

Estimating water availability at ungaged locations in New England

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Committee

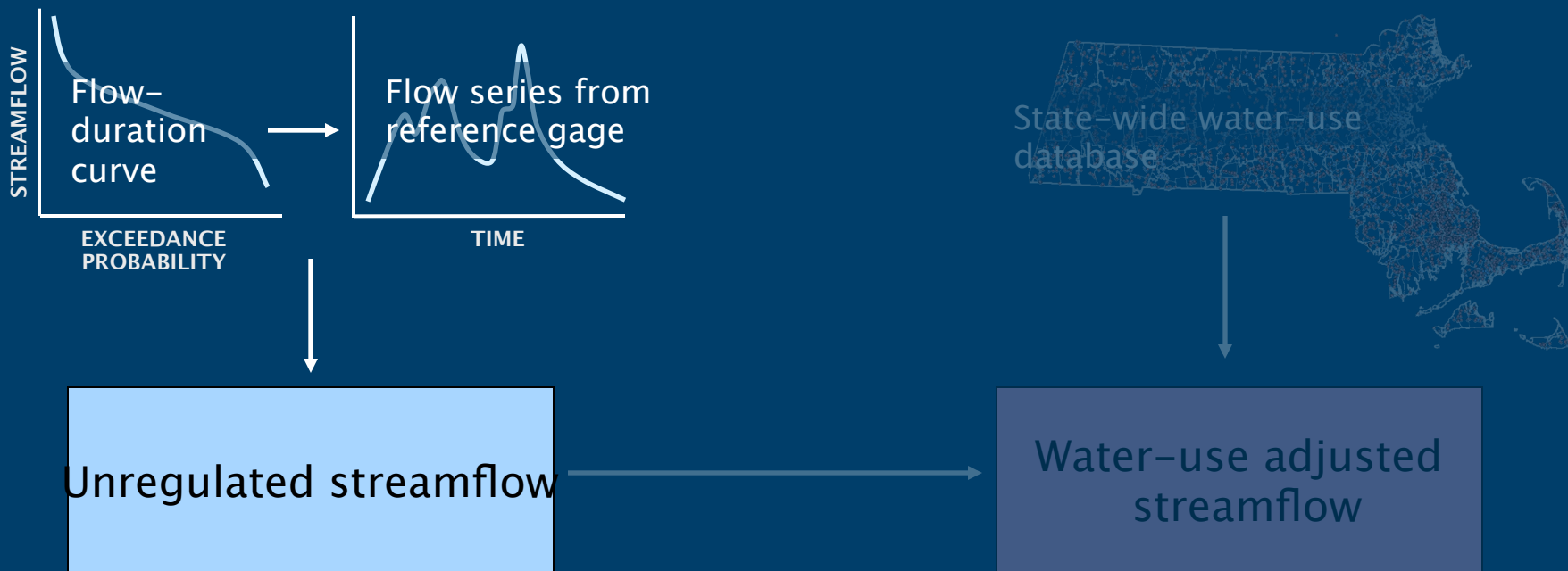
August 4, 2010

U.S. Department of the Interior
U.S. Geological Survey



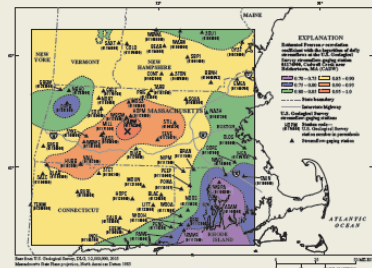
The Connecticut River looking north in the early evening, from the French King Bridge at the Erving-Gill town line in Western Massachusetts.

The Massachusetts Sustainable-Yield Estimator



Prepared in cooperation with the Massachusetts Department of Environmental Protection

The Massachusetts Sustainable-Yield Estimator:
A decision-support tool to assess water availability at ungaged stream locations in Massachusetts



Scientific Investigations Report 2009-5227

U.S. Department of the Interior
U.S. Geological Survey

The Massachusetts Sustainable-Yield Estimator
(Decision-support tool)

Archfield and others [2010]

Examples of existing methods to estimate daily streamflow time series

Drainage–area ratio

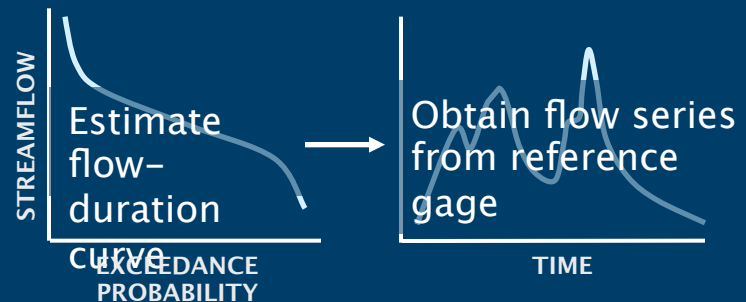
$$Qu_t = \frac{Au}{Ag} Qg_t$$

Scaling by the at–site mean and variance
(Hirsch, 1979)

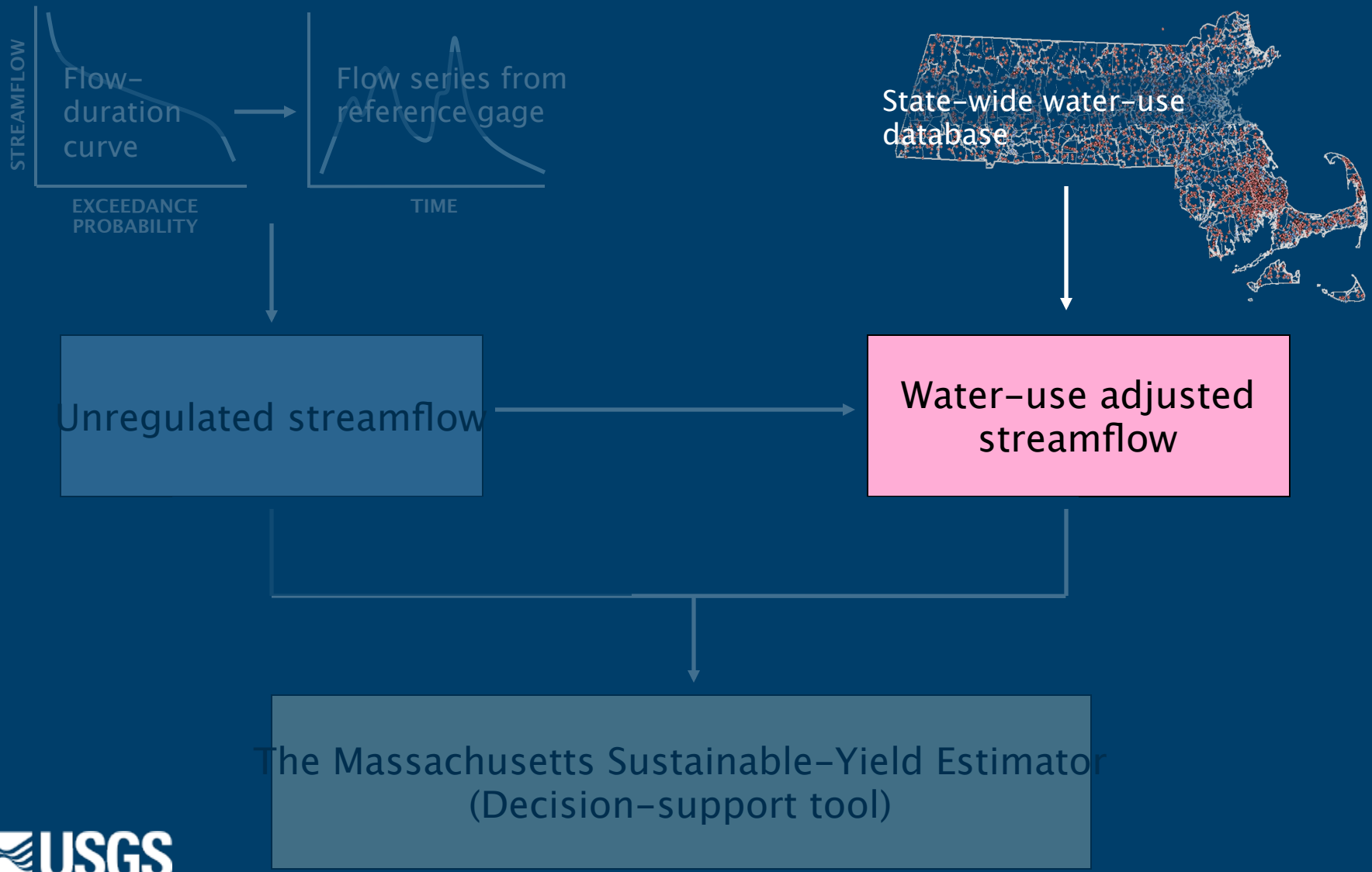
$$Qu_t = \hat{\mu}_u + \hat{\sigma}_u \left(\frac{Qg_t - \hat{\mu}_g}{\hat{\sigma}_g} \right)$$

Non–linear spatial interpolation

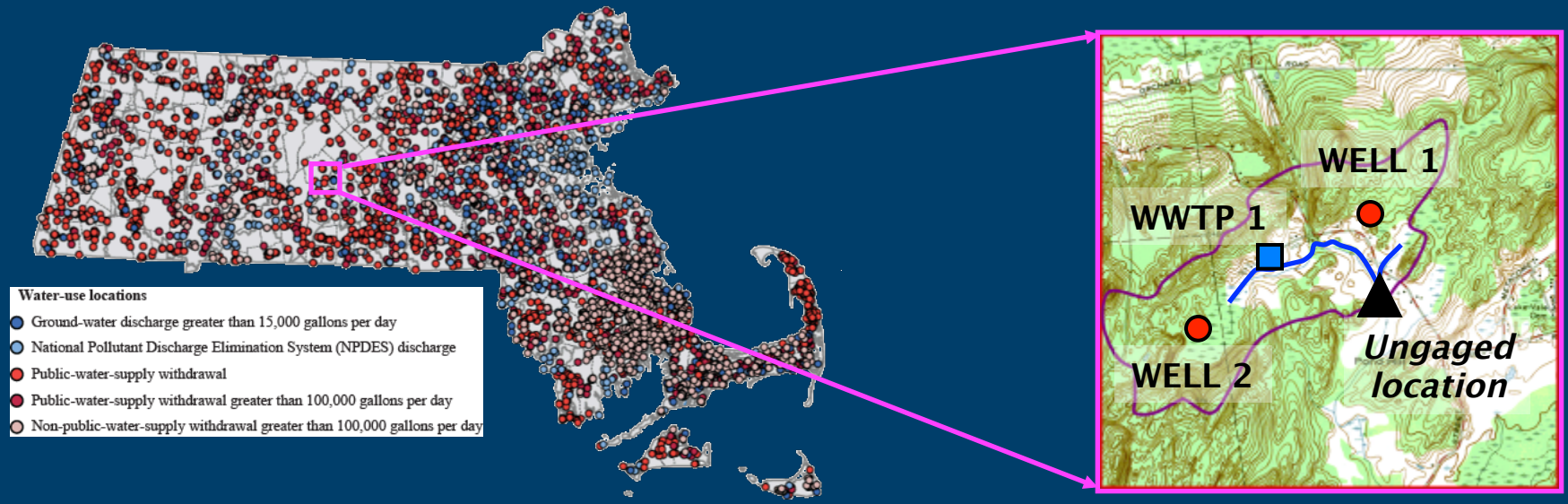
(Fennessey, 1994; Smakhtin, 1999; Smakhtin et al. 1997, Mohamoud, 2008; Archfield and others, 2010)



The Massachusetts Sustainable-Yield Estimator



Estimating regulated streamflow

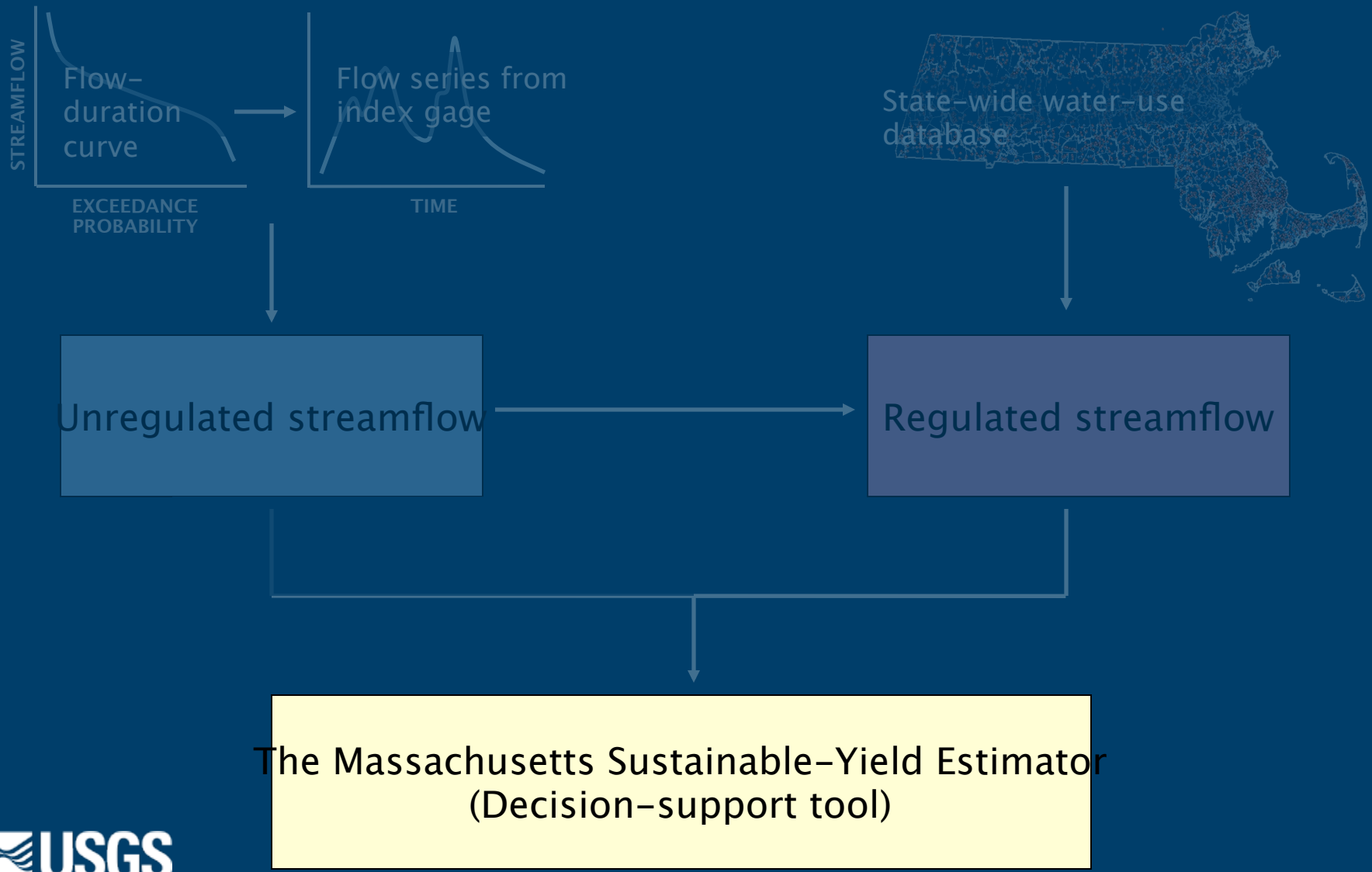


$$\begin{aligned}
 \text{Regulated streamflow}_t &= \text{Unregulated streamflow}_t \\
 &\quad - \Sigma (\text{Surface-water withdrawals}_t) \\
 &\quad - \Sigma (\text{Ground-water withdrawals}_t) \\
 &\quad + \Sigma (\text{Ground-water discharges}_t) \\
 &\quad + \Sigma (\text{Return flows}_t)
 \end{aligned}$$

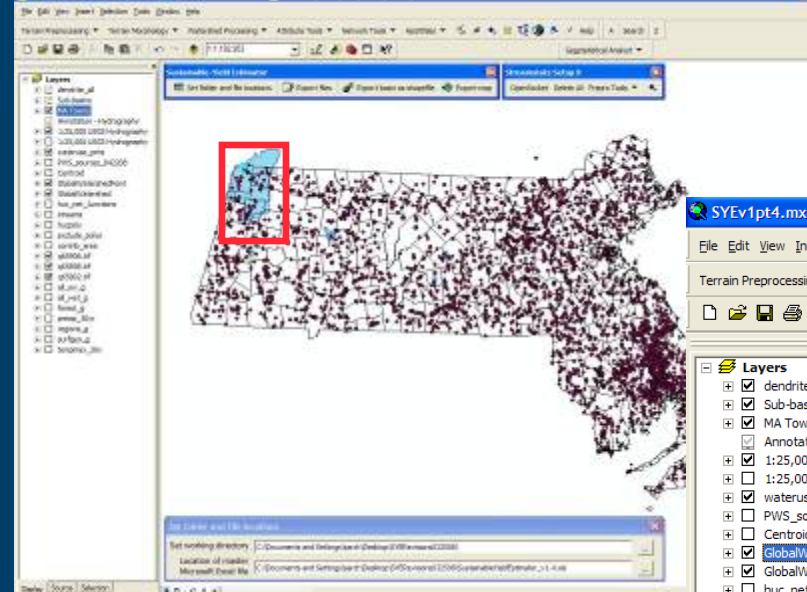
§ If aquifer properties are known, the user has the option to apply the program STRMDEPL, an analytical solution that is used to include the time-varying effects of a ground-water withdrawal or discharge on streamflow



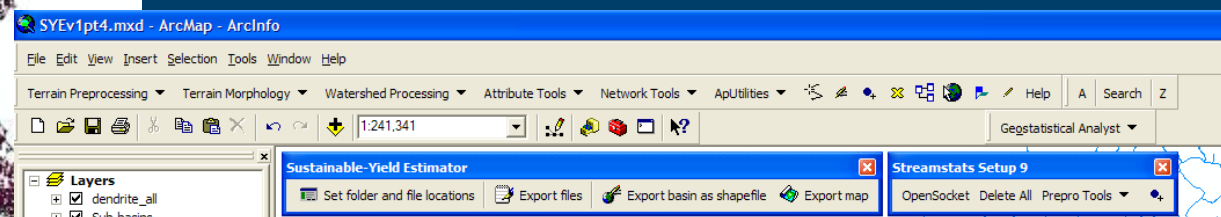
The Massachusetts Sustainable-Yield Estimator



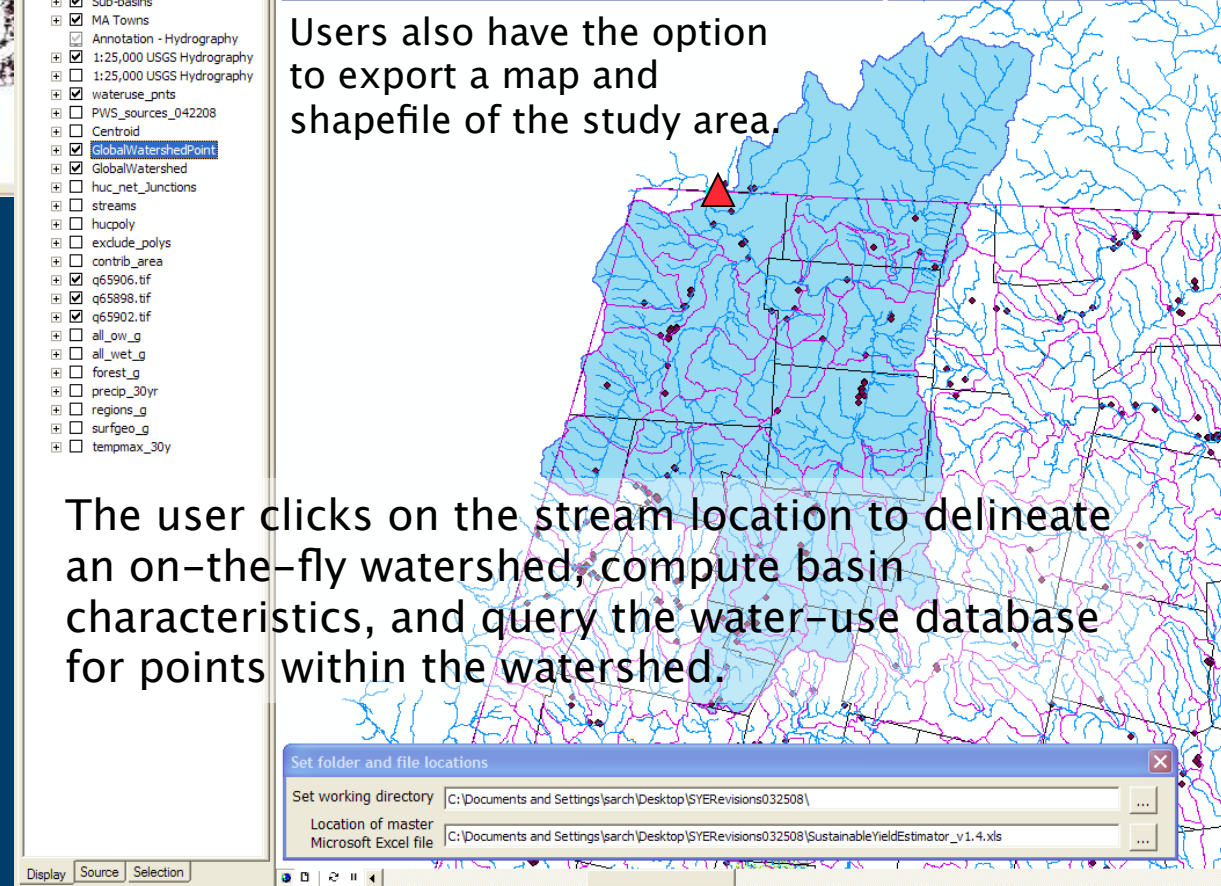
Point-and-click GIS user-interface built on StreamStats



Users begin by opening an ESRI ArcMap document and locating the stream of interest.



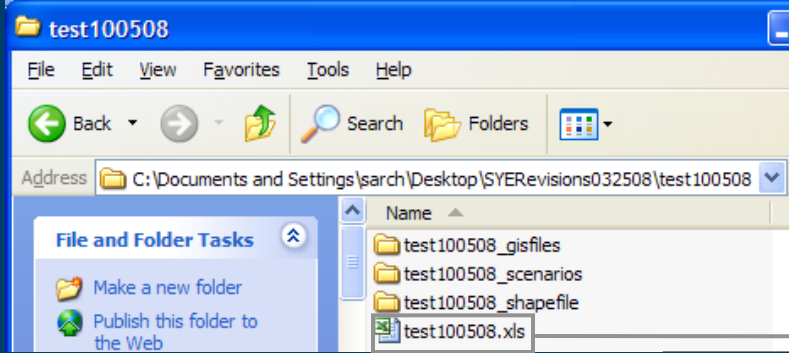
Users also have the option to export a map and shapefile of the study area.



The user clicks on the stream location to delineate an on-the-fly watershed, compute basin characteristics, and query the water-use database for points within the watershed.



Navigating the tool



All relevant data is stored in a user-specified location and project folder.

A master Microsoft Excel file guides the user through the post-processing, graphing and reporting of the results.

A screenshot of the Microsoft Excel application window titled 'SustainableYieldEstimator_v1.4_7.xls'. The spreadsheet content includes:
Project name: test100508
ArcMap files are located in: C:\Documents and Settings\sarch\Desktop\SYERevisions032508
Water-use database located in: C:\Documents and Settings\sarch\Desktop\SYERevisions032508
Index-gage spreadsheet located in: C:\Documents and Settings\sarch\Desktop\SYERevisions122807
Project description: testing all aspects of program

Controls
A grid of four buttons: 'Compute Unimpacted Streamflow', 'Review Water-Use Data', 'Compute Impacted Streamflows', and 'Compute Sustainable Yield'.

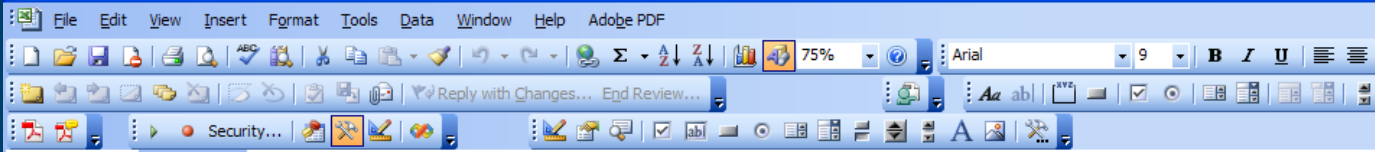
Application Overview
Blue worksheet tabs denote worksheets related to...
Pink worksheet tabs denote worksheets related to...
Yellow worksheet tabs denote worksheets related to...
Grey worksheet tabs denote worksheets with sum...

Methods and documentation
For information on the methods used in the Sustainable Yield Estimator, see the report by Stacey Archfield, S.A., Vogel, R.M., Steeves, P.A., Brandt, J. The Massachusetts Sustainable-Yield Estimator: A continuous daily streamflow at ungaged sites in Massachusetts. U.S. Geological Survey Scientific-Investigations Report 600-01-001.

Contact
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10 Bearfoot Road
Northborough, MA 01532
(508) 490-5072
sarch@usgs.gov

An inset window titled 'Water-use points and data' is overlaid on the spreadsheet, showing a list of water-use points with 'PWS-2002000-20G' selected in a dropdown menu. The list includes: PWS-2002000-20G, GWD-644-01F-G, GWD-686-01F-G, NP-MA0027421-0000-S, PWS-2002000-01G, PWS-2002000-03G, PWS-2002000-04G, PWS-2002000-20G, and PWS-2002000-21G.

The bottom of the Excel window shows the taskbar with several tabs: 'Master', 'BasinCharacteristics', 'IndexGageSelection', 'ContinuousFlowDuration', 'ContinuousDailyFlow', and 'WaterUseData'.



Q40				
A	B	C	D	E
Massachusetts Sustainable Yield Estimator (SYE)				
Summary Report by:				
Date: 10/6/2008 16:03				
Click point (State Plane meters): x = 104394.999983, y = 909234.99997 <i>User can edit cells highlighted yellow.</i>				
Town: 				
DEP Major Watershed: 				
Project Name: testingagain2				
Description: testing all aspects of program				
Period of unimpacted flow selected: 1961 to 2002				
Water-use types: Count: Septic-system return flow:				
PWS sources included 25 / 28 Value 10				
WMA sources (non-PWS) included 1 / 1 Units percent				
NPDES included 0 / 1				
GWID included 2 / 2				
Total water-use points included 28 / 32				
Index-gage site name: 01175670 Sevenmile River near Spencer, MA				
Distance between gages (mi.): 36.98				
Percent difference				
Basin characteristics	Index-gage site	Unimpacted site	Unit	Percent difference
Drainage area	8.80	8.60	miles squared	2.34
Mean basin elevation	873.00	915.40	feet	4.74
Average annual precipitation	48.19	49.69	inches	3.04
Open water	2.33	1.64	percent of basin	34.71
Maximum monthly temperature	13.50	13.59	degrees Celsius	0.67
Wetlands	8.16	2.29	percent of basin	112.28
Sand and gravel deposits	12.65	12.92	percent of basin	2.15
Streamflow statistics at unimpacted site:				
	Unimpacted streamflow		Impacted streamflow	
	cfs	cfsm	cfs	cfsm
Monthly average for JAN	22.15	2.58	20.93	2.43
Monthly average for FEB	20.32	2.36	18.96	2.21
Monthly average for MAR	41.92	4.88	40.37	4.70
Monthly average for APR	41.92	4.88	40.43	4.70
Monthly average for MAY	19.00	2.21	17.59	2.05
Monthly average for JUN	14.14	1.65	12.82	1.49
Monthly average for JUL	4.78	0.56	3.67	0.43
Monthly average for AUG	4.14	0.48	3.17	0.37
Monthly average for SEP	4.02	0.47	3.11	0.36
Monthly average for OCT	8.41	0.98	7.35	0.85
Monthly average for NOV	11.65	1.36	10.54	1.23
Monthly average for DEC	19.01	2.21	17.89	2.08
August median	1.94	0.23	0.85	0.10
Aquatic-Baseflow (ABF) August median	74.38	8.65	43.35	5.04
7-day minimum	2.79	0.32	0.00	0.00
Comments:				
For more information on the methods used in the Sustainable-Yield Estimator application, please see:				
Archfield, S.A., Vogel, R.M., Steeves, P.A., Brandt, S.L., Weiskel, P.W., and Garabedian, S.P., 2009.				
The Massachusetts Sustainable-Yield Estimator: A decision-support system to estimate continuous daily streamflow at unimpacted sites in Massachusetts: U.S. Geological Survey Scientific-Investigations				
Report 2009-XXXX, X p. Available at: http://				
Contact:				
Stacey Archfield, Hydrologist sarch@usgs.gov				
USGS Massachusetts-Rhode Island Water Science Center, Northborough, MA				

Results

Results are summarized for the user in a printable 2-page format.

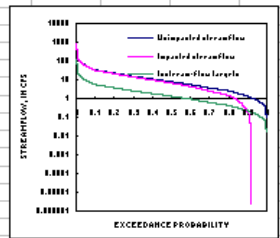


Figure 1. Flow-duration curves in cubic feet per second.

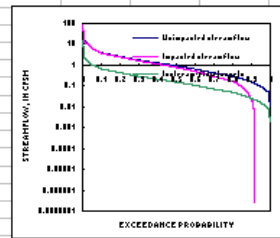


Figure 2. Flow-duration curves in cubic feet per second per mile.

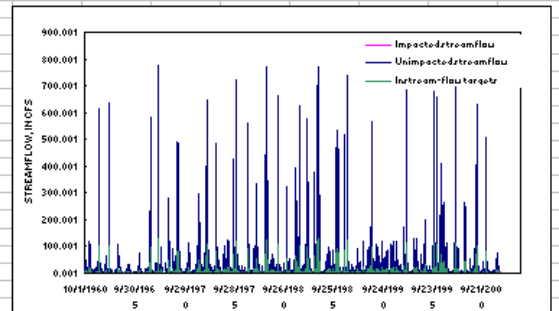


Figure 3. Hydrographs in cubic feet per second.

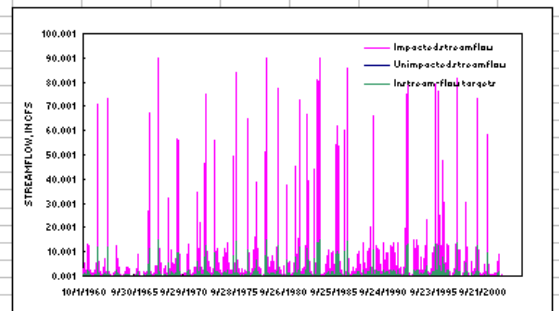
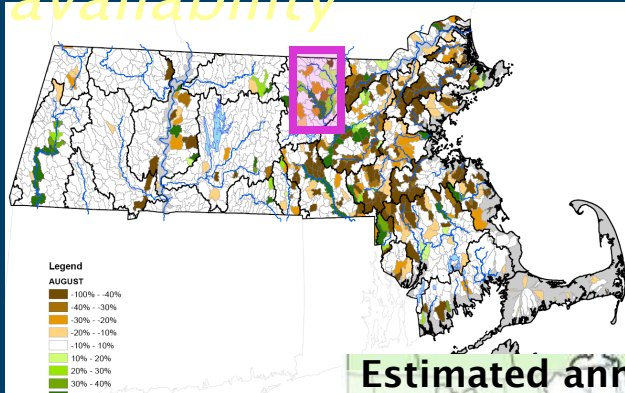


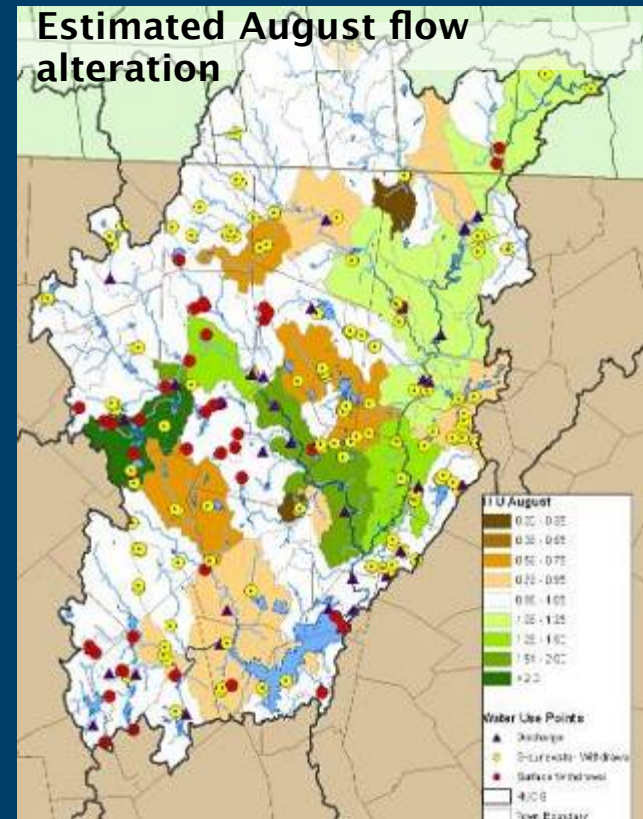
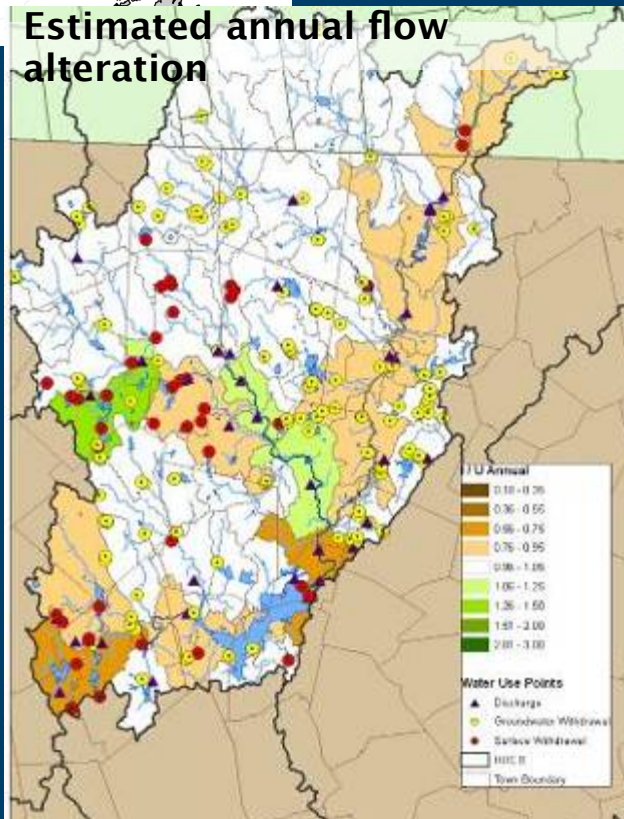
Figure 4. Hydrographs in cubic feet per second per mile.



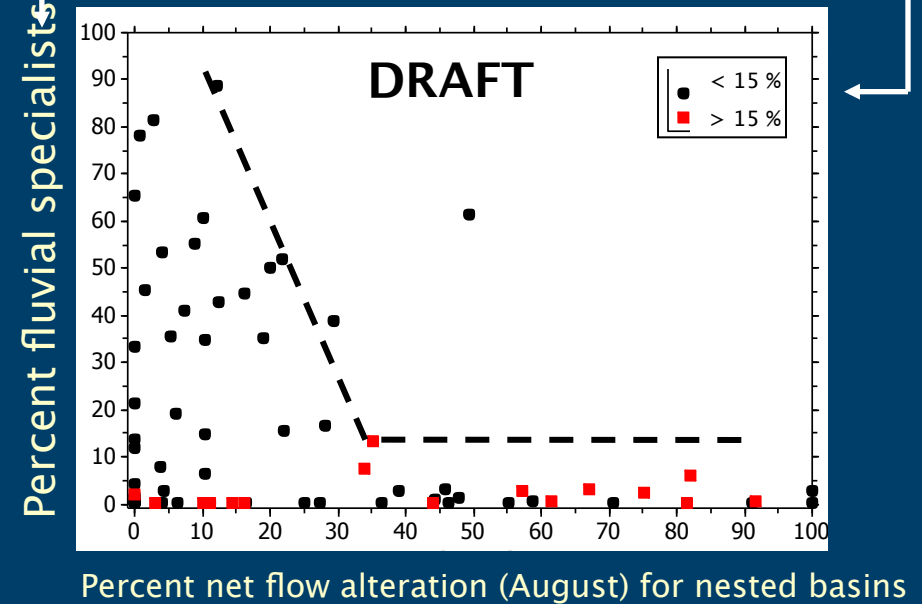
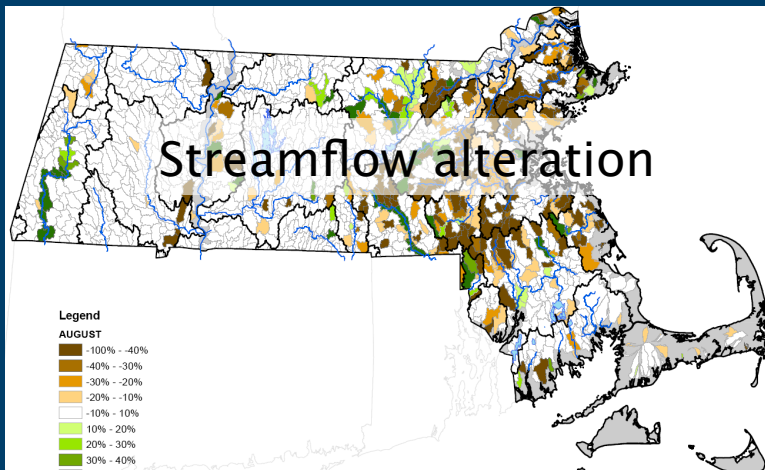
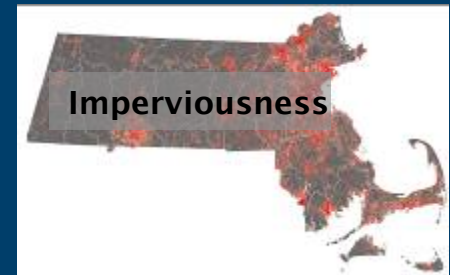
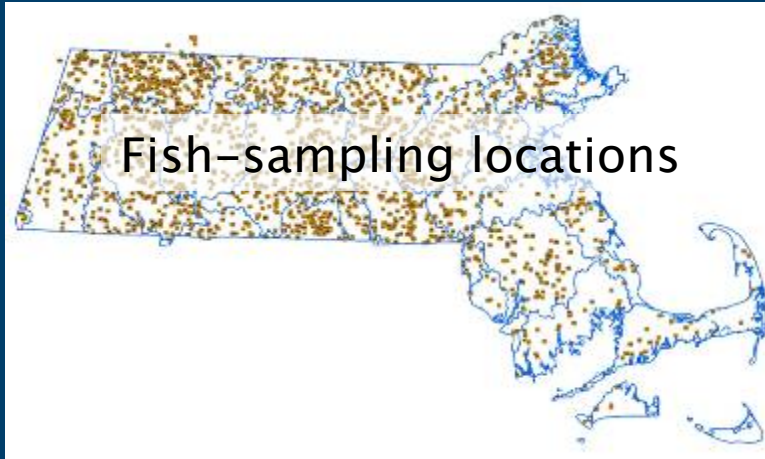
Application: Mapping streamflow alteration and water availability



Weiskel, P.K., Brandt, S.L., DeSimone, L.A., Ostiguy, L.J., and Archfield, S.A., 2010, Indicators of streamflow alteration, habitat fragmentation, impervious cover, and water quality for Massachusetts stream basins, USGS Scientific Investigations Report, 2009-5272



Application: Relating streamflow alteration to fish data



Armstrong, D.S., Richards, T.A., and Brandt, S.L., 2010, Preliminary assessment of factors influencing riverine fish communities in Massachusetts: U.S. Geological Survey Open-File Report 2010-1139, 43 p.

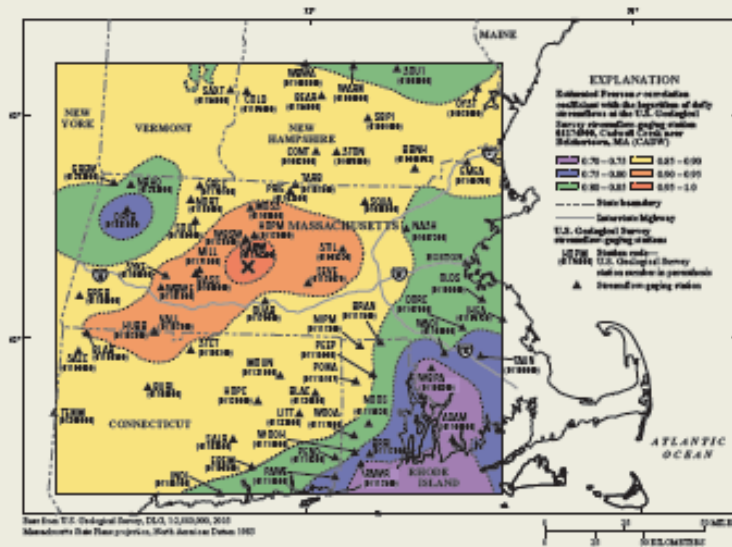


Application: *Regional daily, unregulated streamflows*



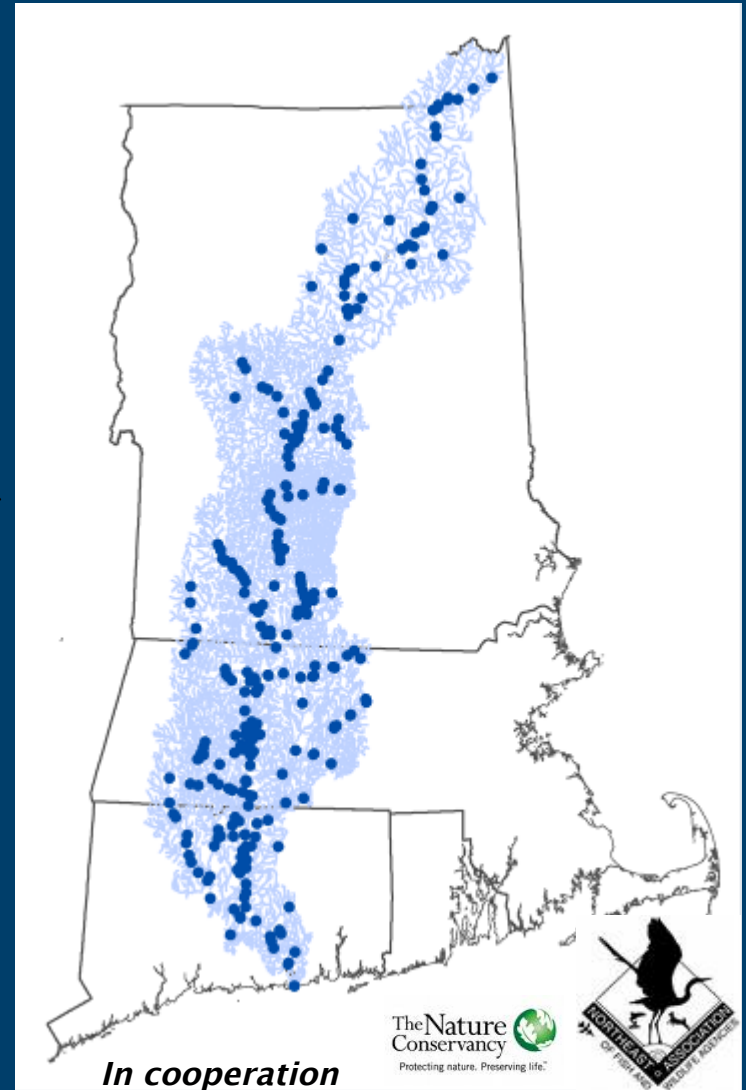
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*In cooperation
with:*



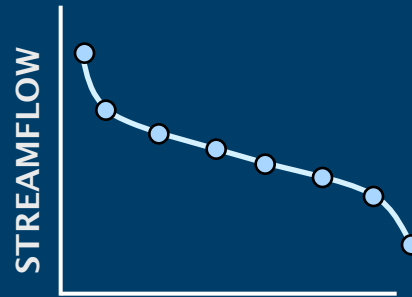
Method to estimate streamflow at ungaged sites

Estimate basin characteristics



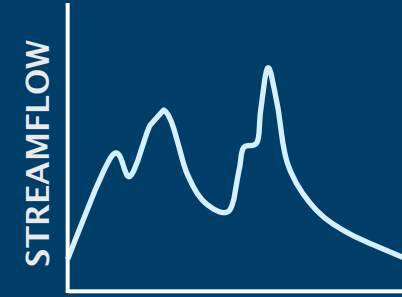
Area = XX.X mi²

Estimate flow-duration curve by solving the regression equations

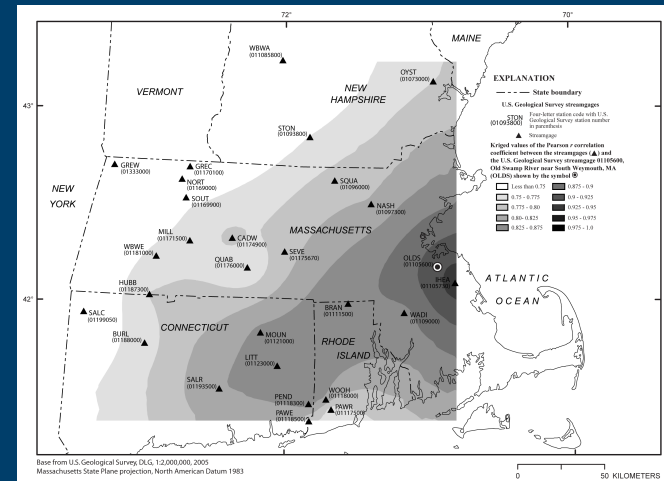
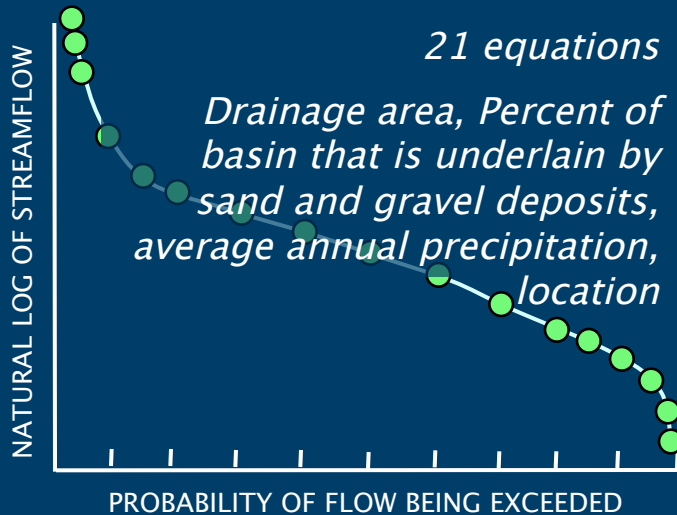


EXCEEDENCE PROBABILITY

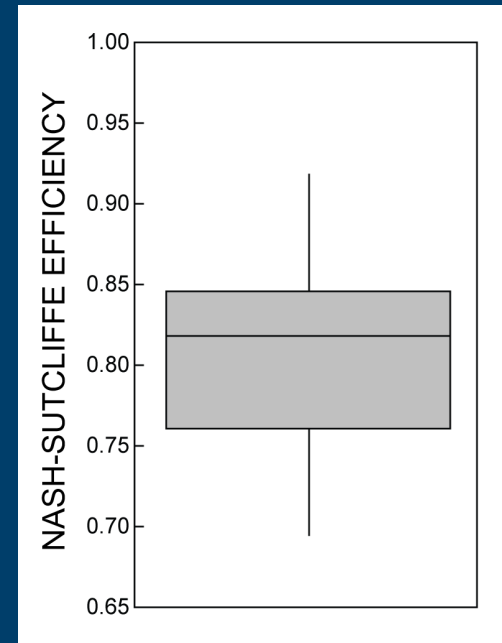
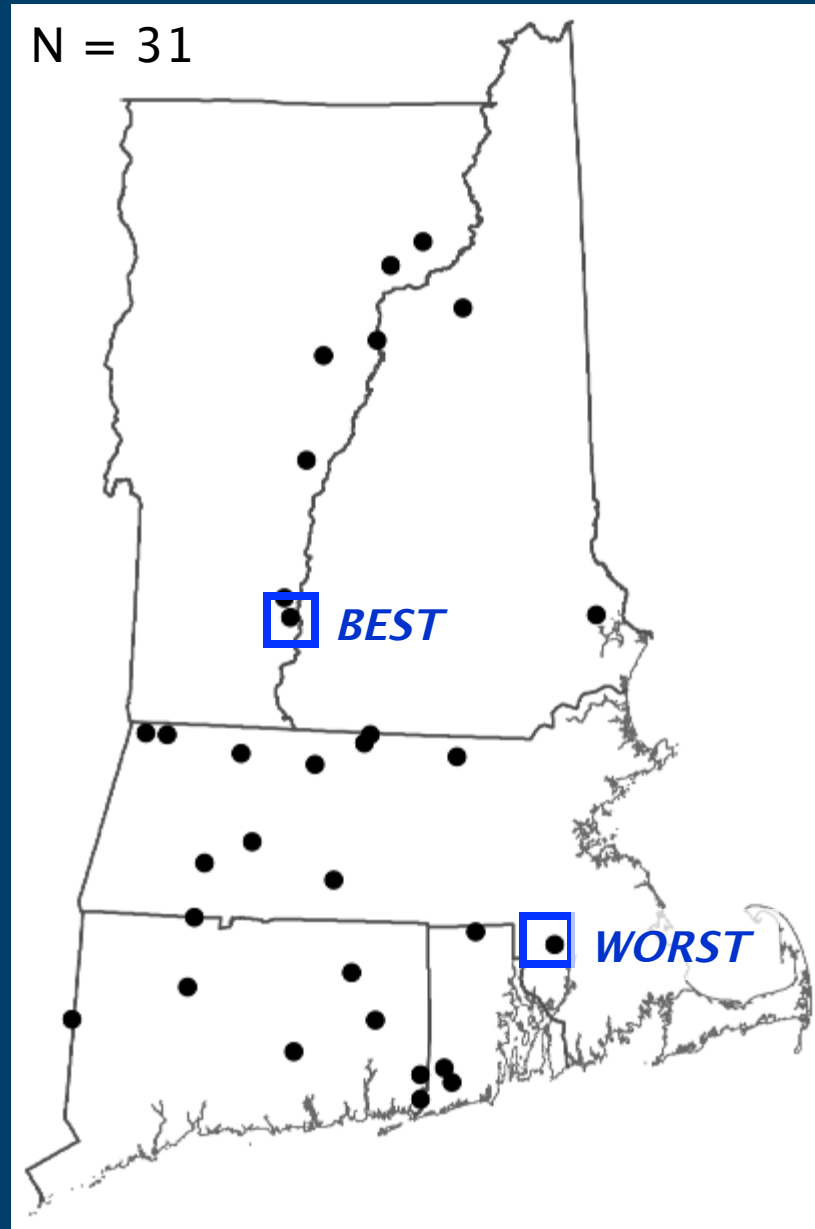
Estimate hydrograph



TIME

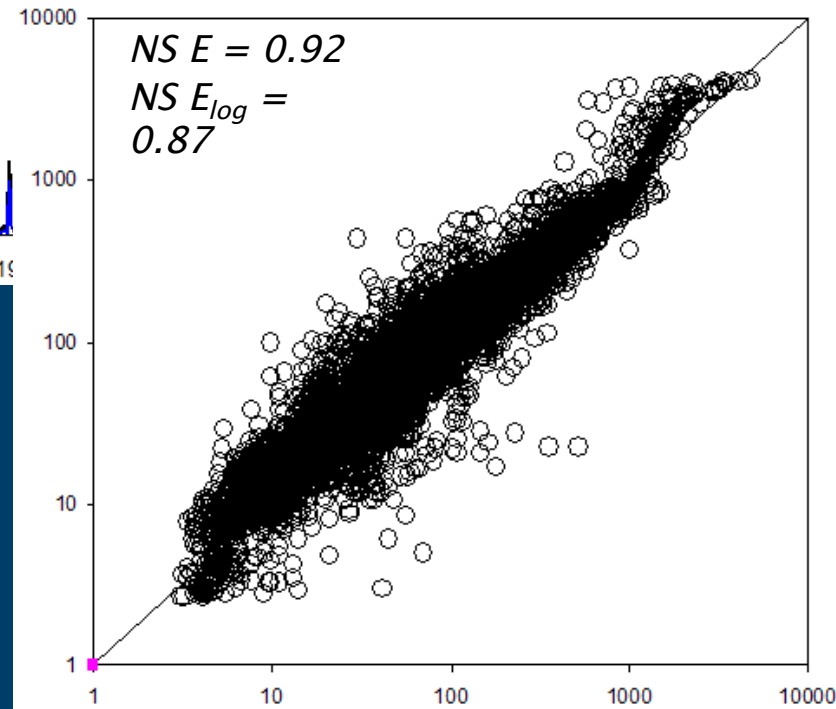
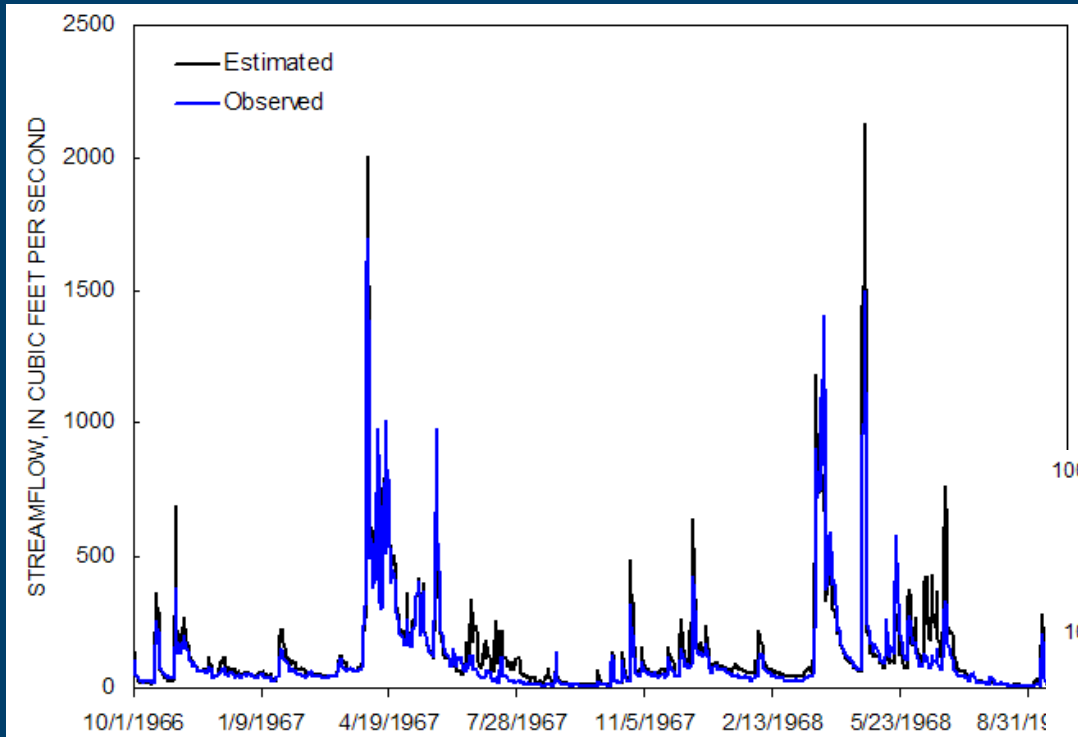


Daily streamflow validation – Summary



Daily streamflow validation – Best fit

01154000, Saxtons River at Saxtons River, VT

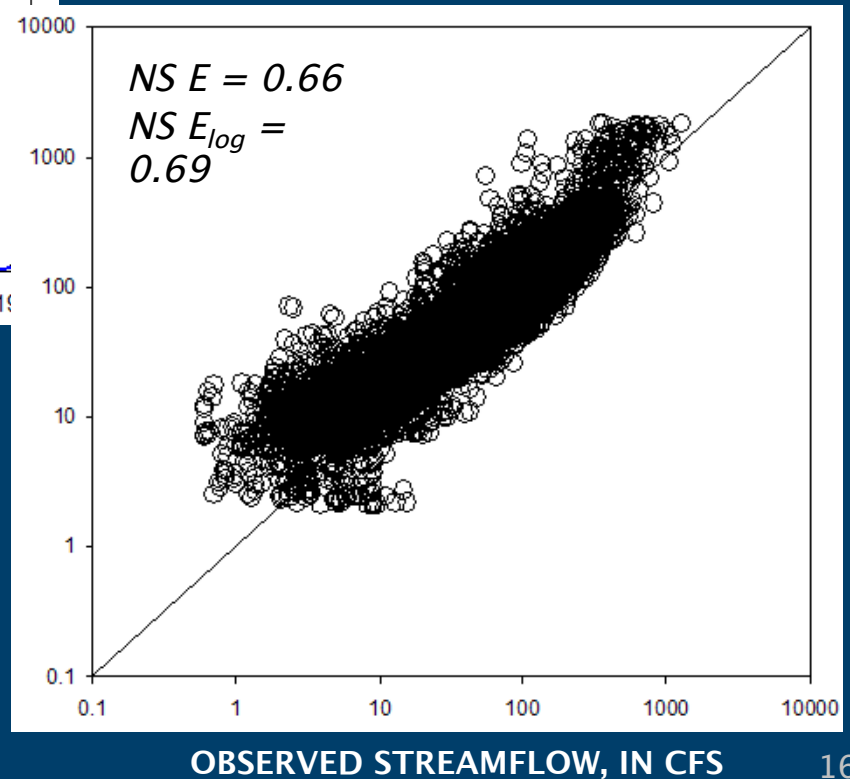
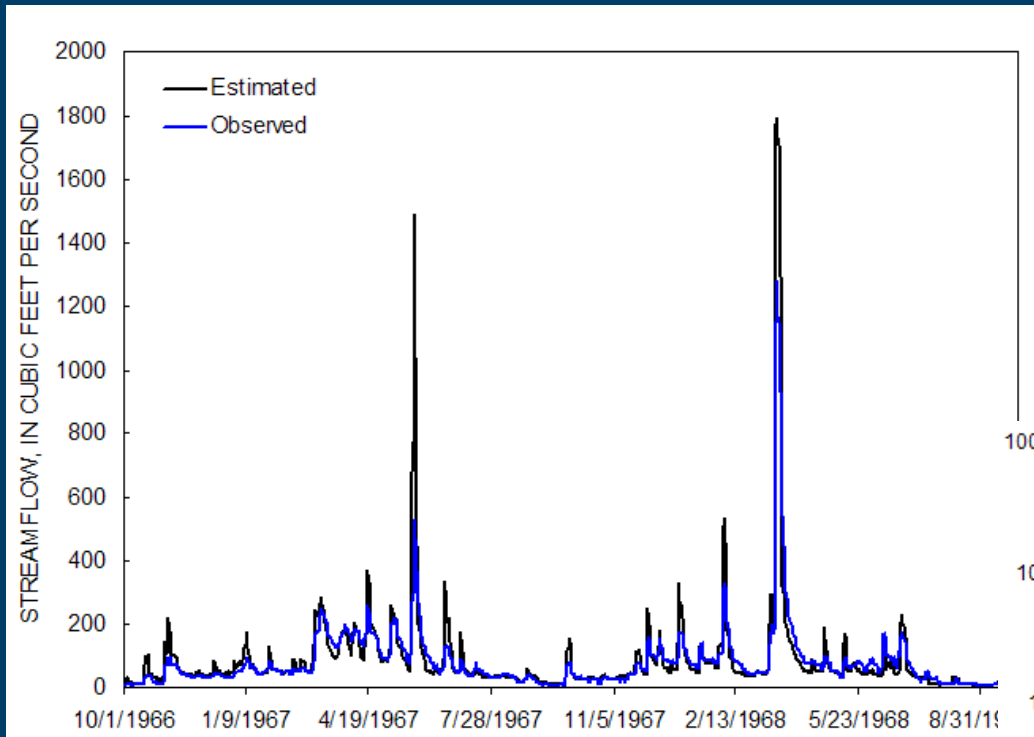


ESTIMATED
STREAMFLOW, IN CFS

OBSERVED STREAMFLOW, IN CFS

Daily streamflow validation – Worst fit

01109000, Wading River near Norton, MA



ESTIMATED
STREAMFLOW, IN CFS

OBSERVED STREAMFLOW, IN CFS

Contact Information

Stacey Archfield

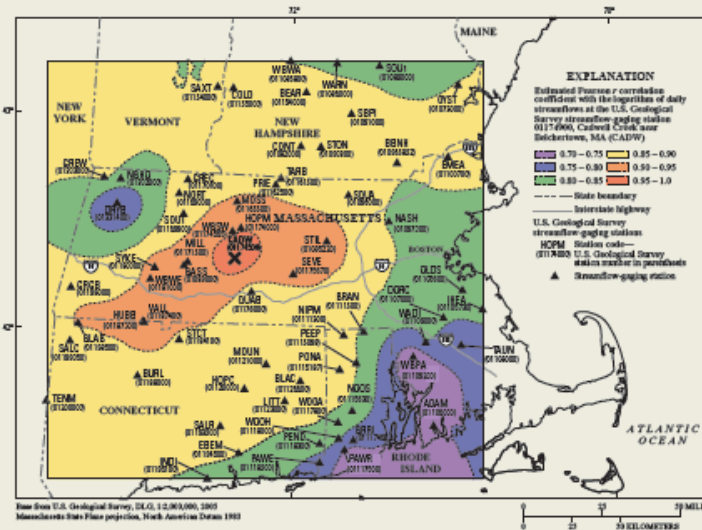
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