The New York Streamflow Estimation Tool

Final Report

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Report Number 15-13

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NYSERDA provides resources, expertise, and objective information so New Yorkers can make confident, informed energy decisions.

Mission Statement:

Advance innovative energy solutions in ways that improve New York's economy and environment.

Vision Statement:

Serve as a catalyst – advancing energy innovation, technology, and investment; transforming New York's economy; and empowering people to choose clean and efficient energy as part of their everyday lives.

The New York Streamflow Estimation Tool

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Notice

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Summary

The ability to estimate daily mean streamflow for any location on a stream in New York State can aid in managing the water resources of the State. Time series hydrologic data are essential to understanding ways to promote healthy instream ecology and to strengthen the scientific basis for sound water management decision making in New York. Generating daily mean flows at ungaged streams allows for estimating streamflow statistics such as flow-duration exceedances, and helps water managers to understand the natural, unaltered flows of a stream, which is critical to the sustainability and health of aquatic freshwater ecosystems. Visit http://pubs.usgs.gov/sir/2014/5220/ to find the full USGS report, NYSET application, and user's guide.

1 Introduction

The lakes, rivers, and streams of New York State provide an essential water resource for the State. Water management agencies require an understanding of natural and low streamflow characteristics for planning and management of waste-loads to streams, permitting streamflow alterations, water-quality evaluations, water-supply design, groundwater management, and aquatic-habitat protection. The seasonal variability of streamflows in New York State presents a challenge for water managers who work to protect the ecosystem during months with lower flows.

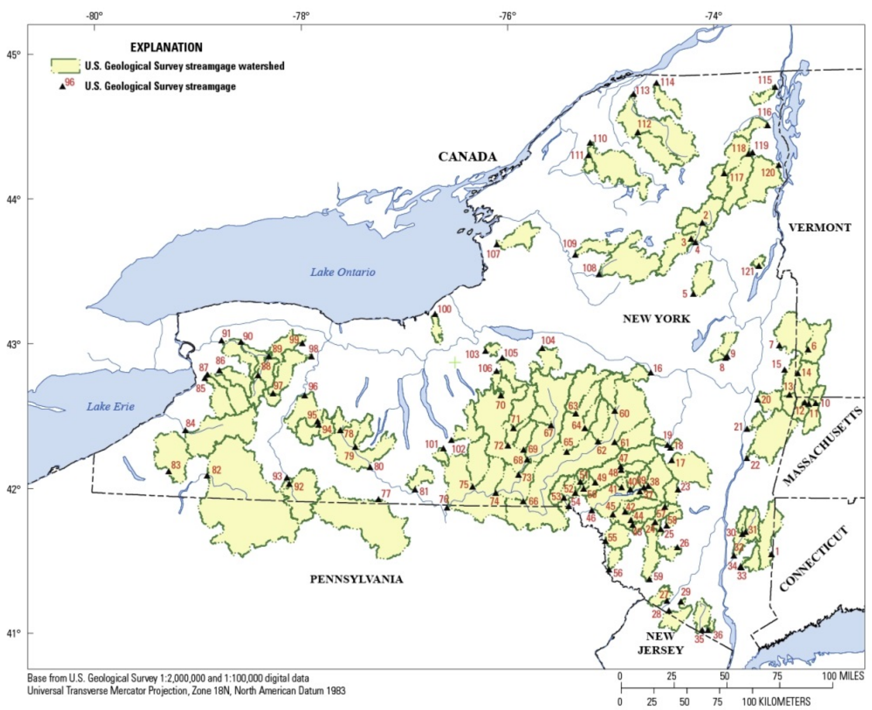
Streamflow in many streams in New York are primarily sustained by the base flows from adjacent aquifers and meltwater runoff from upland parts of the basin. Typically, the period from about late June through early October (corresponding to the growing season) is when streamflows are reduced to their lowest levels of the year and recharge to aquifers is reduced. Similarly, the annual minimum streamflow at many U.S. Geological Survey (USGS) streamgages in New York State is often observed during late summer and early fall (USGS 2012). This naturally occurring low-flow period, combined with permitted water withdrawals, effluent discharges, and increased demand for water can create a shortage of available water and damage to the natural ecosystem. Additionally, changes in climate patterns, such as droughts or floods, and changes in land use, such as increased industrial and suburban growth, may increase alteration to streamflows and aquatic biota natural to the lakes and streams of New York State.

To aid the understanding of natural streamflows, USGS operates more than 240 streamgages in New York State, but these streamgages only monitor a fraction of the thousands of rivers and streams that carry water throughout the State. Streamgage data permits the calculation of daily mean flows, allows for estimating streamflow statistics such as flow-duration exceedances, and helps water managers to understand the natural flow regime of a stream, which is critical to the sustainability and health of aquatic freshwater ecosystems (Vogel et al. 2007, Poff and Zimmerman 2010). USGS, in cooperation with The Nature Conservancy (TNC) and the New York State Energy Research and Development Authority (NYSERDA), has developed the New York Streamflow Estimation Tool (NYSET) to estimate unaltered daily mean streamflow and streamflow statistics at ungaged locations across New York State (excluding Long Island). The data are essential to understanding ways to promote healthy instream ecology and to strengthen the scientific basis for sound water management decision making in New York State.

2 Development of the NYSET

The NYSET is a computer application that couples data from the USGS streamflow network for selected streamgages in New York and surrounding states with shared hydrologic boundaries (Gazoorian 2014; Figure 1), with explanatory physical and climate basin characteristics to estimate the natural unaltered streamflows at ungaged stream locations. With the NYSET, a daily mean hydrograph can be estimated for the period from October 1, 1960, to September 30, 2010, at ungaged locations across the State. The estimated daily mean time series is used to estimate unaltered streamflow statistics, representing flows that are minimally altered by regulation, diversion, mining, and other anthropogenic activities.

Figure 1. Locations of U.S. Geological Survey reference streamgages in and near New York



A graphical user interface, with an integrated spreadsheet summary report (Figure 2), has been developed to display the estimated daily streamflow statistics and evaluate different water management or water withdrawal scenarios with the estimated data. The NYSET is an interactive tool that can assist water managers with permitting water withdrawals, implementing habitat protection, estimating contaminant loads, or determining the potential affect from chemical spills, among other uses. In addition, the New York Streamflow Estimation Tool provides a means for quantitative flow assessments at ungaged locations that can be used to address the objectives of the Clean Water Act—to restore and maintain the chemical, physical, and biological integrity of the Nation's waters.

Figure 2. Screen capture of summary report generated by the New York Streamflow Estimation Tool showing flow-duration curves and a hydrograph

USGS NY WSC Streamflow Estimation Tool (NYSET)

Summary Report by: userID   Date: 12/4/14

Project Description:

Reference streamgage: 01350000 Schoharie Creek at Prattsville, NY
Correlation coefficient: 0.98
Distance from ungaged site: 12.45

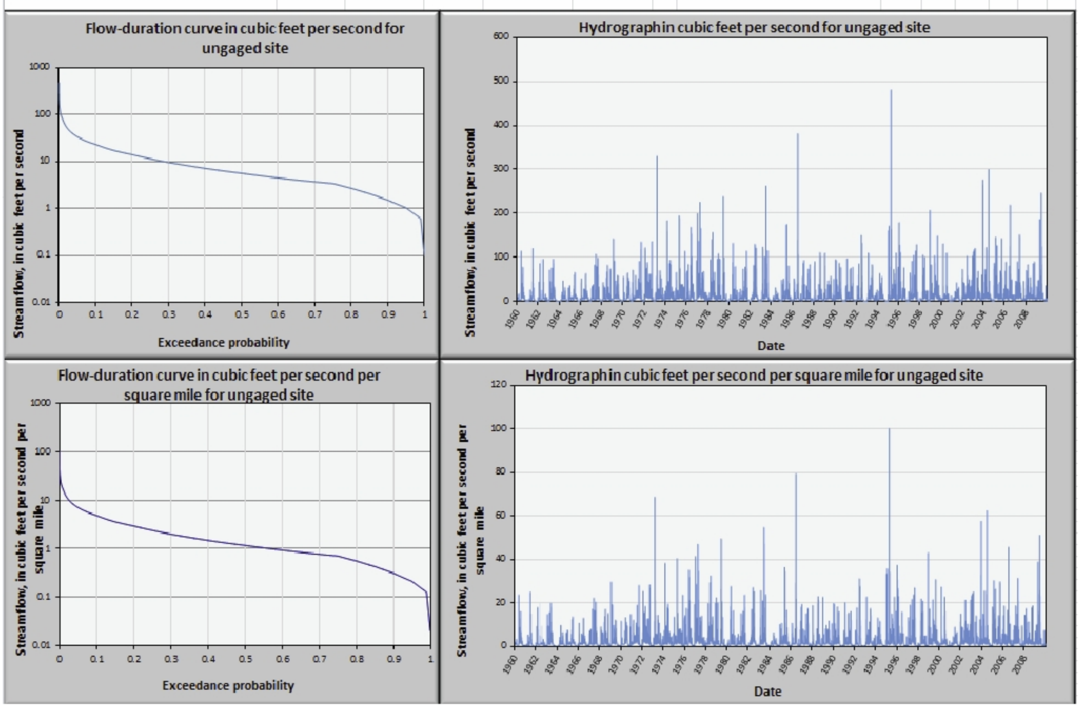
Export Daily Values

Basin characteristics	Ungaged site	Reference streamgage	Range*	Units	different from reference
Drainage area	4.80	237.00	3.14–4,780	miles squared	-97.97
Mean annual runoff, 1951 - 1980	30.20	27.60	11.6–37.4	inches	9.42
Percent of basin underlain by hydrologic soils group A	1.24	2.54	0.52–51.9	percent	-1.30
Percent of basin underlain by hydrologic soils group B	1.46	3.25	1.16–69.6	percent	-1.79
Slope of lower half of channel	53.20	21.50	1.56–152	feet/ mile	147.44
Percent of basin above 1200 ft sea level	100.00	99.70	0.00–100	percent	0.30
Mean May precipitation, 1971 - 2000	5.27	4.42	3.15–5.68	inches	19.23
Mean June precipitation, 1971 - 2000	5.07	4.23	3.59–5.33	inches	19.86
Mean July precipitation, 1971 - 2000	5.13	4.00	3.20–5.26	inches	28.25
Mean Summer precipitation, 1971 - 2000	15.10	12.10	10.48–15.51	inches	24.79
Maximun June temperature, 1971 - 2000	68.90	71.80	68.8–78.8	degrees Fahrenhe	-4.04
X location of basin centroid	561544.00	560452.76	–	UTM meters	-
Y location of basin centroid	4670100.00	4678527.28	–	UTM meters	-
X location of basin outlet	559845.00	546444.42	–	UTM meters	-
Y location of basin outlet	4670505.00	4685407.78	–	UTM meters	-

*Streamflow estimates may not be valid if value for ungaged site is outside of this range

Streamflow statistics for ungaged site, 1961 - 2010, in cubic feet per second	
Mean daily streamflow	10.40
Median daily streamflow	5.60
7Q2	0.99
7Q10	0.36

Monthly streamflow statistics for ungaged site, 1961 - 2010 in cubic feet per second	Mean	Q10	Q50	Q75	Q95	Q99
January	11.13	21.55	5.83	4.32	3.25	2.91
February	10.31	20.76	6.34	4.22	2.78	2.21
March	18.31	37.20	11.40	6.59	3.72	2.53
April	21.88	40.36	15.65	9.56	6.12	5.12
May	12.25	23.90	8.42	5.68	3.98	3.40
June	7.83	14.23	4.37	3.40	1.70	1.09
July	4.28	6.84	3.09	1.83	0.77	0.63
August	3.26	5.32	2.04	1.20	0.65	0.22
September	4.74	8.78	1.84	1.12	0.48	0.12
October	7.81	16.43	3.80	1.81	0.75	0.33
November	10.94	21.07	6.89	4.14	1.66	0.20
December	12.16	24.03	7.21	4.96	3.54	2.56

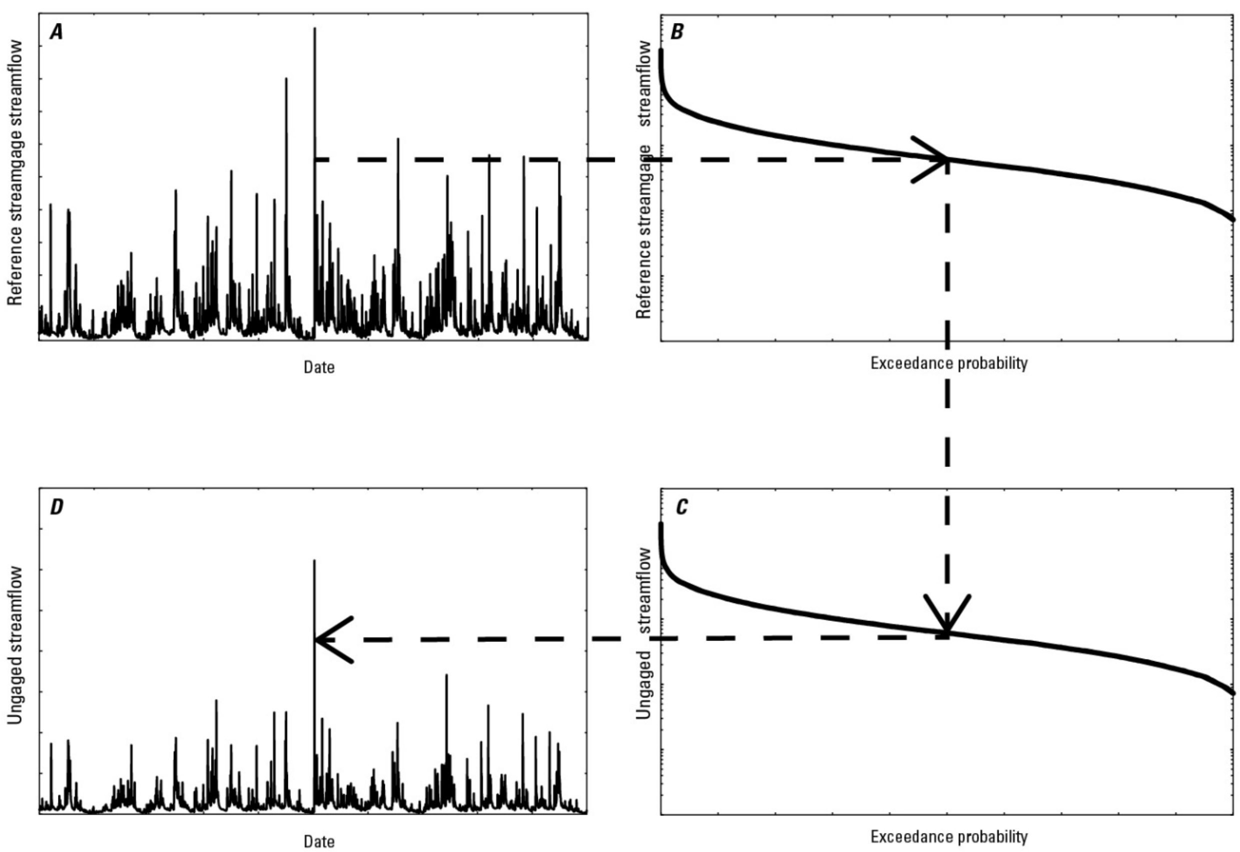


The NYSET equates the streamflow as a percentile from the flow-duration curve (FDC) for a particular day at an ungaged location with the streamflow as a percentile for the same day at a reference streamgage by applying a modified QPPQ (discharge-probability/ probability-discharge) method (Figure 3). The QPPQ method assumes equivalence of streamflow, as a percentile from the FDC for a particular day at a reference streamgage, where streamflow is measured, to the streamflow as a percentile from the FDC for the same day at an ungaged location (Fennessey 1994, Hughes and Smakhtin 1996, Smakhtin 1999, Smakhtin and Masse 2000, Mohamoud 2008, Archfield et al. 2010, Shu and Ourda 2012, Stuckey et al. 2012, Linhart et al. 2013).

Figure 3The QPPQ method (Fennessey 1994) used in the New York Streamflow Estimation Tool (NYSET)

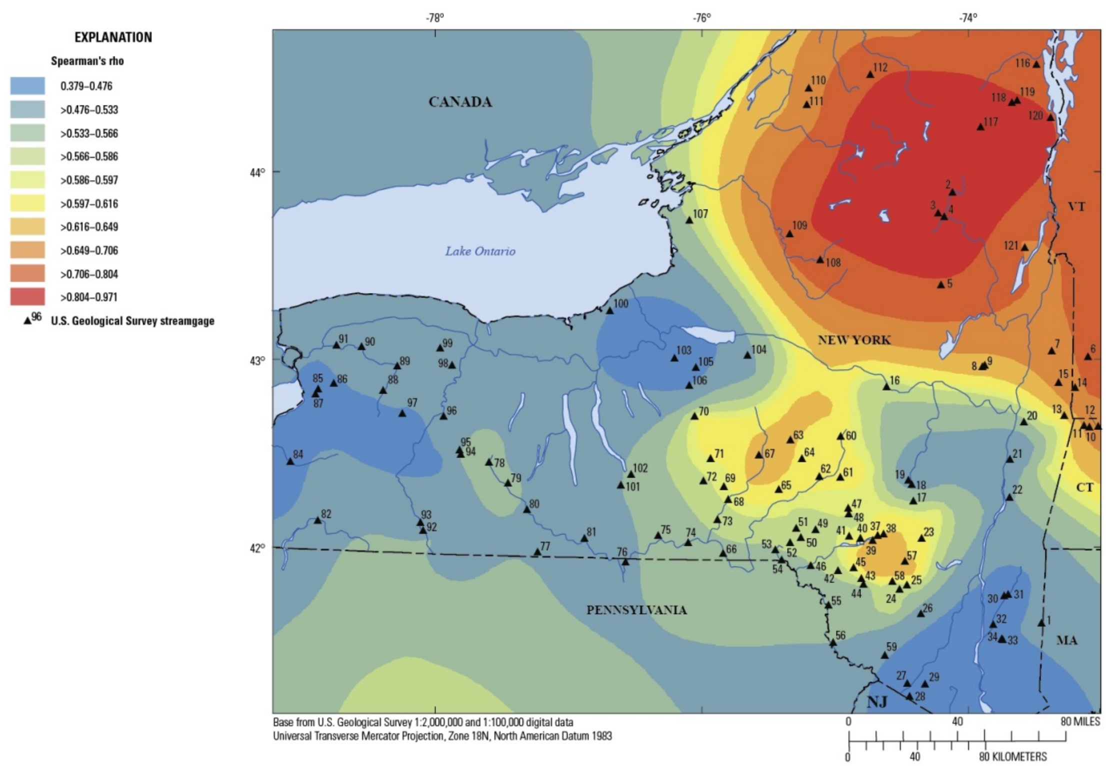
Showing *A,* observed daily mean streamflow at a reference streamgage, *B,* flow-duration curve at the reference streamgage, *C*, constructed flow-duration curve at the ungaged location, and *D,* estimated daily mean streamflow at the ungaged location.

Modified from Stuckey et al (2012).



Estimated streamflow correlations at ungaged locations, by map correlation, are used to select an appropriate reference streamgage for streamflow estimation (Archfield and Vogel 2010; Figure 4). The map correlation method was used for the selection of a reference streamgage with minimally altered streamflow in and near New York using a spherical variogram model (Archfield and Vogel 2010). Regression equations were developed using basin characteristics to predict flow-duration exceedance probabilities for 17 percentiles along the FDC with data from 90 streamgages. A complete daily FDC is constructed by interpolating between the 17 percentiles. The estimated FDC is used to select streamflow percentiles corresponding to percentiles at the reference streamgage.

Figure 4. Example correlation map for U.S. Geological Survey streamgage 01312000 (no. 2 on map), Hudson River near Newcomb, NY

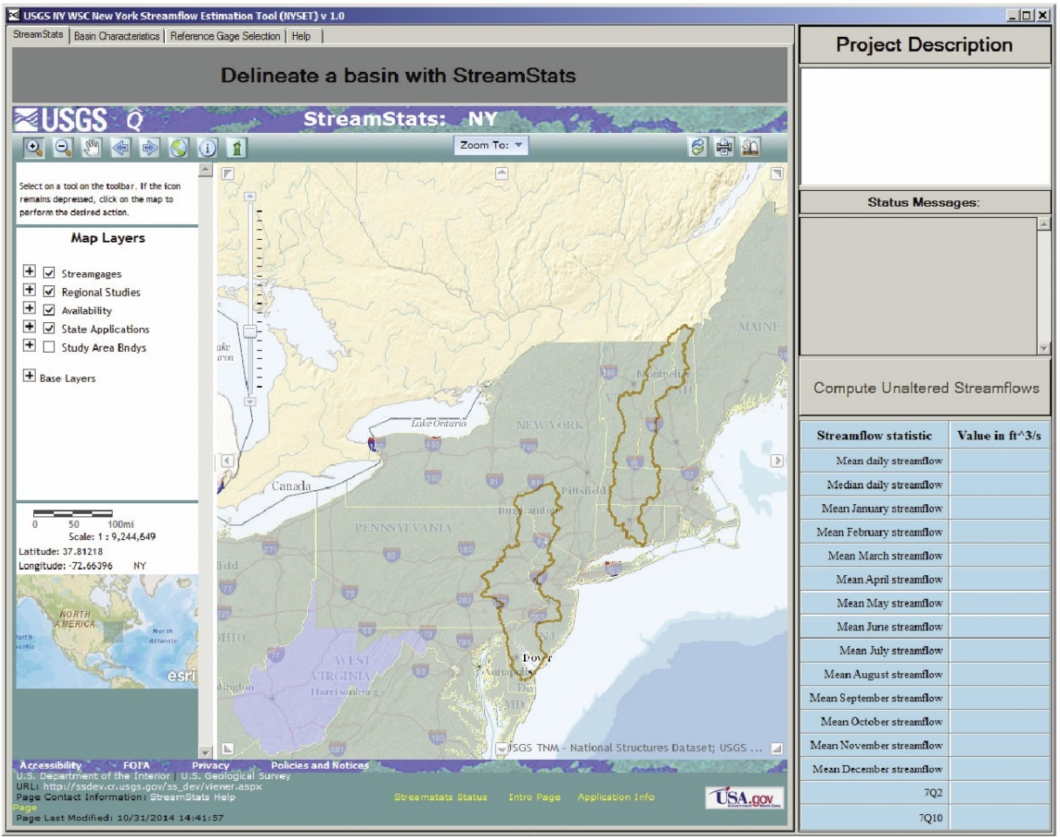


3 Using the NYSET

The NYSET generates daily mean streamflow estimates for a user-specified, ungaged location. Users can select a location, delineate the contributing drainage area and import basin characteristics to NYSET using the integrated USGS StreamStats interface (Figure 5). A reference streamgage is selected using the map correlation method as a default. The user has the option to make a manual selection. After a reference streamgage is identified, the NYSET then equates the percentiles at the gaged site with percentiles at the ungaged location for each date from October 1, 1960, to September 30, 2010. Regression equations and interpolation are used to convert the percentiles to streamflow at the ungaged location. The NYSET outputs a summary report in the form of a Microsoft Excel spreadsheet. This summary includes basin characteristic information for the ungaged location and reference streamgages, percent difference in basin characteristics between the two locations, and any warnings associated with the basin characteristics. Mean and median streamflows, 7Q2 (minimum 7-day, 2-year discharge), 7Q10 (minimum 7-day, 10-year discharge), and select monthly flow statistics are computed for the ungaged location. FDCs and hydrographs are presented for the ungaged location in cubic feet per second and cubic feet per second per square mile. The estimated daily flows for the ungaged location can be easily exported to a text file, which can be used in a statistical software package to determine additional daily streamflow statistics.

Estimates of streamflow by the NYSET are derived from regression equations, and streamflow estimates may not be valid for streams with basin characteristics outside the range used to develop the equations. Results from the NYSET also may not be valid where groundwater and surface-water divides are not coincident. Estimated streamflows produced by the NYSET do not include alterations to streamflow by regulation, mining, or other large water uses.

Figure 5. Screen capture of StreamStats main screen of the New York Streamflow Estimation Tool



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