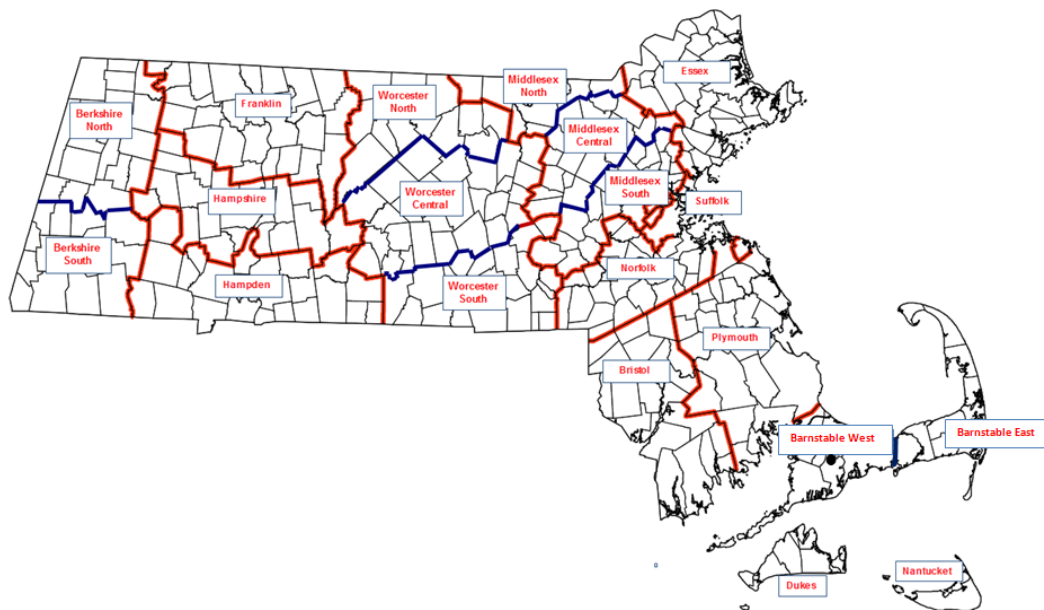


Figure 2 - Massachusetts State map showing the twenty rainfall areas

The EFH-2 computer program uses equations to relate unit peak discharge (cubic feet per second per inch of runoff per acre of drainage area) to time of concentration in hours. The equations and coefficients for the four northeast rainfall distributions are included in Appendix 3. Plots of the rainfall distributions for Regions A, B, C, and D are included in Appendix 4. Appendix 5 includes a graph which is an alternative to running the EFH-2 computer program. Within the accuracy of reading the graph, the result will be close to that derived from the EFH-2 computer program.

Example Application of the EFH-2 Computer Program in Massachusetts

For this example, we select a small watershed in the Worcester Central region. The drainage area is 10 acres, the curve number is 82, length is 800 feet, and watershed slope is 3 percent. From the rainfall distribution map above, the rainfall distribution region is “D”.

1. Open the EFH-2 program from the Engineering Applications programs. Open the “Basic Data” tab. In the State window enter MA. In the County window, use the pull-down menu to select the town of Worcester. The name “NRCC_D” next to the county name designates this county is in NRCC Rainfall Distribution Type D region and that the rainfall data source is the NRCC website.

The screenshot shows a software window titled "EFH-2 Estimating Runoff and Peak Discharge". The window has a menu bar (File, Edit, View, Tools, Help) and a toolbar with icons for file operations and help. The main area is divided into four tabs: "Introduction", "Basic data", "Rainfall/Discharge data", and "RCN". The "Basic data" tab is selected and contains the following fields:

- Client:
- State:
- County: (dropdown menu is open showing: WINCHESTER MIDDLE, WINDSOR BERKSHIRE, WINTHROP SUFFOLK (, WOBURN MIDDLESEX, WORCESTER WORCE, WORTHINGTON HAMP, WRENTHAM NORFOLK, YARMOUTH BARNSTA)
- Practice:
- By:
- Date:
- Drainage Area..... acres
- Runoff Curve Number...
- Watershed Length feet
- Watershed Slope percent
- Time of Concentration.. hours

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.

EFH-2 Estimating Runoff and Peak Discharge

File Edit View Tools Help

Introduction **Basic data** Rainfall/Discharge data RCN

Client: Example - EFH2 NRCC State: MA County: WORCESTER WORCE

Practice: Diversion

By: NRCS Date: 2/28/2013

Drainage Area..... 10 acres user entered

Runoff Curve Number... 82 user entered

Watershed Length 800 feet

Watershed Slope 3 percent

Time of Concentration .. 0.24 hours calculated

- Open the Rainfall/Discharge data tab. Select the rainfall type NRCC_D from the pull down menu. Once the rainfall type is selected, the peak discharges and runoff depths are calculated.

EFH-2 Estimating Runoff and Peak Discharge

File Edit View Tools Help

Introduction Basic data **Rainfall/Discharge data** RCN

Rainfall - Type: NRCC_D

	Frequency (yrs)	24-HR Rain (in)	Peak Flow (cfs)	Runoff (in)
Storm #1	1	2.58	9	1.06
Storm #2	2	3.13	12	1.48
Storm #3	5	3.93	18	2.14
Storm #4	10	4.68	23	2.79
Storm #5	25	5.88	32	3.88
Storm #6	50	7.00	41	4.92
Storm #7	100	8.34	51	6.18

- To complete the project, click File Save and File Print.

Appendix 1. County rainfall database (county.MA). Table 1 lists the rainfall data compiled from the NRCC web site (www.precip.net) and imported into the EFH-2 executable program file “county.MA”.

Table A1.1 Massachusetts rainfall data by town and county [inches]

Town and County	1-YR	2-YR	5-YR	10-YR	25-YR	50-YR	100-YR
ABINGTON PLYMOUTH COUNTY NRCC-C	2.78	3.35	4.18	4.95	6.19	7.33	8.68
ACTON MIDDLESEX COUNTY CENTRAL NRCC-D	2.58	3.09	3.90	4.65	5.87	7.00	8.36
ACUSHNET BRISTOL COUNTY NRCC-C	2.74	3.30	4.12	4.88	6.10	7.22	8.56
ADAMS BERKSHIRE COUNTY NORTH NRCC-B	2.42	2.81	3.48	4.09	5.07	5.97	7.04
AGAWAM HAMPDEN COUNTY NRCC-C	2.60	3.11	3.89	4.60	5.74	6.80	8.05
ALFORD BERKSHIRE COUNTY SOUTH NRCC-C	2.50	2.94	3.69	4.38	5.50	6.54	7.78
AMESBURY ESSEX COUNTY NRCC-D	2.63	3.15	4.02	4.83	6.16	7.42	8.94
AMHERST HAMPSHIRE COUNTY NRCC-C	2.55	3.07	3.80	4.47	5.54	6.52	7.68
ANDOVER ESSEX COUNTY NRCC-D	2.63	3.15	4.02	4.83	6.16	7.42	8.94
AQUINNAH DUKES COUNTY NRCC-C	2.80	3.31	4.14	4.91	6.16	7.30	8.67
ARLINGTON MIDDLESEX COUNTY SOUTH NRCC-D	2.64	3.16	3.99	4.77	6.03	7.21	8.62
ASHBURNHAM WORCESTER COUNTY NORTH NRCC-C	2.47	2.95	3.68	4.35	5.43	6.42	7.60
ASHBY MIDDLESEX COUNTY NORTH NRCC-C	2.52	3.00	3.76	4.46	5.60	6.66	7.92
ASHFIELD FRANKLIN COUNTY NRCC-C	2.48	3.02	3.70	4.33	5.32	6.22	7.29
ASHLAND MIDDLESEX COUNTY SOUTH NRCC-D	2.64	3.16	3.99	4.77	6.03	7.21	8.62
ATHOL WORCESTER COUNTY NORTH NRCC-C	2.47	2.95	3.68	4.35	5.43	6.42	7.60
ATTLEBORO BRISTOL COUNTY NRCC-C	2.74	3.30	4.12	4.88	6.10	7.22	8.56
AUBURN WORCESTER COUNTY SOUTH NRCC-D	2.65	3.22	4.05	4.83	6.08	7.24	8.64
AVON NORFOLK COUNTY NRCC-C	2.69	3.22	4.07	4.86	6.15	7.35	8.80
AYER MIDDLESEX COUNTY NORTH NRCC-C	2.52	3.00	3.76	4.46	5.60	6.66	7.92
BARNSTABLE BARNSTABLE COUNTY WEST NRCC-C	2.80	3.32	4.14	4.89	6.10	7.22	8.55
BARRE WORCESTER COUNTY CENTRAL NRCC-D	2.58	3.13	3.93	4.68	5.88	7.00	8.34
BECKETT BERKSHIRE COUNTY SOUTH NRCC-C	2.50	2.94	3.69	4.38	5.50	6.54	7.78
BEDFORD MIDDLESEX COUNTY CENTRAL NRCC-D	2.58	3.09	3.90	4.65	5.87	7.00	8.36
BELCHERTOWN HAMPSHIRE COUNTY NRCC-C	2.55	3.07	3.80	4.47	5.54	6.52	7.68
BELLINGHAM NORFOLK COUNTY NRCC-C	2.69	3.22	4.07	4.86	6.15	7.35	8.80
BELMONT MIDDLESEX COUNTY SOUTH NRCC-D	2.64	3.16	3.99	4.77	6.03	7.21	8.62
BERKLEY BRISTOL COUNTY NRCC-C	2.74	3.30	4.12	4.88	6.10	7.22	8.56
BERLIN WORCESTER COUNTY CENTRAL NRCC-D	2.58	3.13	3.93	4.68	5.88	7.00	8.34
BERNARDSTON FRANKLIN COUNTY NRCC-C	2.48	3.02	3.70	4.33	5.32	6.22	7.29
BEVERLY ESSEX COUNTY NRCC-D	2.63	3.15	4.02	4.83	6.16	7.42	8.94
BILLERICA MIDDLESEX COUNTY CENTRAL NRCC-D	2.58	3.09	3.90	4.65	5.87	7.00	8.36
BLACKSTONE WORCESTER COUNTY SOUTH NRCC-D	2.65	3.22	4.05	4.83	6.08	7.24	8.64
BLANDFORD HAMPDEN COUNTY NRCC-C	2.60	3.11	3.89	4.60	5.74	6.80	8.05
BOLTON WORCESTER COUNTY CENTRAL NRCC-D	2.58	3.13	3.93	4.68	5.88	7.00	8.34
BOSTON SUFFOLK COUNTY NRCC-D	2.72	3.26	4.11	4.90	6.19	7.39	8.83
BOURNE BARNSTABLE COUNTY WEST NRCC-C	2.80	3.32	4.14	4.89	6.10	7.22	8.55
BOXBOROUGH MIDDLESEX COUNTY CENTRAL NRCC-D	2.58	3.09	3.90	4.65	5.87	7.00	8.36
BOXFORD ESSEX COUNTY NRCC-D	2.63	3.15	4.02	4.83	6.16	7.42	8.94
BOYLSTON WORCESTER COUNTY CENTRAL NRCC-D	2.58	3.13	3.93	4.68	5.88	7.00	8.34
BRAINTREE NORFOLK COUNTY NRCC-C	2.69	3.22	4.07	4.86	6.15	7.35	8.80
BREWSTER BARNSTABLE COUNTY EAST NRCC-C	2.74	3.26	4.03	4.74	5.88	6.92	8.15
BRIDGEWATER PLYMOUTH COUNTY NRCC-C	2.78	3.35	4.18	4.95	6.19	7.33	8.68
BRIMFIELD HAMPDEN COUNTY NRCC-C	2.60	3.11	3.89	4.60	5.74	6.80	8.05
BROCKTON PLYMOUTH COUNTY NRCC-C	2.78	3.35	4.18	4.95	6.19	7.33	8.68
BROOKFIELD WORCESTER COUNTY CENTRAL NRCC-D	2.58	3.13	3.93	4.68	5.88	7.00	8.34
BROOKLINE NORFOLK COUNTY NRCC-C	2.69	3.22	4.07	4.86	6.15	7.35	8.80
BUCKLAND FRANKLIN COUNTY NRCC-C	2.48	3.02	3.70	4.33	5.32	6.22	7.29
BURLINGTON MIDDLESEX COUNTY SOUTH NRCC-D	2.64	3.16	3.99	4.77	6.03	7.21	8.62
CAMBRIDGE MIDDLESEX COUNTY SOUTH NRCC-D	2.64	3.16	3.99	4.77	6.03	7.21	8.62
CANTON NORFOLK COUNTY NRCC-C	2.69	3.22	4.07	4.86	6.15	7.35	8.80
CARLISLE MIDDLESEX COUNTY CENTRAL NRCC-D	2.58	3.09	3.90	4.65	5.87	7.00	8.36

CARVER PLYMOUTH COUNTY NRCC-C	2.78	3.35	4.18	4.95	6.19	7.33	8.68
CHARLEMONT FRANKLIN COUNTY NRCC-C	2.48	3.02	3.70	4.33	5.32	6.22	7.29
CHARLTON WORCESTER COUNTY SOUTH NRCC-D	2.65	3.22	4.05	4.83	6.08	7.24	8.64
CHATHAM BARNSTABLE COUNTY EAST NRCC-C	2.74	3.26	4.03	4.74	5.88	6.92	8.15
CHELMSFORD MIDDLESEX COUNTY CENTRAL NRCC-D	2.58	3.09	3.90	4.65	5.87	7.00	8.36
CHELSEA SUFFOLK COUNTY NRCC-D	2.72	3.26	4.11	4.90	6.19	7.39	8.83
CHESHIRE BERKSHIRE COUNTY NORTH NRCC-B	2.42	2.81	3.48	4.09	5.07	5.97	7.04
CHESTER HAMPDEN COUNTY NRCC-C	2.60	3.11	3.89	4.60	5.74	6.80	8.05
CHESTERFIELD HAMPSHIRE COUNTY NRCC-C	2.55	3.07	3.80	4.47	5.54	6.52	7.68
CHICOPEE HAMPDEN COUNTY NRCC-C	2.60	3.11	3.89	4.60	5.74	6.80	8.05
CHILMARK DUKES COUNTY NRCC-C	2.80	3.31	4.14	4.91	6.16	7.30	8.67
CLARKSBURG BERKSHIRE COUNTY NORTH NRCC-B	2.42	2.81	3.48	4.09	5.07	5.97	7.04
CLINTON WORCESTER COUNTY CENTRAL NRCC-D	2.58	3.13	3.93	4.68	5.88	7.00	8.34
COHASSET NORFOLK COUNTY NRCC-C	2.69	3.22	4.07	4.86	6.15	7.35	8.80
COLRAIN FRANKLIN COUNTY NRCC-C	2.48	3.02	3.70	4.33	5.32	6.22	7.29
CONCORD MIDDLESEX COUNTY CENTRAL NRCC-D	2.58	3.09	3.90	4.65	5.87	7.00	8.36
CONWAY FRANKLIN COUNTY NRCC-C	2.48	3.02	3.70	4.33	5.32	6.22	7.29
CUMMINGTON HAMPSHIRE COUNTY NRCC-C	2.55	3.07	3.80	4.47	5.54	6.52	7.68
DALTON BERKSHIRE COUNTY NORTH NRCC-B	2.42	2.81	3.48	4.09	5.07	5.97	7.04
DANVERS ESSEX COUNTY NRCC-D	2.63	3.15	4.02	4.83	6.16	7.42	8.94
DARTMOUTH BRISTOL COUNTY NRCC-C	2.74	3.30	4.12	4.88	6.10	7.22	8.56
DEDHAM NORFOLK COUNTY NRCC-C	2.69	3.22	4.07	4.86	6.15	7.35	8.80
DEERFIELD FRANKLIN COUNTY NRCC-C	2.48	3.02	3.70	4.33	5.32	6.22	7.29
DENNIS BARNSTABLE COUNTY EAST NRCC-C	2.74	3.26	4.03	4.74	5.88	6.92	8.15
DIGHTON BRISTOL COUNTY NRCC-C	2.74	3.30	4.12	4.88	6.10	7.22	8.56
DOUGLAS WORCESTER COUNTY SOUTH NRCC-D	2.65	3.22	4.05	4.83	6.08	7.24	8.64
DOVER NORFOLK COUNTY NRCC-C	2.69	3.22	4.07	4.86	6.15	7.35	8.80
DRACUT MIDDLESEX COUNTY NORTH NRCC-C	2.52	3.00	3.76	4.46	5.60	6.66	7.92
DUDLEY WORCESTER COUNTY SOUTH NRCC-D	2.65	3.22	4.05	4.83	6.08	7.24	8.64
DUNSTABLE MIDDLESEX COUNTY NORTH NRCC-C	2.52	3.00	3.76	4.46	5.60	6.66	7.92
DUXBURY PLYMOUTH COUNTY NRCC-C	2.78	3.35	4.18	4.95	6.19	7.33	8.68
EAST BRIDGEWATER PLYMOUTH COUNTY NRCC-C	2.78	3.35	4.18	4.95	6.19	7.33	8.68
EAST BROOKFIELD WORCESTER COUNTY CENTRAL NRCC-D	2.58	3.13	3.93	4.68	5.88	7.00	8.34
EAST LONGMEADOW HAMPDEN COUNTY NRCC-C	2.60	3.11	3.89	4.60	5.74	6.80	8.05
EASTHAM BARNSTABLE COUNTY EAST NRCC-C	2.74	3.26	4.03	4.74	5.88	6.92	8.15
EASTHAMPTON HAMPSHIRE COUNTY NRCC-C	2.55	3.07	3.80	4.47	5.54	6.52	7.68
EASTON BRISTOL COUNTY NRCC-C	2.74	3.30	4.12	4.88	6.10	7.22	8.56
EDGARTOWN DUKES COUNTY NRCC-C	2.80	3.31	4.14	4.91	6.16	7.30	8.67
EGREMONT BERKSHIRE COUNTY SOUTH NRCC-C	2.50	2.94	3.69	4.38	5.50	6.54	7.78
ERVING FRANKLIN COUNTY NRCC-C	2.48	3.02	3.70	4.33	5.32	6.22	7.29
ESSEX ESSEX COUNTY NRCC-D	2.63	3.15	4.02	4.83	6.16	7.42	8.94
EVERETT MIDDLESEX COUNTY SOUTH NRCC-D	2.64	3.16	3.99	4.77	6.03	7.21	8.62
FAIRHAVEN BRISTOL COUNTY NRCC-C	2.74	3.30	4.12	4.88	6.10	7.22	8.56
FALL RIVER BRISTOL COUNTY NRCC-C	2.74	3.30	4.12	4.88	6.10	7.22	8.56
FALMOUTH BARNSTABLE COUNTY WEST NRCC-C	2.80	3.32	4.14	4.89	6.10	7.22	8.55
FITCHBURG WORCESTER COUNTY NORTH NRCC-C	2.47	2.95	3.68	4.35	5.43	6.42	7.60
FLORIDA BERKSHIRE COUNTY NORTH NRCC-B	2.42	2.81	3.48	4.09	5.07	5.97	7.04
FOXBOROUGH NORFOLK COUNTY NRCC-C	2.69	3.22	4.07	4.86	6.15	7.35	8.80
FRAMINGHAM MIDDLESEX COUNTY SOUTH NRCC-D	2.64	3.16	3.99	4.77	6.03	7.21	8.62
FRANKLIN NORFOLK COUNTY NRCC-C	2.69	3.22	4.07	4.86	6.15	7.35	8.80
FREETOWN BRISTOL COUNTY NRCC-C	2.74	3.30	4.12	4.88	6.10	7.22	8.56
GARDNER WORCESTER COUNTY NORTH NRCC-C	2.47	2.95	3.68	4.35	5.43	6.42	7.60
GEORGETOWN ESSEX COUNTY NRCC-D	2.63	3.15	4.02	4.83	6.16	7.42	8.94
GILL FRANKLIN COUNTY NRCC-C	2.48	3.02	3.70	4.33	5.32	6.22	7.29
GLOUCESTER ESSEX COUNTY NRCC-D	2.63	3.15	4.02	4.83	6.16	7.42	8.94
GOSHEN HAMPSHIRE COUNTY NRCC-C	2.55	3.07	3.80	4.47	5.54	6.52	7.68
GOSNOLD DUKES COUNTY NRCC-C	2.80	3.31	4.14	4.91	6.16	7.30	8.67
GRAFTON WORCESTER COUNTY SOUTH NRCC-D	2.65	3.22	4.05	4.83	6.08	7.24	8.64
GRANBY HAMPSHIRE COUNTY NRCC-C	2.55	3.07	3.80	4.47	5.54	6.52	7.68
GRANVILLE HAMPDEN COUNTY NRCC-C	2.60	3.11	3.89	4.60	5.74	6.80	8.05

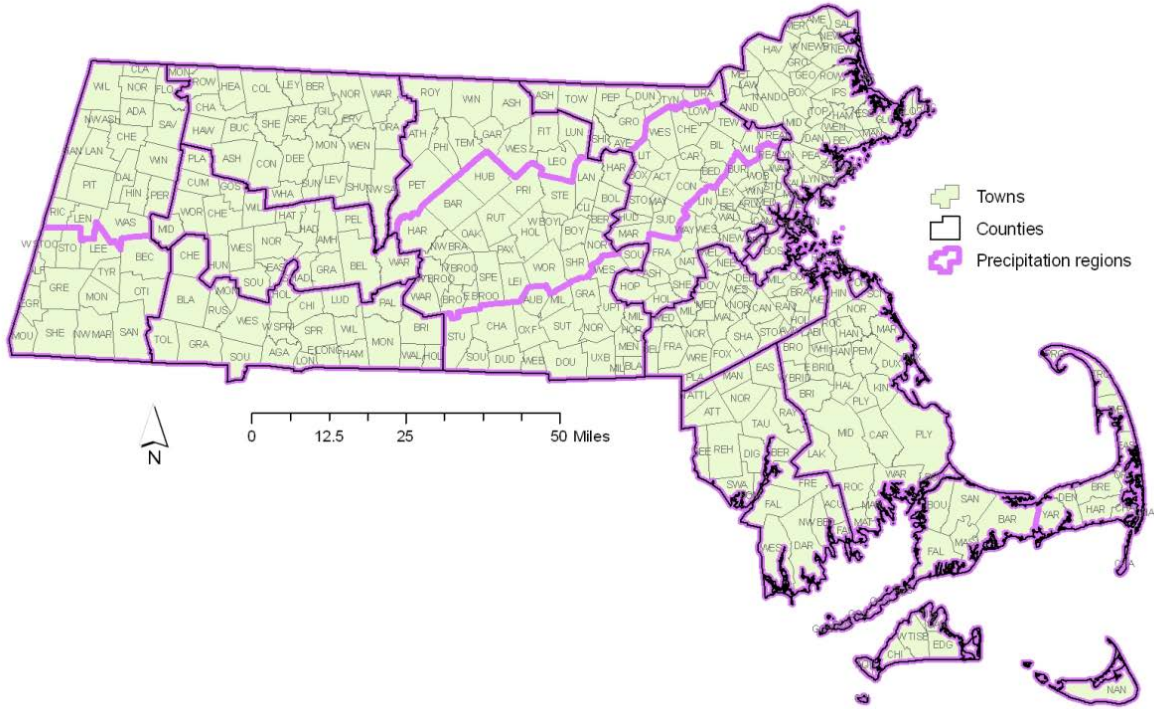
GREAT BARRINGTON BERKSHIRE COUNTY SOUTH NRCC-C	2.50	2.94	3.69	4.38	5.50	6.54	7.78
GREENFIELD FRANKLIN COUNTY NRCC-C	2.48	3.02	3.70	4.33	5.32	6.22	7.29
GROTON MIDDLESEX COUNTY NORTH NRCC-C	2.52	3.00	3.76	4.46	5.60	6.66	7.92
GROVELAND ESSEX COUNTY NRCC-D	2.63	3.15	4.02	4.83	6.16	7.42	8.94
HADLEY HAMPSHIRE COUNTY NRCC-C	2.55	3.07	3.80	4.47	5.54	6.52	7.68
HALIFAX PLYMOUTH COUNTY NRCC-C	2.78	3.35	4.18	4.95	6.19	7.33	8.68
HAMILTON ESSEX COUNTY NRCC-D	2.63	3.15	4.02	4.83	6.16	7.42	8.94
HAMPDEN HAMPDEN COUNTY NRCC-C	2.60	3.11	3.89	4.60	5.74	6.80	8.05
HANCOCK BERKSHIRE COUNTY NORTH NRCC-B	2.42	2.81	3.48	4.09	5.07	5.97	7.04
HANOVER PLYMOUTH COUNTY NRCC-C	2.78	3.35	4.18	4.95	6.19	7.33	8.68
HANSON PLYMOUTH COUNTY NRCC-C	2.78	3.35	4.18	4.95	6.19	7.33	8.68
HARDWICK WORCESTER COUNTY CENTRAL NRCC-D	2.58	3.13	3.93	4.68	5.88	7.00	8.34
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HARWICH BARNSTABLE COUNTY EAST NRCC-C	2.74	3.26	4.03	4.74	5.88	6.92	8.15
HATFIELD HAMPSHIRE COUNTY NRCC-C	2.55	3.07	3.80	4.47	5.54	6.52	7.68
HAVERHILL ESSEX COUNTY NRCC-D	2.63	3.15	4.02	4.83	6.16	7.42	8.94
HAWLEY FRANKLIN COUNTY NRCC-C	2.48	3.02	3.70	4.33	5.32	6.22	7.29
HEATH FRANKLIN COUNTY NRCC-C	2.48	3.02	3.70	4.33	5.32	6.22	7.29
HINGHAM PLYMOUTH COUNTY NRCC-C	2.78	3.35	4.18	4.95	6.19	7.33	8.68
HINSDALE BERKSHIRE COUNTY NORTH NRCC-B	2.42	2.81	3.48	4.09	5.07	5.97	7.04
HOLBROOK NORFOLK COUNTY NRCC-C	2.69	3.22	4.07	4.86	6.15	7.35	8.80
HOLDEN WORCESTER COUNTY CENTRAL NRCC-D	2.58	3.13	3.93	4.68	5.88	7.00	8.34
HOLLAND HAMPDEN COUNTY NRCC-C	2.60	3.11	3.89	4.60	5.74	6.80	8.05
HOLLISTON MIDDLESEX COUNTY SOUTH NRCC-D	2.64	3.16	3.99	4.77	6.03	7.21	8.62
HOLYOKE HAMPDEN COUNTY NRCC-C	2.60	3.11	3.89	4.60	5.74	6.80	8.05
HOPEDALE WORCESTER COUNTY SOUTH NRCC-D	2.65	3.22	4.05	4.83	6.08	7.24	8.64
HOPKINTON MIDDLESEX COUNTY SOUTH NRCC-D	2.64	3.16	3.99	4.77	6.03	7.21	8.62
HUBBARDSTON WORCESTER COUNTY CENTRAL NRCC-D	2.58	3.13	3.93	4.68	5.88	7.00	8.34
HUDSON MIDDLESEX COUNTY CENTRAL NRCC-D	2.58	3.09	3.90	4.65	5.87	7.00	8.36
HULL PLYMOUTH COUNTY NRCC-C	2.78	3.35	4.18	4.95	6.19	7.33	8.68
HUNTINGTON HAMPSHIRE COUNTY NRCC-C	2.55	3.07	3.80	4.47	5.54	6.52	7.68
IPSWICH ESSEX COUNTY NRCC-D	2.63	3.15	4.02	4.83	6.16	7.42	8.94
KINGSTON PLYMOUTH COUNTY NRCC-C	2.78	3.35	4.18	4.95	6.19	7.33	8.68
LAKEVILLE PLYMOUTH COUNTY NRCC-C	2.78	3.35	4.18	4.95	6.19	7.33	8.68
LANCASTER WORCESTER COUNTY CENTRAL NRCC-D	2.58	3.13	3.93	4.68	5.88	7.00	8.34
LANESBOROUGH BERKSHIRE COUNTY NORTH NRCC-B	2.42	2.81	3.48	4.09	5.07	5.97	7.04
LAWRENCE ESSEX COUNTY NRCC-D	2.63	3.15	4.02	4.83	6.16	7.42	8.94
LEE BERKSHIRE COUNTY SOUTH NRCC-C	2.50	2.94	3.69	4.38	5.50	6.54	7.78
LEICESTER WORCESTER COUNTY CENTRAL NRCC-D	2.58	3.13	3.93	4.68	5.88	7.00	8.34
LENOX BERKSHIRE COUNTY NORTH NRCC-B	2.42	2.81	3.48	4.09	5.07	5.97	7.04
LEOMINSTER WORCESTER COUNTY NORTH NRCC-C	2.47	2.95	3.68	4.35	5.43	6.42	7.60
LEVERETT FRANKLIN COUNTY NRCC-C	2.48	3.02	3.70	4.33	5.32	6.22	7.29
LEXINGTON MIDDLESEX COUNTY SOUTH NRCC-D	2.64	3.16	3.99	4.77	6.03	7.21	8.62
LEYDEN FRANKLIN COUNTY NRCC-C	2.48	3.02	3.70	4.33	5.32	6.22	7.29
LINCOLN MIDDLESEX COUNTY SOUTH NRCC-D	2.64	3.16	3.99	4.77	6.03	7.21	8.62
LITTLETON MIDDLESEX COUNTY CENTRAL NRCC-D	2.58	3.09	3.90	4.65	5.87	7.00	8.36
LONGMEADOW HAMPDEN COUNTY NRCC-C	2.60	3.11	3.89	4.60	5.74	6.80	8.05
LOWELL MIDDLESEX COUNTY CENTRAL NRCC-D	2.58	3.09	3.90	4.65	5.87	7.00	8.36
LUDLOW HAMPDEN COUNTY NRCC-C	2.60	3.11	3.89	4.60	5.74	6.80	8.05
LUNENBURG WORCESTER COUNTY NORTH NRCC-C	2.47	2.95	3.68	4.35	5.43	6.42	7.60
LYNN ESSEX COUNTY NRCC-D	2.63	3.15	4.02	4.83	6.16	7.42	8.94
LYNNFIELD ESSEX COUNTY NRCC-D	2.63	3.15	4.02	4.83	6.16	7.42	8.94
MALDEN MIDDLESEX COUNTY SOUTH NRCC-D	2.64	3.16	3.99	4.77	6.03	7.21	8.62
MANCHESTER ESSEX COUNTY NRCC-D	2.63	3.15	4.02	4.83	6.16	7.42	8.94
MANSFIELD BRISTOL COUNTY NRCC-C	2.74	3.30	4.12	4.88	6.10	7.22	8.56
MARBLEHEAD ESSEX COUNTY NRCC-D	2.63	3.15	4.02	4.83	6.16	7.42	8.94
MARION PLYMOUTH COUNTY NRCC-C	2.78	3.35	4.18	4.95	6.19	7.33	8.68
MARLBOROUGH MIDDLESEX COUNTY CENTRAL NRCC-D	2.58	3.09	3.90	4.65	5.87	7.00	8.36
MARSHFIELD PLYMOUTH COUNTY NRCC-C	2.78	3.35	4.18	4.95	6.19	7.33	8.68
MASHPEE BARNSTABLE COUNTY WEST NRCC-C	2.80	3.32	4.14	4.89	6.10	7.22	8.55

MATTAPOISETT PLYMOUTH COUNTY NRCC-C	2.78	3.35	4.18	4.95	6.19	7.33	8.68
MAYNARD MIDDLESEX COUNTY CENTRAL NRCC-D	2.58	3.09	3.90	4.65	5.87	7.00	8.36
MEDFIELD NORFOLK COUNTY NRCC-C	2.69	3.22	4.07	4.86	6.15	7.35	8.80
MEDFORD MIDDLESEX COUNTY SOUTH NRCC-D	2.64	3.16	3.99	4.77	6.03	7.21	8.62
MEDWAY NORFOLK COUNTY NRCC-C	2.69	3.22	4.07	4.86	6.15	7.35	8.80
MELROSE MIDDLESEX COUNTY SOUTH NRCC-D	2.64	3.16	3.99	4.77	6.03	7.21	8.62
MENDON WORCESTER COUNTY SOUTH NRCC-D	2.65	3.22	4.05	4.83	6.08	7.24	8.64
MERRIMAC ESSEX COUNTY NRCC-D	2.63	3.15	4.02	4.83	6.16	7.42	8.94
METHUEN ESSEX COUNTY NRCC-D	2.63	3.15	4.02	4.83	6.16	7.42	8.94
MIDDLEBOROUGH PLYMOUTH COUNTY NRCC-C	2.78	3.35	4.18	4.95	6.19	7.33	8.68
MIDDLEFIELD HAMPSHIRE COUNTY NRCC-C	2.55	3.07	3.80	4.47	5.54	6.52	7.68
MIDDLETON ESSEX COUNTY NRCC-D	2.63	3.15	4.02	4.83	6.16	7.42	8.94
MILFORD WORCESTER COUNTY SOUTH NRCC-D	2.65	3.22	4.05	4.83	6.08	7.24	8.64
MILLBURY WORCESTER COUNTY SOUTH NRCC-D	2.65	3.22	4.05	4.83	6.08	7.24	8.64
MILLIS NORFOLK COUNTY NRCC-C	2.69	3.22	4.07	4.86	6.15	7.35	8.80
MILLVILLE WORCESTER COUNTY SOUTH NRCC-D	2.65	3.22	4.05	4.83	6.08	7.24	8.64
MILTON NORFOLK COUNTY NRCC-C	2.69	3.22	4.07	4.86	6.15	7.35	8.80
MONROE FRANKLIN COUNTY NRCC-C	2.48	3.02	3.70	4.33	5.32	6.22	7.29
MONSON HAMPDEN COUNTY NRCC-C	2.60	3.11	3.89	4.60	5.74	6.80	8.05
MONTAGUE FRANKLIN COUNTY NRCC-C	2.48	3.02	3.70	4.33	5.32	6.22	7.29
MONTEREY BERKSHIRE COUNTY SOUTH NRCC-C	2.50	2.94	3.69	4.38	5.50	6.54	7.78
MONTGOMERY HAMPDEN COUNTY NRCC-C	2.60	3.11	3.89	4.60	5.74	6.80	8.05
MOUNT WASHINGTON BERKSHIRE COUNTY SOUTH NRCC-C	2.50	2.94	3.69	4.38	5.50	6.54	7.78
NAHANT ESSEX COUNTY NRCC-D	2.63	3.15	4.02	4.83	6.16	7.42	8.94
NANTUCKET NANTUCKET COUNTY NRCC-B	2.68	3.13	3.90	4.61	5.74	6.78	8.02
NATICK MIDDLESEX COUNTY SOUTH NRCC-D	2.64	3.16	3.99	4.77	6.03	7.21	8.62
NEEDHAM NORFOLK COUNTY NRCC-C	2.69	3.22	4.07	4.86	6.15	7.35	8.80
NEW ASHFORD BERKSHIRE COUNTY NORTH NRCC-B	2.42	2.81	3.48	4.09	5.07	5.97	7.04
NEW BEDFORD BRISTOL COUNTY NRCC-C	2.74	3.30	4.12	4.88	6.10	7.22	8.56
NEW BRAintree WORCESTER COUNTY CENTRAL NRCC-D	2.58	3.13	3.93	4.68	5.88	7.00	8.34
NEW MARLBOROUGH BERKSHIRE COUNTY SOUTH NRCC-C	2.50	2.94	3.69	4.38	5.50	6.54	7.78
NEW SALEM FRANKLIN COUNTY NRCC-C	2.48	3.02	3.70	4.33	5.32	6.22	7.29
NEWBURY ESSEX COUNTY NRCC-D	2.63	3.15	4.02	4.83	6.16	7.42	8.94
NEWBURYPORT ESSEX COUNTY NRCC-D	2.63	3.15	4.02	4.83	6.16	7.42	8.94
NEWTON MIDDLESEX COUNTY SOUTH NRCC-D	2.64	3.16	3.99	4.77	6.03	7.21	8.62
NORFOLK NORFOLK COUNTY NRCC-C	2.69	3.22	4.07	4.86	6.15	7.35	8.80
NORTH ADAMS BERKSHIRE COUNTY NORTH NRCC-B	2.42	2.81	3.48	4.09	5.07	5.97	7.04
NORTH ANDOVER ESSEX COUNTY NRCC-D	2.63	3.15	4.02	4.83	6.16	7.42	8.94
NORTH ATTLEBOROUGH BRISTOL COUNTY NRCC-C	2.74	3.30	4.12	4.88	6.10	7.22	8.56
NORTH BROOKFIELD WORCESTER COUNTY CENTRAL NRCC-D	2.58	3.13	3.93	4.68	5.88	7.00	8.34
NORTH READING MIDDLESEX COUNTY CENTRAL NRCC-D	2.58	3.09	3.90	4.65	5.87	7.00	8.36
NORTHAMPTON HAMPSHIRE COUNTY NRCC-C	2.55	3.07	3.80	4.47	5.54	6.52	7.68
NORTHBOROUGH WORCESTER COUNTY CENTRAL NRCC-D	2.58	3.13	3.93	4.68	5.88	7.00	8.34
NORTHBRIDGE WORCESTER COUNTY SOUTH NRCC-D	2.65	3.22	4.05	4.83	6.08	7.24	8.64
NORTHFIELD FRANKLIN COUNTY NRCC-C	2.48	3.02	3.70	4.33	5.32	6.22	7.29
NORTON BRISTOL COUNTY NRCC-C	2.74	3.30	4.12	4.88	6.10	7.22	8.56
NORWELL PLYMOUTH COUNTY NRCC-C	2.78	3.35	4.18	4.95	6.19	7.33	8.68
NORWOOD NORFOLK COUNTY NRCC-C	2.69	3.22	4.07	4.86	6.15	7.35	8.80
OAK BLUFFS DUKES COUNTY NRCC-C	2.80	3.31	4.14	4.91	6.16	7.30	8.67
OAKHAM WORCESTER COUNTY CENTRAL NRCC-D	2.58	3.13	3.93	4.68	5.88	7.00	8.34
ORANGE FRANKLIN COUNTY NRCC-C	2.48	3.02	3.70	4.33	5.32	6.22	7.29
ORLEANS BARNSTABLE COUNTY EAST NRCC-C	2.74	3.26	4.03	4.74	5.88	6.92	8.15
OTIS BERKSHIRE COUNTY SOUTH NRCC-C	2.50	2.94	3.69	4.38	5.50	6.54	7.78
OXFORD WORCESTER COUNTY SOUTH NRCC-D	2.65	3.22	4.05	4.83	6.08	7.24	8.64
PALMER HAMPDEN COUNTY NRCC-C	2.60	3.11	3.89	4.60	5.74	6.80	8.05
PAXTON WORCESTER COUNTY CENTRAL NRCC-D	2.58	3.13	3.93	4.68	5.88	7.00	8.34
PEABODY ESSEX COUNTY NRCC-D	2.63	3.15	4.02	4.83	6.16	7.42	8.94
PELHAM HAMPSHIRE COUNTY NRCC-C	2.55	3.07	3.80	4.47	5.54	6.52	7.68
PEMBROKE PLYMOUTH COUNTY NRCC-C	2.78	3.35	4.18	4.95	6.19	7.33	8.68
PEPPERELL MIDDLESEX COUNTY NORTH NRCC-C	2.52	3.00	3.76	4.46	5.60	6.66	7.92

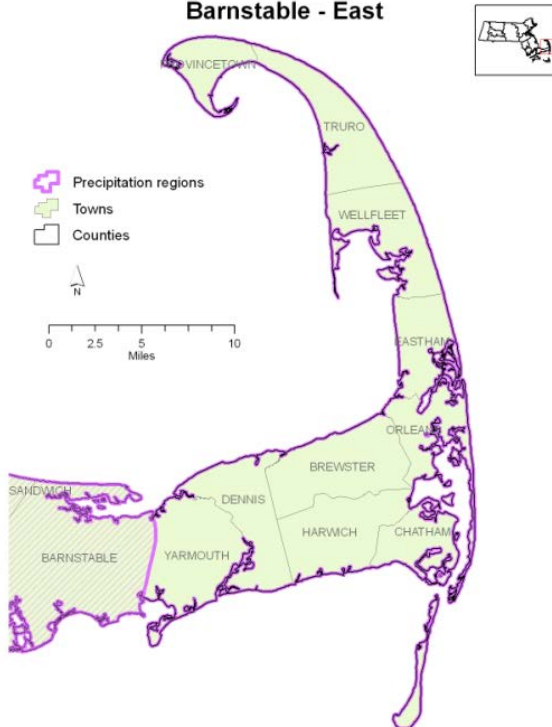
PERU BERKSHIRE COUNTY NORTH NRCC-B	2.42	2.81	3.48	4.09	5.07	5.97	7.04
PETERSHAM WORCESTER COUNTY NORTH NRCC-C	2.47	2.95	3.68	4.35	5.43	6.42	7.60
PHILLIPSTON WORCESTER COUNTY NORTH NRCC-C	2.47	2.95	3.68	4.35	5.43	6.42	7.60
PITTSFIELD BERKSHIRE COUNTY NORTH NRCC-B	2.42	2.81	3.48	4.09	5.07	5.97	7.04
PLAINFIELD HAMPSHIRE COUNTY NRCC-C	2.55	3.07	3.80	4.47	5.54	6.52	7.68
PLAINVILLE NORFOLK COUNTY NRCC-C	2.69	3.22	4.07	4.86	6.15	7.35	8.80
PLYMOUTH PLYMOUTH COUNTY NRCC-C	2.78	3.35	4.18	4.95	6.19	7.33	8.68
PLYMPTON PLYMOUTH COUNTY NRCC-C	2.78	3.35	4.18	4.95	6.19	7.33	8.68
PRINCETON WORCESTER COUNTY CENTRAL NRCC-D	2.58	3.13	3.93	4.68	5.88	7.00	8.34
PROVINCETOWN BARNSTABLE COUNTY EAST NRCC-C	2.74	3.26	4.03	4.74	5.88	6.92	8.15
QUINCY NORFOLK COUNTY NRCC-C	2.69	3.22	4.07	4.86	6.15	7.35	8.80
RANDOLPH NORFOLK COUNTY NRCC-C	2.69	3.22	4.07	4.86	6.15	7.35	8.80
RAYNHAM BRISTOL COUNTY NRCC-C	2.74	3.30	4.12	4.88	6.10	7.22	8.56
READING MIDDLESEX COUNTY SOUTH NRCC-D	2.64	3.16	3.99	4.77	6.03	7.21	8.62
REHOBOTH BRISTOL COUNTY NRCC-C	2.74	3.30	4.12	4.88	6.10	7.22	8.56
REVERE SUFFOLK COUNTY NRCC-D	2.72	3.26	4.11	4.90	6.19	7.39	8.83
RICHMOND BERKSHIRE COUNTY NORTH NRCC-B	2.42	2.81	3.48	4.09	5.07	5.97	7.04
ROCHESTER PLYMOUTH COUNTY NRCC-C	2.78	3.35	4.18	4.95	6.19	7.33	8.68
ROCKLAND PLYMOUTH COUNTY NRCC-C	2.78	3.35	4.18	4.95	6.19	7.33	8.68
ROCKPORT ESSEX COUNTY NRCC-D	2.63	3.15	4.02	4.83	6.16	7.42	8.94
ROWE FRANKLIN COUNTY NRCC-C	2.48	3.02	3.70	4.33	5.32	6.22	7.29
ROWLEY ESSEX COUNTY NRCC-D	2.63	3.15	4.02	4.83	6.16	7.42	8.94
ROYALSTON WORCESTER COUNTY NORTH NRCC-C	2.47	2.95	3.68	4.35	5.43	6.42	7.60
RUSSELL HAMPDEN COUNTY NRCC-C	2.60	3.11	3.89	4.60	5.74	6.80	8.05
RUTLAND WORCESTER COUNTY CENTRAL NRCC-D	2.58	3.13	3.93	4.68	5.88	7.00	8.34
SALEM ESSEX COUNTY NRCC-D	2.63	3.15	4.02	4.83	6.16	7.42	8.94
SALISBURY ESSEX COUNTY NRCC-D	2.63	3.15	4.02	4.83	6.16	7.42	8.94
SANDSFIELD BERKSHIRE COUNTY SOUTH NRCC-C	2.50	2.94	3.69	4.38	5.50	6.54	7.78
SANDWICH BARNSTABLE COUNTY WEST NRCC-C	2.80	3.32	4.14	4.89	6.10	7.22	8.55
SAUGUS ESSEX COUNTY NRCC-D	2.63	3.15	4.02	4.83	6.16	7.42	8.94
SAVOY BERKSHIRE COUNTY NORTH NRCC-B	2.42	2.81	3.48	4.09	5.07	5.97	7.04
SCITUATE PLYMOUTH COUNTY NRCC-C	2.78	3.35	4.18	4.95	6.19	7.33	8.68
SEEKONK BRISTOL COUNTY NRCC-C	2.74	3.30	4.12	4.88	6.10	7.22	8.56
SHARON NORFOLK COUNTY NRCC-C	2.69	3.22	4.07	4.86	6.15	7.35	8.80
SHEFFIELD BERKSHIRE COUNTY SOUTH NRCC-C	2.50	2.94	3.69	4.38	5.50	6.54	7.78
SHELBURNE FRANKLIN COUNTY NRCC-C	2.48	3.02	3.70	4.33	5.32	6.22	7.29
SHERBORN MIDDLESEX COUNTY SOUTH NRCC-D	2.64	3.16	3.99	4.77	6.03	7.21	8.62
SHIRLEY MIDDLESEX COUNTY NORTH NRCC-C	2.52	3.00	3.76	4.46	5.60	6.66	7.92
SHREWSBURY WORCESTER COUNTY CENTRAL NRCC-D	2.58	3.13	3.93	4.68	5.88	7.00	8.34
SHUTESBURY FRANKLIN COUNTY NRCC-C	2.48	3.02	3.70	4.33	5.32	6.22	7.29
SOMERSET BRISTOL COUNTY NRCC-C	2.74	3.30	4.12	4.88	6.10	7.22	8.56
SOMERVILLE MIDDLESEX COUNTY SOUTH NRCC-D	2.64	3.16	3.99	4.77	6.03	7.21	8.62
SOUTH HADLEY HAMPSHIRE COUNTY NRCC-C	2.55	3.07	3.80	4.47	5.54	6.52	7.68
SOUTHAMPTON HAMPSHIRE COUNTY NRCC-C	2.55	3.07	3.80	4.47	5.54	6.52	7.68
SOUTHBOROUGH WORCESTER COUNTY SOUTH NRCC-D	2.65	3.22	4.05	4.83	6.08	7.24	8.64
SOUTHBRIDGE WORCESTER COUNTY SOUTH NRCC-D	2.65	3.22	4.05	4.83	6.08	7.24	8.64
SOUTHWICK HAMPDEN COUNTY NRCC-C	2.60	3.11	3.89	4.60	5.74	6.80	8.05
SPENCER WORCESTER COUNTY CENTRAL NRCC-D	2.58	3.13	3.93	4.68	5.88	7.00	8.34
SPRINGFIELD HAMPDEN COUNTY NRCC-C	2.60	3.11	3.89	4.60	5.74	6.80	8.05
STERLING WORCESTER COUNTY CENTRAL NRCC-D	2.58	3.13	3.93	4.68	5.88	7.00	8.34
STOCKBRIDGE BERKSHIRE COUNTY SOUTH NRCC-C	2.50	2.94	3.69	4.38	5.50	6.54	7.78
STONEHAM MIDDLESEX COUNTY SOUTH NRCC-D	2.64	3.16	3.99	4.77	6.03	7.21	8.62
STOUGHTON NORFOLK COUNTY NRCC-C	2.69	3.22	4.07	4.86	6.15	7.35	8.80
STOW MIDDLESEX COUNTY CENTRAL NRCC-D	2.58	3.09	3.90	4.65	5.87	7.00	8.36
STURBRIDGE WORCESTER COUNTY SOUTH NRCC-D	2.65	3.22	4.05	4.83	6.08	7.24	8.64
SUDBURY MIDDLESEX COUNTY CENTRAL NRCC-D	2.58	3.09	3.90	4.65	5.87	7.00	8.36
SUNDERLAND FRANKLIN COUNTY NRCC-C	2.48	3.02	3.70	4.33	5.32	6.22	7.29
SUTTON WORCESTER COUNTY SOUTH NRCC-D	2.65	3.22	4.05	4.83	6.08	7.24	8.64
SWAMPSCOTT ESSEX COUNTY NRCC-D	2.63	3.15	4.02	4.83	6.16	7.42	8.94
SWANSEA BRISTOL COUNTY NRCC-C	2.74	3.30	4.12	4.88	6.10	7.22	8.56

TAUNTON BRISTOL COUNTY NRCC-C	2.74	3.30	4.12	4.88	6.10	7.22	8.56
TEMPLETON WORCESTER COUNTY NORTH NRCC-C	2.47	2.95	3.68	4.35	5.43	6.42	7.60
TEWKSBURY MIDDLESEX COUNTY CENTRAL NRCC-D	2.58	3.09	3.90	4.65	5.87	7.00	8.36
TISBURY DUKES COUNTY NRCC-C	2.80	3.31	4.14	4.91	6.16	7.30	8.67
TOLLAND HAMPDEN COUNTY NRCC-C	2.60	3.11	3.89	4.60	5.74	6.80	8.05
TOPSFIELD ESSEX COUNTY NRCC-D	2.63	3.15	4.02	4.83	6.16	7.42	8.94
TOWNSEND MIDDLESEX COUNTY NORTH NRCC-C	2.52	3.00	3.76	4.46	5.60	6.66	7.92
TRURO BARNSTABLE COUNTY EAST NRCC-C	2.74	3.26	4.03	4.74	5.88	6.92	8.15
TYNGSBOROUGH MIDDLESEX COUNTY NORTH NRCC-C	2.52	3.00	3.76	4.46	5.60	6.66	7.92
TYRINGHAM BERKSHIRE COUNTY SOUTH NRCC-C	2.50	2.94	3.69	4.38	5.50	6.54	7.78
UPTON WORCESTER COUNTY SOUTH NRCC-D	2.65	3.22	4.05	4.83	6.08	7.24	8.64
UXBRIDGE WORCESTER COUNTY SOUTH NRCC-D	2.65	3.22	4.05	4.83	6.08	7.24	8.64
WAKEFIELD MIDDLESEX COUNTY SOUTH NRCC-D	2.64	3.16	3.99	4.77	6.03	7.21	8.62
WALES HAMPDEN COUNTY NRCC-C	2.60	3.11	3.89	4.60	5.74	6.80	8.05
WALPOLE NORFOLK COUNTY NRCC-C	2.69	3.22	4.07	4.86	6.15	7.35	8.80
WALTHAM MIDDLESEX COUNTY SOUTH NRCC-D	2.64	3.16	3.99	4.77	6.03	7.21	8.62
WARE HAMPSHIRE COUNTY NRCC-C	2.55	3.07	3.80	4.47	5.54	6.52	7.68
WAREHAM PLYMOUTH COUNTY NRCC-C	2.78	3.35	4.18	4.95	6.19	7.33	8.68
WARREN WORCESTER COUNTY CENTRAL NRCC-D	2.58	3.13	3.93	4.68	5.88	7.00	8.34
WARWICK FRANKLIN COUNTY NRCC-C	2.48	3.02	3.70	4.33	5.32	6.22	7.29
WASHINGTON BERKSHIRE COUNTY NORTH NRCC-B	2.42	2.81	3.48	4.09	5.07	5.97	7.04
WATERTOWN MIDDLESEX COUNTY SOUTH NRCC-D	2.64	3.16	3.99	4.77	6.03	7.21	8.62
WAYLAND MIDDLESEX COUNTY SOUTH NRCC-D	2.64	3.16	3.99	4.77	6.03	7.21	8.62
WEBSTER WORCESTER COUNTY SOUTH NRCC-D	2.65	3.22	4.05	4.83	6.08	7.24	8.64
WELLESLEY NORFOLK COUNTY NRCC-C	2.69	3.22	4.07	4.86	6.15	7.35	8.80
WELLFLEET BARNSTABLE COUNTY EAST NRCC-C	2.74	3.26	4.03	4.74	5.88	6.92	8.15
WENDELL FRANKLIN COUNTY NRCC-C	2.48	3.02	3.70	4.33	5.32	6.22	7.29
WENHAM ESSEX COUNTY NRCC-D	2.63	3.15	4.02	4.83	6.16	7.42	8.94
WEST BOYLSTON WORCESTER COUNTY CENTRAL NRCC-D	2.58	3.13	3.93	4.68	5.88	7.00	8.34
WEST BRIDGEWATER PLYMOUTH COUNTY NRCC-C	2.78	3.35	4.18	4.95	6.19	7.33	8.68
WEST BROOKFIELD WORCESTER COUNTY CENTRAL NRCC-D	2.58	3.13	3.93	4.68	5.88	7.00	8.34
WEST NEWBURY ESSEX COUNTY NRCC-D	2.63	3.15	4.02	4.83	6.16	7.42	8.94
WEST SPRINGFIELD HAMPDEN COUNTY NRCC-C	2.60	3.11	3.89	4.60	5.74	6.80	8.05
WEST STOCKBRIDGE BERKSHIRE COUNTY SOUTH NRCC-C	2.50	2.94	3.69	4.38	5.50	6.54	7.78
WEST TISBURY DUKES COUNTY NRCC-C	2.80	3.31	4.14	4.91	6.16	7.30	8.67
WESTBOROUGH WORCESTER COUNTY SOUTH NRCC-D	2.65	3.22	4.05	4.83	6.08	7.24	8.64
WESTFIELD HAMPDEN COUNTY NRCC-C	2.60	3.11	3.89	4.60	5.74	6.80	8.05
WESTFORD MIDDLESEX COUNTY CENTRAL NRCC-D	2.58	3.09	3.90	4.65	5.87	7.00	8.36
WESTHAMPTON HAMPSHIRE COUNTY NRCC-C	2.55	3.07	3.80	4.47	5.54	6.52	7.68
WESTMINSTER WORCESTER COUNTY NORTH NRCC-C	2.47	2.95	3.68	4.35	5.43	6.42	7.60
WESTON MIDDLESEX COUNTY SOUTH NRCC-D	2.64	3.16	3.99	4.77	6.03	7.21	8.62
WESTPORT BRISTOL COUNTY NRCC-C	2.74	3.30	4.12	4.88	6.10	7.22	8.56
WESTWOOD NORFOLK COUNTY NRCC-C	2.69	3.22	4.07	4.86	6.15	7.35	8.80
WEYMOUTH NORFOLK COUNTY NRCC-C	2.69	3.22	4.07	4.86	6.15	7.35	8.80
WHATELY FRANKLIN COUNTY NRCC-C	2.48	3.02	3.70	4.33	5.32	6.22	7.29
WHITMAN PLYMOUTH COUNTY NRCC-C	2.78	3.35	4.18	4.95	6.19	7.33	8.68
WILBRAHAM HAMPDEN COUNTY NRCC-C	2.60	3.11	3.89	4.60	5.74	6.80	8.05
WILLIAMSBURG HAMPSHIRE COUNTY NRCC-C	2.55	3.07	3.80	4.47	5.54	6.52	7.68
WILLIAMSTOWN BERKSHIRE COUNTY NORTH NRCC-B	2.42	2.81	3.48	4.09	5.07	5.97	7.04
WILMINGTON MIDDLESEX COUNTY CENTRAL NRCC-D	2.58	3.09	3.90	4.65	5.87	7.00	8.36
WINCHENDON WORCESTER COUNTY NORTH NRCC-C	2.47	2.95	3.68	4.35	5.43	6.42	7.60
WINCHESTER MIDDLESEX COUNTY SOUTH NRCC-D	2.64	3.16	3.99	4.77	6.03	7.21	8.62
WINDSOR BERKSHIRE COUNTY NORTH NRCC-B	2.42	2.81	3.48	4.09	5.07	5.97	7.04
WINTHROP SUFFOLK COUNTY NRCC-D	2.72	3.26	4.11	4.90	6.19	7.39	8.83
WOBURN MIDDLESEX COUNTY SOUTH NRCC-D	2.64	3.16	3.99	4.77	6.03	7.21	8.62
WORCESTER WORCESTER COUNTY CENTRAL NRCC-D	2.58	3.13	3.93	4.68	5.88	7.00	8.34
WORTHINGTON HAMPSHIRE COUNTY NRCC-C	2.55	3.07	3.80	4.47	5.54	6.52	7.68
WRENTHAM NORFOLK COUNTY NRCC-C	2.69	3.22	4.07	4.86	6.15	7.35	8.80
YARMOUTH BARNSTABLE COUNTY EAST NRCC-C	2.74	3.26	4.03	4.74	5.88	6.92	8.15

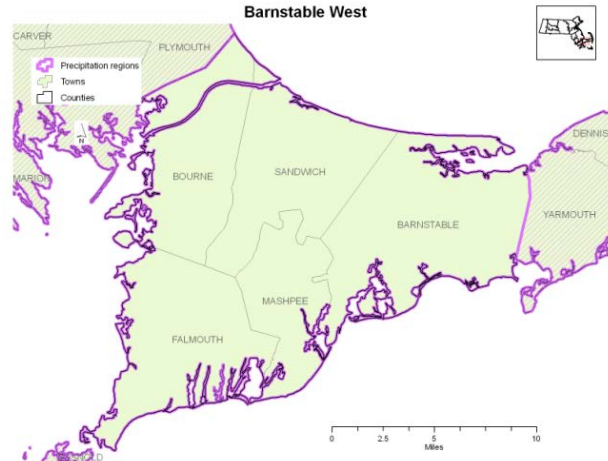
Figure A1. Maps of MA towns included in each precipitation area



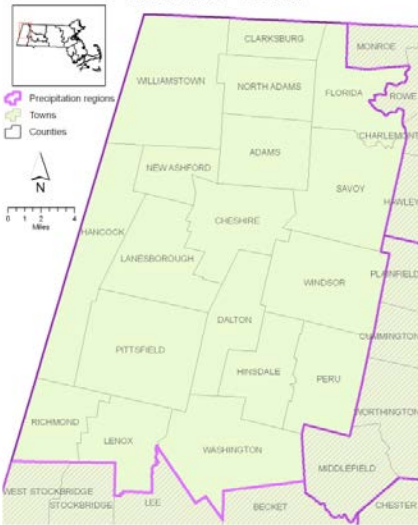
Barnstable - East



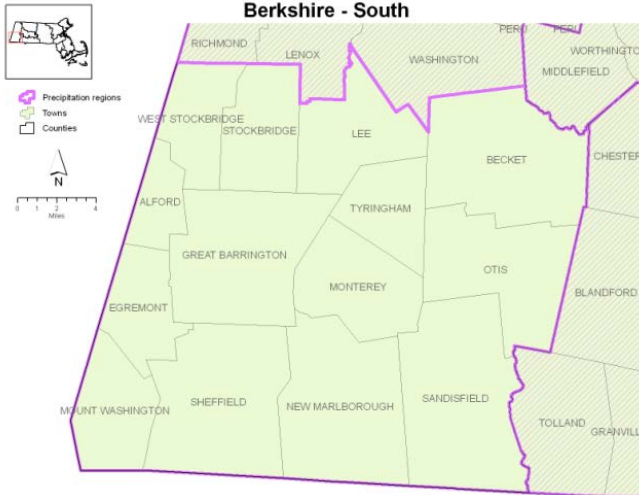
Barnstable West



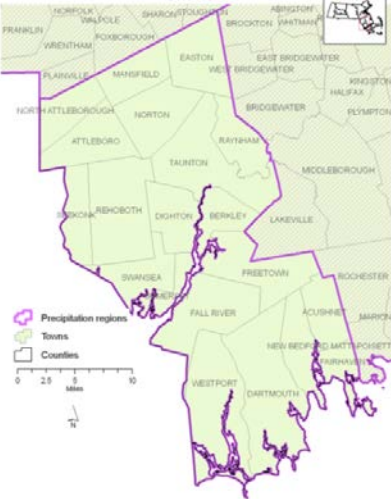
Berkshire - North



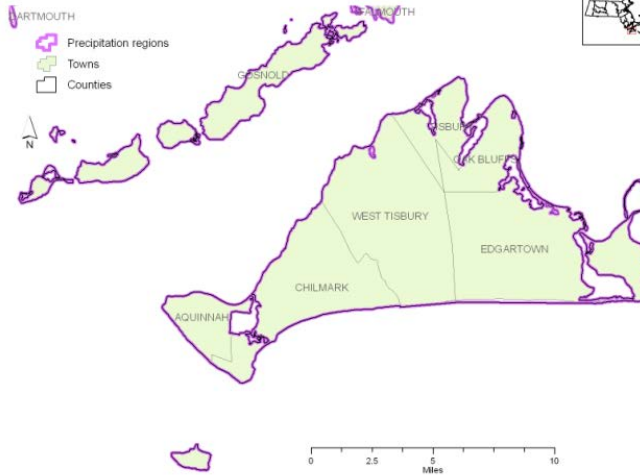
Berkshire - South



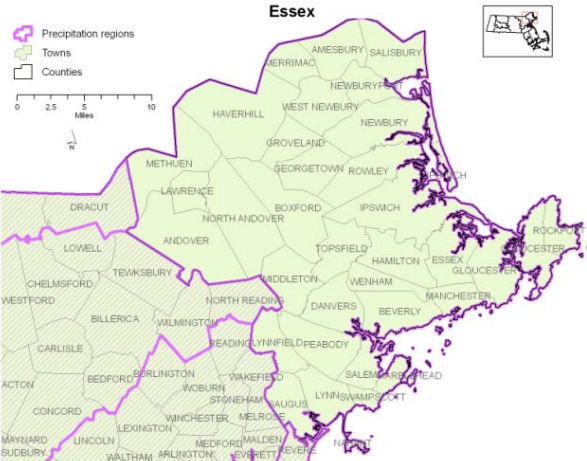
Bristol



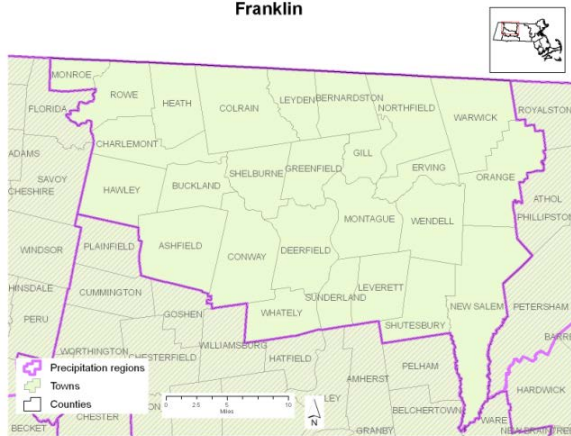
Dukes



Essex

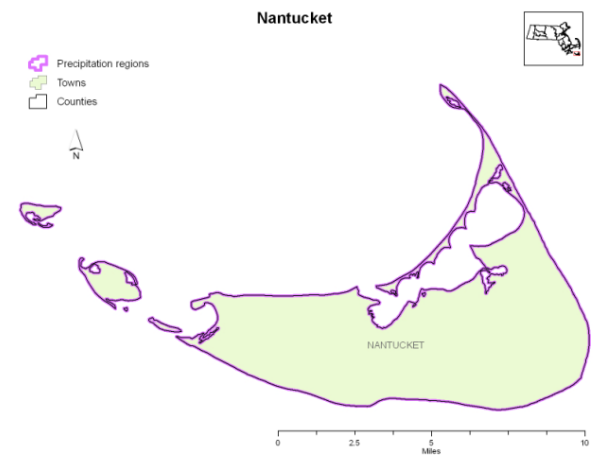
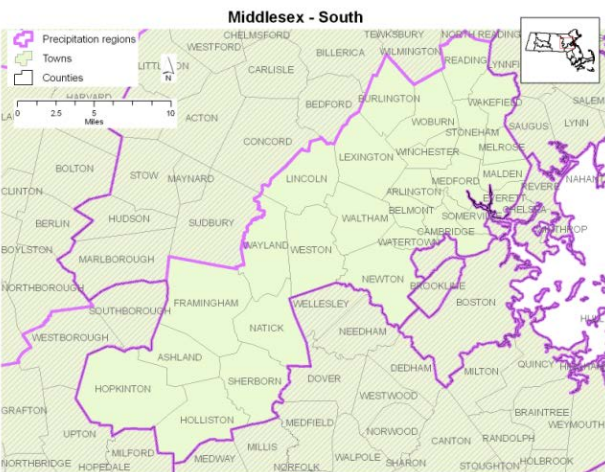
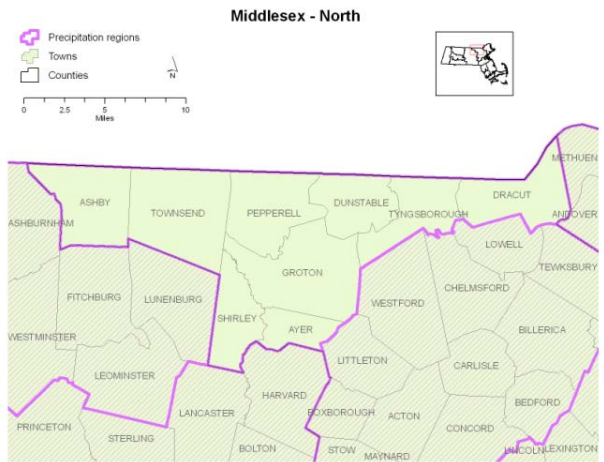
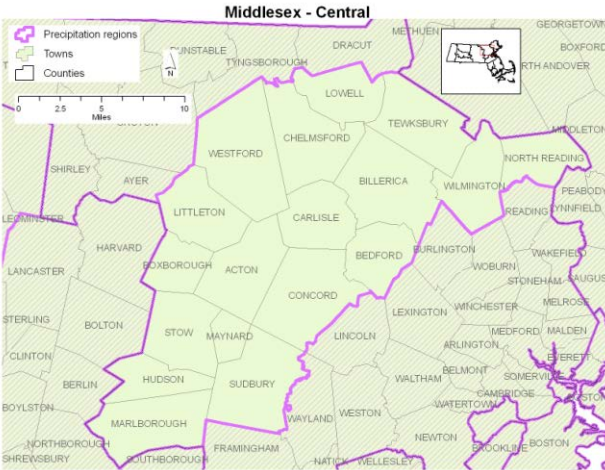
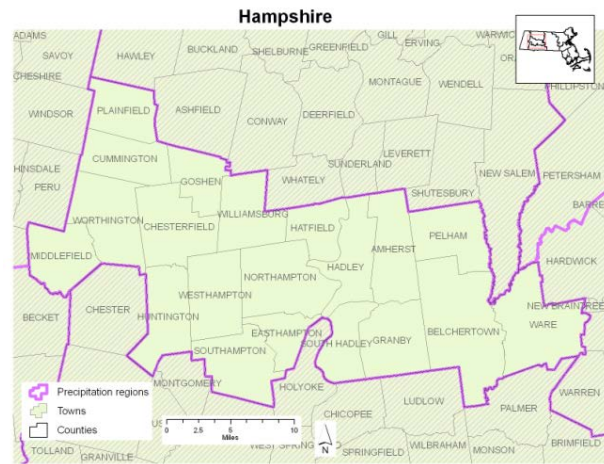
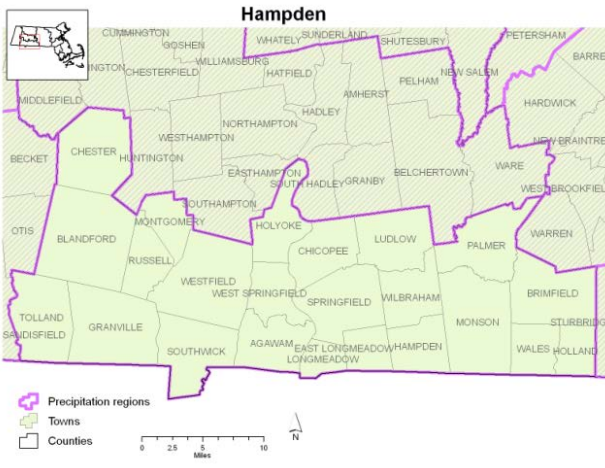


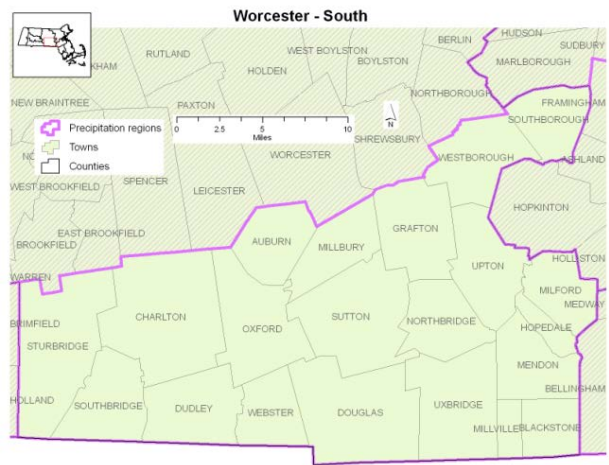
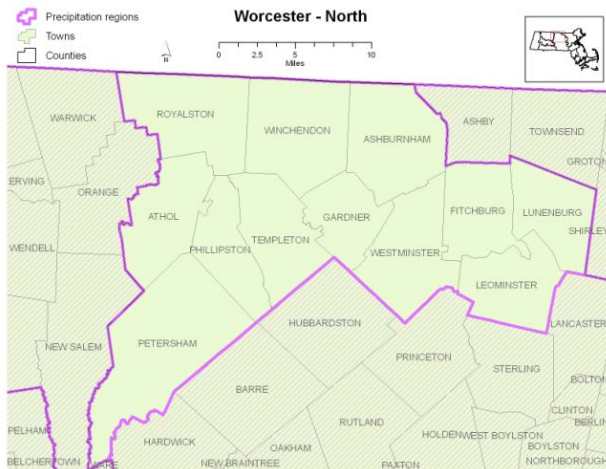
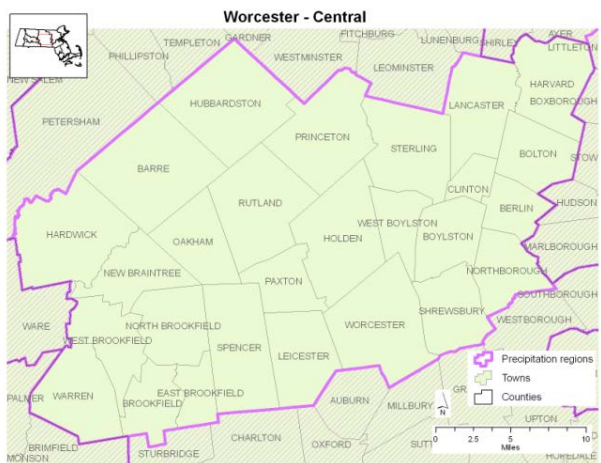
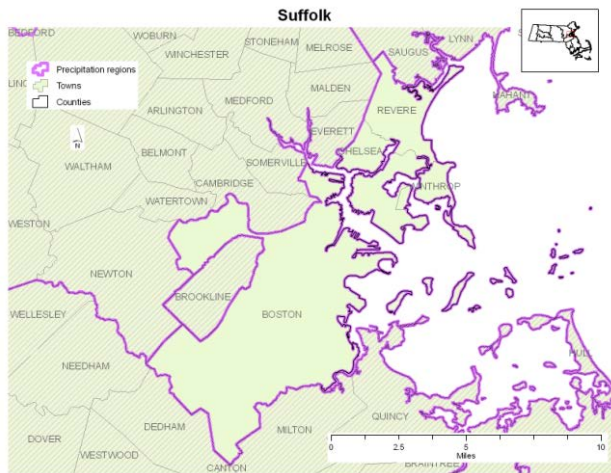
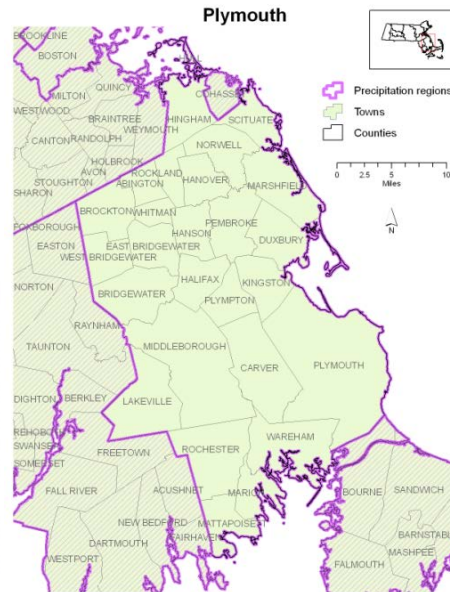
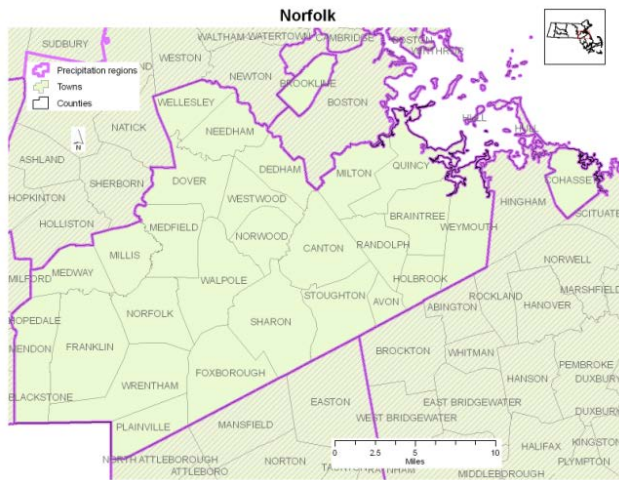
Franklin



Estimating Runoff and Peak Discharges

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Appendix 2. Representative points in each MA precipitation region included in the rainfall database.

Table A2.1 Latitude and Longitude of Rainfall Data Points

County	Latitude (dd)	Longitude (dd)
Barnstable East	41.714	-70.137
Barnstable West	41.677	-70.488
Berkshire North	42.469	-73.180
Berkshire South	42.187	-73.245
Bristol	41.744	-71.073
Dukes	41.401	-70.652
Essex	42.702	-71.056
Franklin	42.529	-72.662
Hampden	42.096	-72.662
Hampshire	42.330	-72.681
Middlesex Central	42.537	-71.346
Middlesex North	42.654	-71.487
Middlesex South	42.436	-71.270
Nantucket	41.269	-70.065
Norfolk	42.210	-71.276
Plymouth	41.879	-70.829
Suffolk	42.326	-71.065
Worcester Central	42.363	-71.980
Worcester North	42.588	-72.060
Worcester South	42.121	-71.862

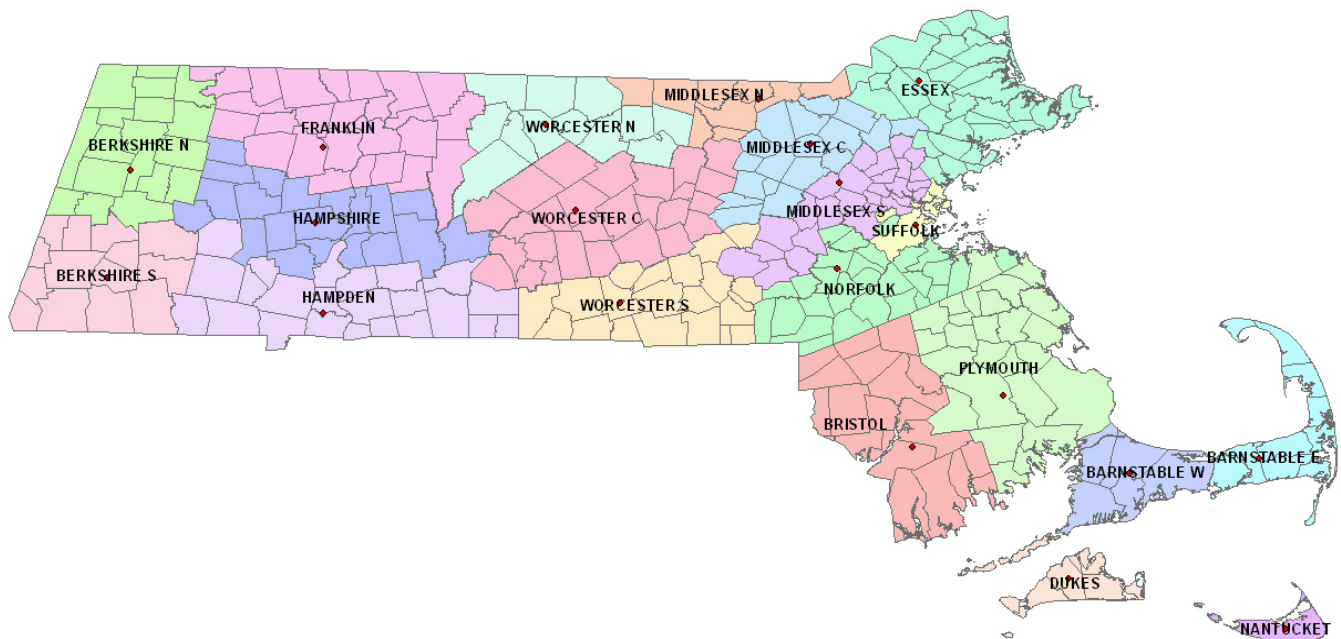


Table A2.2 Massachusetts rainfall data for the precipitation data points listed in Appendix 2 [inches]

24-hr Storm	1yr	2yr	5yr	10yr	25yr	50yr	100yr
Rainfall Area and Type							
Barnstable East – NRCC_C	2.74	3.26	4.03	4.74	5.88	6.92	8.15
Barnstable West – NRCC_C	2.80	3.32	4.14	4.89	6.10	7.22	8.55
Berkshire North – NRCC_B	2.42	2.81	3.48	4.09	5.07	5.97	7.04
Berkshire South – NRCC_C	2.50	2.94	3.69	4.38	5.50	6.54	7.78
Bristol - NRCC_C	2.74	3.30	4.12	4.88	6.10	7.22	8.56
Dukes – NRCC_C	2.80	3.31	4.14	4.91	6.16	7.30	8.67
Essex – NRCC_D	2.63	3.15	4.02	4.83	6.16	7.42	8.94
Franklin – NRCC_C	2.48	3.02	3.70	4.33	5.32	6.22	7.29
Hampden – NRCC_C	2.60	3.11	3.89	4.60	5.74	6.80	8.05
Hampshire – NRCC_C	2.55	3.07	3.80	4.47	5.54	6.52	7.68
Middlesex Central – NRCC_D	2.58	3.09	3.90	4.65	5.87	7.00	8.36
Middlesex North – NRCC_C	2.52	3.00	3.76	4.46	5.60	6.66	7.92
Middlesex South – NRCC_D	2.64	3.16	3.99	4.77	6.03	7.21	8.62
Nantucket – NRCC_B	2.68	3.13	3.90	4.61	5.74	6.78	8.02
Norfolk – NRCC_C	2.69	3.22	4.07	4.86	6.15	7.35	8.80
Plymouth – NRCC_C	2.78	3.35	4.18	4.95	6.19	7.33	8.68
Suffolk – NRCC_D	2.72	3.26	4.11	4.90	6.19	7.39	8.83
Worcester Central – NRCC_D	2.58	3.13	3.93	4.68	5.88	7.00	8.34
Worcester North – NRCC_C	2.47	2.95	3.68	4.35	5.43	6.42	7.60
Worcester South – NRCC_D	2.65	3.22	4.05	4.83	6.08	7.24	8.64

Appendix 3. Rainfall distribution database (type.rf)

The peak discharge results of EFH-2 are derived from results of WinTR-20 runs. To simplify the estimation of peak discharge, WinTR-20 was run for times of concentration of 0.1 to 10.0 hours and Ia/P ratios of 0.1, 0.2, 0.3, 0.4 and 0.5. Ia 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.

$$Ia = 0.2 * ((1000 / CN) - 10) \tag{Eq. 1}$$

where CN = NRCS runoff curve number.

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

$$qu = 10 ^ { (Coeff_1 + Coeff_2 * LOG(Tc) + Coeff_3 * (LOG(Tc))^2) } \tag{Eq. 2}$$

The coefficients to be used with each rainfall distribution are tabulated below. For example, the equation applicable to the Region C rainfall distribution region of Massachusetts and Ia/P ratio of 0.1 is:

$$qu = 10 ^ { (2.4626 - 0.5834 * LOG(Tc) - 0.1182 * (LOG(Tc))^2) } \tag{Eq. 3}$$

For a time of concentration of 0.24 hours and Ia/P ratio of 0.1, the unit peak discharge, qu = 600.87 cfs / inch / sq mile.

If the drainage area, A, is 10 acres (0.0156 square miles) and there are 1.5 inches of runoff, Q, the peak discharge, qp, is:

The peak discharge is calculated using the following equation: qp = qu x A x Q, where qu is the unit peak discharge, A is the drainage area, and Q is the runoff.

$$qp = 600.87 * 0.0156 * 1.5 = 14.1 \text{ cfs} \tag{Eq. 4}$$

Table A3.1 Regions B, C and D Rainfall Distribution Coefficients

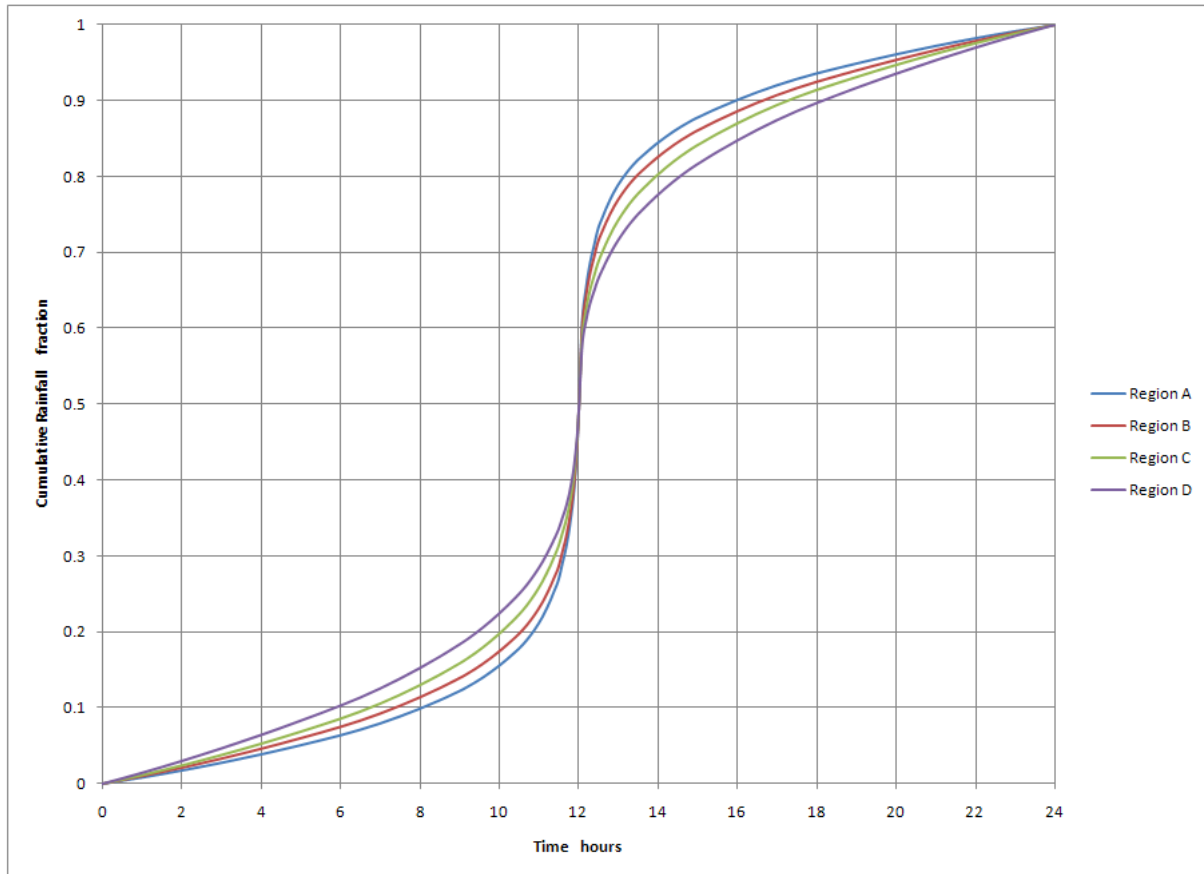
	Ia/P	Coeff_1	Coeff_2	Coeff_3
NE_B, 5	0.1	2.5150	-0.6034	-0.1344
	0.2	2.4934	-0.6134	-0.1226
	0.3	2.4410	-0.6056	-0.0986
	0.4	2.3540	-0.5600	-0.0725
	0.5	2.2249	-0.4247	-0.0996

	la/P	Coeff_1	Coeff_2	Coeff_3
NE_C, 5	0.1	2.4626	-0.5834	-0.1182
	0.2	2.4410	-0.5918	-0.1070
	0.3	2.3847	-0.5827	-0.0797
	0.4	2.2861	-0.5322	-0.0459
	0.5	2.1322	-0.3695	-0.0700

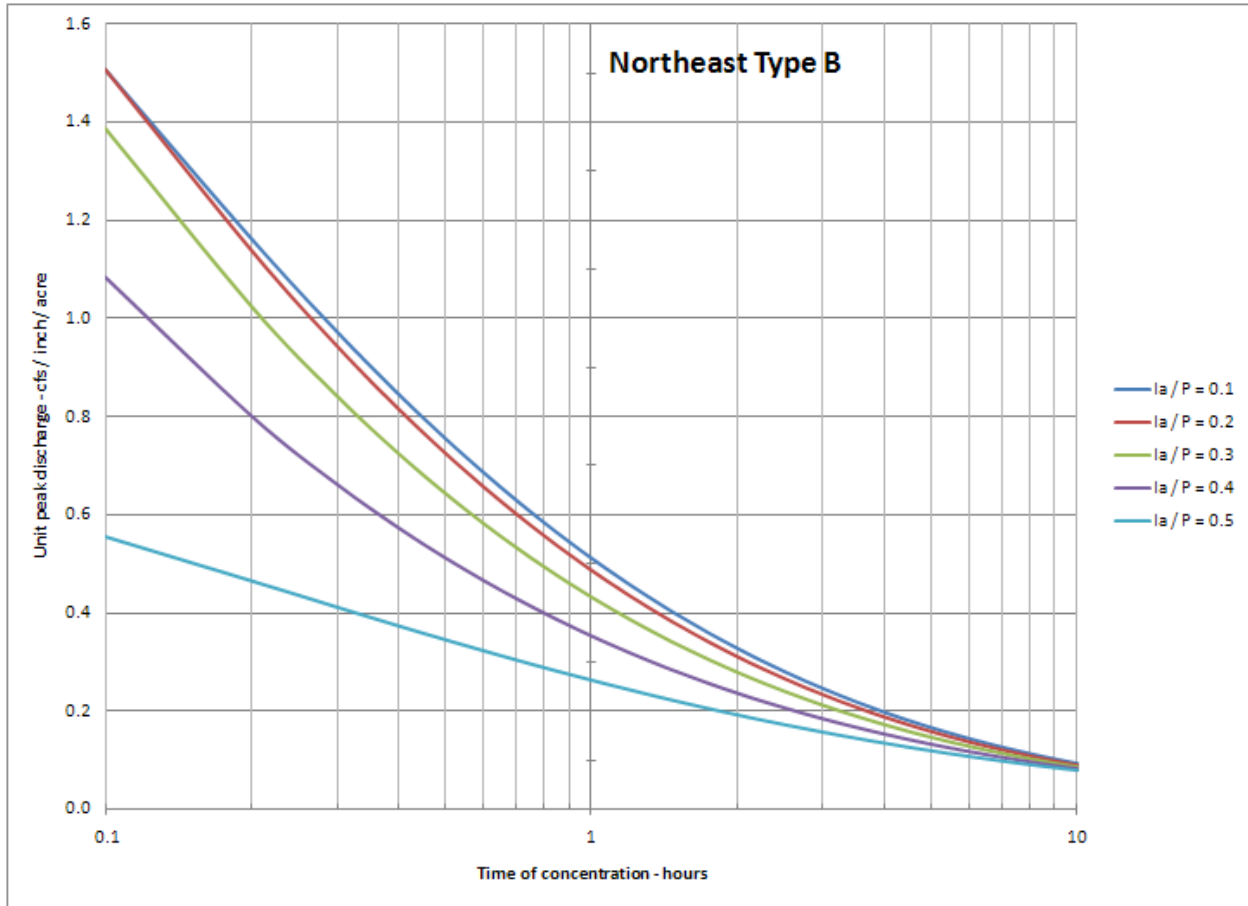
	la/P	Coeff_1	Coeff_2	Coeff_3
NE_D, 5	0.1	2.4114	-0.5687	-0.1068
	0.2	2.3894	-0.5765	-0.0953
	0.3	2.3298	-0.5683	-0.0668
	0.4	2.2183	-0.5161	-0.0223
	0.5	2.0357	-0.3283	-0.0388

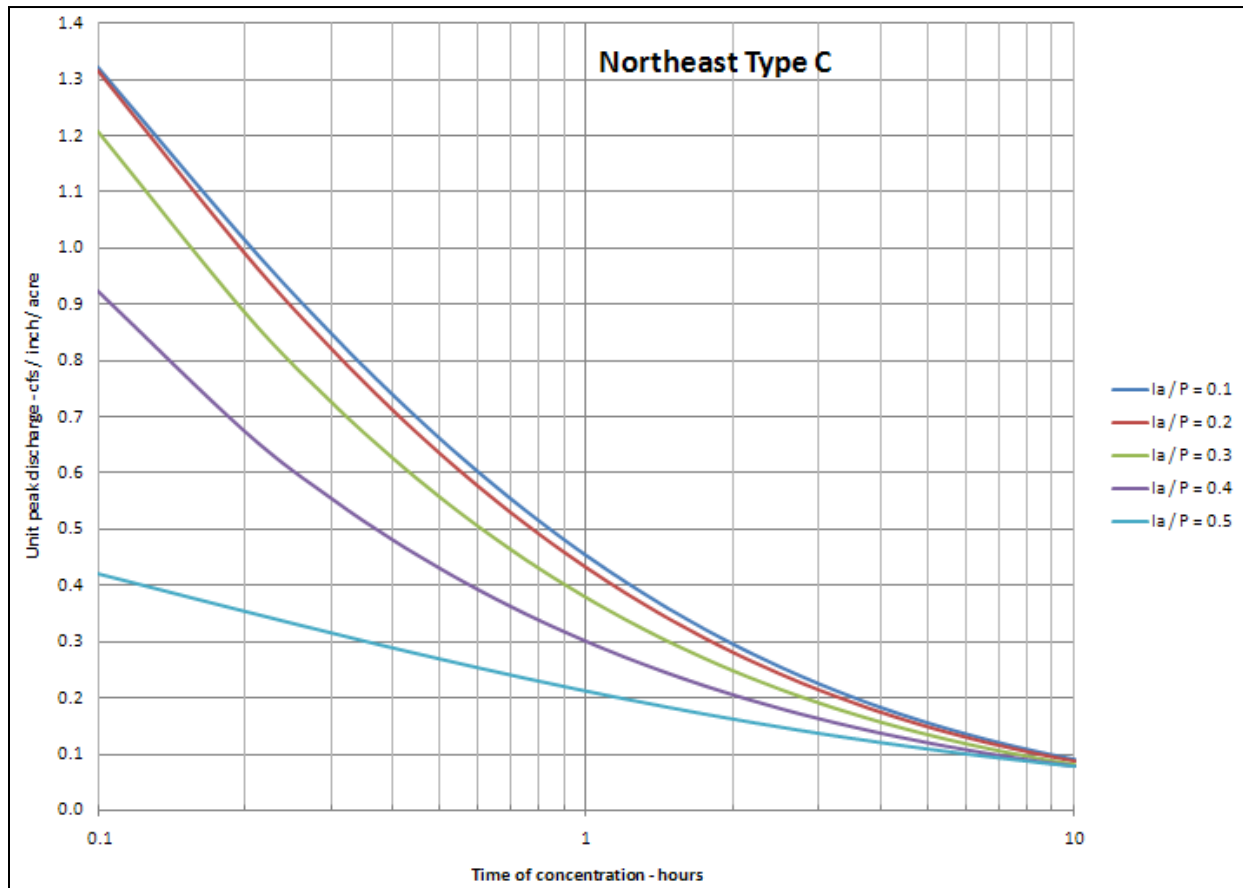
Appendix 4. Plot of the Northeast Regional Rainfall Distributions

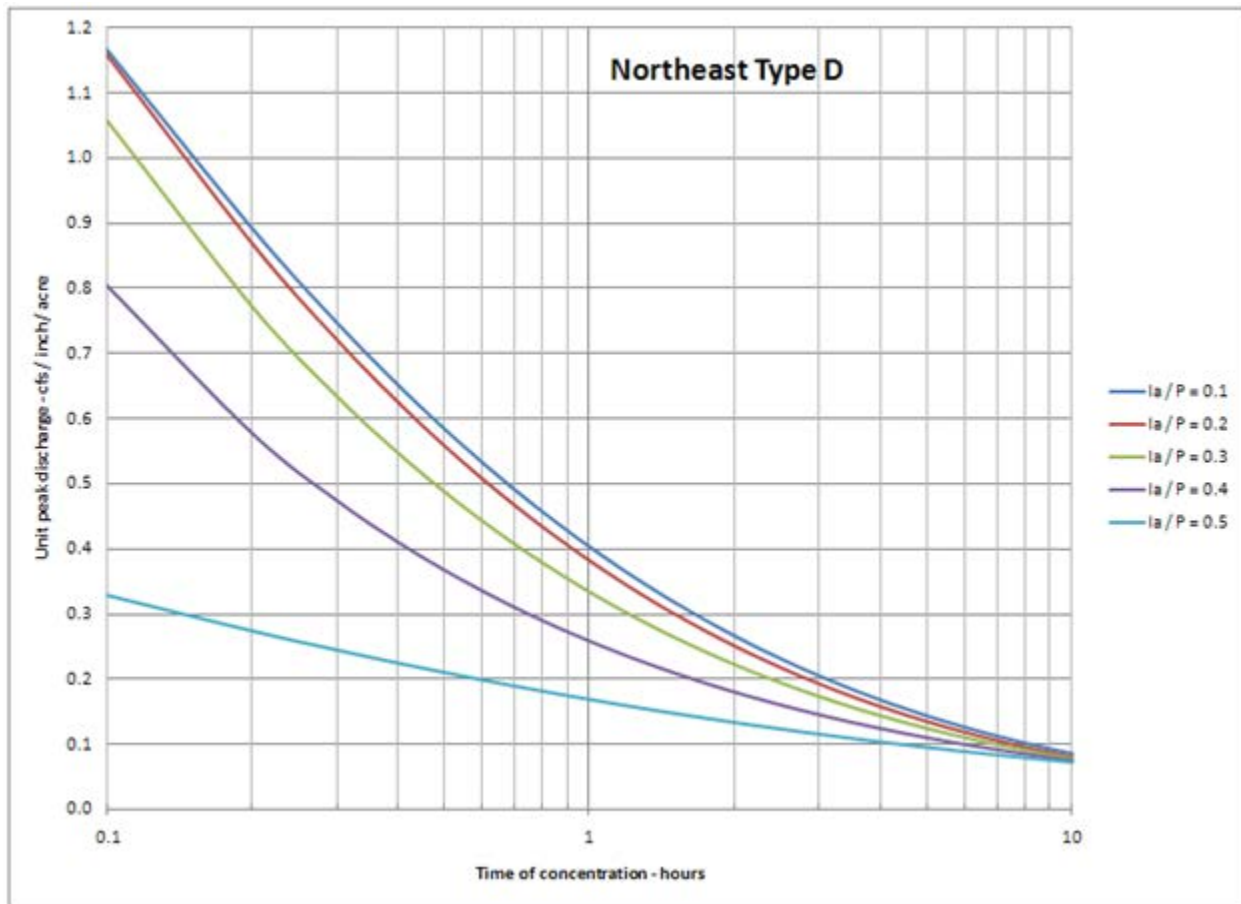
The following plots are for use with 24-hour design storms. They represent the accumulated rainfall during the 24-hour storm duration on a non-dimensional basis. The maximum accumulated rainfall in the plot is 1.0 which represents the total storm 24-hour rainfall. These rainfall distributions are represented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



Appendix 5. Plots of the Northeast Types B, C, and D Distribution Unit Peak Discharge







Application of Unit Peak Discharge Calculation using a Chart

Given an Ia/P ratio and a time of concentration, unit peak discharge for the selected rainfall distribution type can be calculated in cubic feet per second per inch of runoff per acre of drainage area using the following procedure:

1. Derive input data: Drainage Area (DA), Runoff Curve Number (CN), Watershed Length (L), Watershed Slope (Y), Time of Concentration (T_c), 24-hour rainfall, and rainfall distribution.
2. Compute inches of Runoff
3. Compute the Ia/P ratio
4. Read the unit peak discharge from the plot of the appropriate rainfall distribution using the watershed time of concentration and Ia/P ratio from step 3.
5. Calculate the Peak discharge, $q_p = \text{drainage area} \times \text{inches of runoff} \times \text{unit peak discharge}$

Appendix 6. Instructions for Incorporating Updated Rainfall into the EFH-2 Computer Program

The EFH-2 Runoff and Peak Discharge software requires a rainfall database (**County.ma**) rainfall and distribution types (**type.rf**). These databases are available on the Massachusetts NRCS Sharepoint Engineering site and will replace the TP40 based databases. The following describes the steps to use the current databases with the EFH-2 computer program.

1. Navigate to the MA Hydrology section of the Massachusetts NRCS Sharepoint site at: <https://nrsc.sc.egov.usda.gov/east/ma/default.aspx> NRCS Massachusetts > Shared Documents > Engineering > MA Hydrology
2. Individually, save “**County.ma**” and “**Type.rf**” into C:\Program Files\USDA\EFH2* on your computer. Select “Yes” to replace the existing TP40 based data file with the same name currently located in that folder. The EFH-2 software now has the updated databases with NRCC rainfall depths and rainfall distribution types for Massachusetts.

* This folder may be named EFM2 on some computers. The folder can be renamed EFH2 without affecting the program.
3. Within the EFH-2 computer program, type “MA” for the state under the Basic Data tab to see every rainfall zone in Massachusetts. This supplement provides an example application of the Massachusetts rainfall data in EFH-2 software.