Using the Surface Water Toolbox for Estimating Critical Flow Statistics

Webcast sponsored by EPA's Watershed Academy

Thursday, February 8, 2018

1:00pm – 3:00pm Eastern

Speakers:

- **Jenny Molloy,** Lead Environmental Protection Specialist, Water Permits Division, U.S. Environmental Protection Agency
- **Brian Nickel,** Environmental Engineer, Water Protection Division, Region 10, U.S. Environmental Protection Agency
- **Julie Kiang,** Supervisory Hydrologist, U.S. Geological Survey

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Webcast Logistics

- **To Ask a Question** – Type your question in the "Q&A" box on the right side of your screen and click the "Send" icon.
- **To Report Technical Issues** (such as audio problems) – Type your issue in the "Q&A" box on the right side of your screen and click the "Send" icon. We will respond by posting an answer in the same "Questions" box.

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Use of SW Toolbox for NPDES Permitting

By Brian Nickel
EPA Region 10
NPDES Permits Unit

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Permit Limits Overview

- NPDES permits contain the more stringent of two general types of limits for each parameter.
  - Technology-based (TBELs)
    - Based on the performance of available treatment technology and includes cost considerations.
  - Water Quality-based (WQBELs)
    - Derived from the ambient water quality standards necessary to meet water quality standards in the receiving water.
    - The cost of meeting water quality standards is not considered.

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Water Quality-based Effluent Limits (WQBELs)

- Water quality criteria include:
  - A magnitude (e.g., 10 μg/L)
  - An averaging period or duration, and
    - Most "acute" aquatic life criteria (also called criterion maximum concentrations or CMC) have an averaging period of 1 hour
    - Most "chronic" aquatic life criteria (also called criterion continuous concentrations or CCC) have an averaging period of 4 days.
  - An allowable excursion frequency.
    - Most aquatic life criteria have an allowable excursion frequency of once every three years.
  - Most human health criteria are based on a lifetime of exposure (~70 years).
- The goal of a WQBEL is to ensure compliance with all components of a water quality criterion (magnitude, duration, and frequency).

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Calculating WQBELs

- Dynamic modeling
  - Attempts to use "real" data or statistical distributions for effluent and receiving water characteristics to arrive at limits that match the magnitude, duration, and frequency components of the criteria.
    - These are more accurate than steady-state models, but are more complex and require much more data to implement.
- Steady-state modeling
  - This approach is simpler and requires much less data than dynamic modeling techniques.
  - This is the approach for which critical stream flow statistics are necessary (assuming that dilution is being considered).

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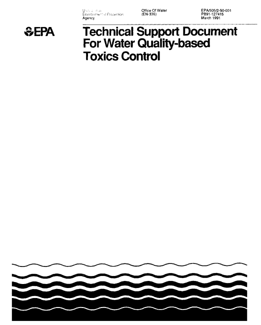
Background on Critical Flows

- The EPA's Technical Support Document for Water Quality-based Toxics Control (TSD) recommends critical flows for use in steady-state modeling.
  - Aquatic Life (Appendix D):
    - Hydrologically-based
      - 1Q10 for criterion maximum concentration (CMC or acute criteria)
      - 7Q10 for criterion continuous concentrate (CCC or chronic criteria)
    - Biologically-based
      - 1B3 for CMC/acute
      - 4B3 for CCC/chronic
      - Can be customized for any allowable averaging period and excursion frequency specified in the criteria.
  - Human Health (Section 4.6.2)
    - Harmonic Mean
      - 30Q5 for human health criteria for non-carcinogens was superseded by the "Revisions to the Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health" (65 FR 66444, November 3, 2000)
- Additional detail is provided in the Technical Guidance Manual for Performing Wasteload Allocations, Book VI: Design Conditions – Chapter 1: Stream Design Flow for Steady-State Modeling (1986).



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Why SW Toolbox?

- Easily find and download stream gauge data
  - Map-based tool
  - By station ID
- Import data from non-USGS sources
- Better understand your data
  - Find number of excursions below critical flows per three years
  - Detect outliers
  - Detect trends
  - Compare datasets
  - Produce graphs
    - Time-series
    - Frequency graphs

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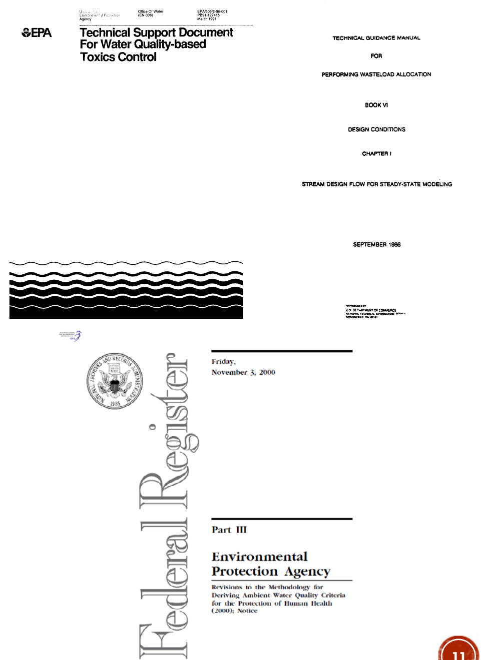
Further Reading

- Technical Support Document for Water Quality-based Toxics Control (1991) https://www3.epa.gov/npdes/pubs/owm0264.pdf
- Technical Guidance Manual for Performing Wasteload Allocations, Book VI: Design Conditions – Chapter 1: Stream Design Flow for Steady-State Modeling (1986) https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P100BK6P.txt
- Design flows for human health in Revisions to the Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health (2000) https://www.federalregister.gov/d/00-27924/p-166



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USGS-EPA SWTOOLBOX

Overview and Demo

February 8, 2018

Julie Kiang, USGS
Brian Nickel, EPA
Jenny Molloy, EPA

USGS
science for a changing world

Background

Joint EPA-USGS project on critical low flows
(7Q10 and biologically-based flows)

Goals:

- Improve and merge low flow software
- Investigate trends in low flows
- Test different regionalization methods

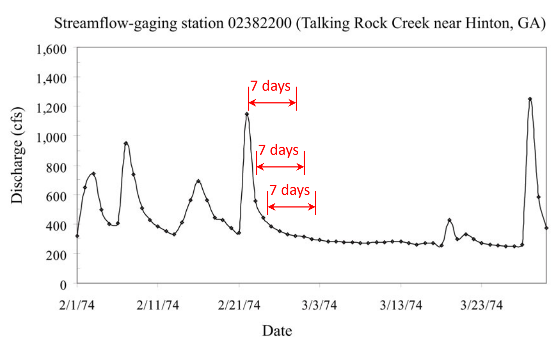
Critical Low Flows

- Hydrologically-based flow statistics
  - 7Q10
  - 7Q2
  - Etc.
- Biologically-based flow statistics
  - 1B3
  - 4B3
  - Etc.
- Harmonic Mean

2/16/2018

HYDROLOGICALLY-BASED FLOWS: 7Q10 (AND FRIENDS)

7Q10 Computation (part 1)



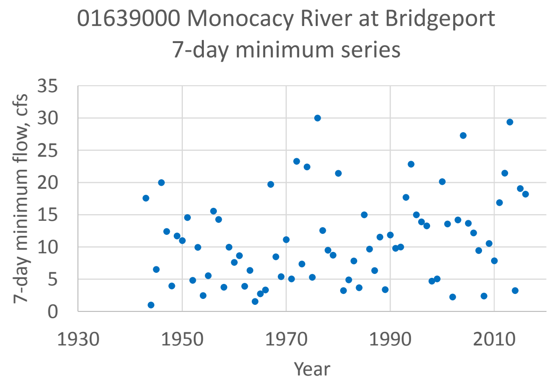
Climatic Year	Annual Q_7
1974	37.6
1975	68.4
1976	56.4
1977	40.4
1978	36.3
1979	82.9
1980	46.1
1981	26.6
1982	49.9
1983	54.1
1984	66.3
1985	41.6
1986	12.0
1987	9.7
1988	10.9
1989	78.9
1990	44.0
1991	57.6
1992	57.1
1993	27.6
1994	67.4
1995	28.6
1996	46.3
1997	45.0
1998	34.0
1999	38.0
2000	25.1
2001	36.3

<u>Procedure</u>:

- 7-day averaging window.
- Window moved to next consecutive day. All values recorded.
- Smallest value chosen to represent that climatic year.

HYDROLOGICALLY-BASED FLOWS

7Q10 Computation (part 2)



Procedure (cont.):

- Inspect time series
  - Obvious problems?
  - Trends?

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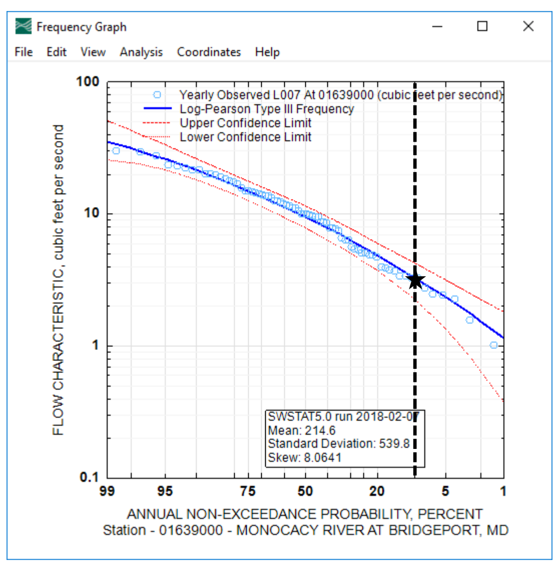
7Q10 Computation (part 3)

Procedure (cont.):

- Fit statistical distribution (Log-Pearson Type III)
  - Base 10 logarithms of time series used
  - Based on mean, standard deviation and skew
  - Conditional probability adjustment required for zero flows



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Other hydrologically-based flows used same procedure, but:

- Different averaging window
- Different non-exceedance probability and return period

For example:

7Q2: 7-day minimum, 2-year return period
(50% non-exceedance probability)

30Q2: 30-day minimum, 2-year return period
(50% non-exceedance probability)

Note that a similar procedure is used for peak flow frequency analysis.

BUT, there are additional “extensions” and details that are NOT implemented in SWToolbox.

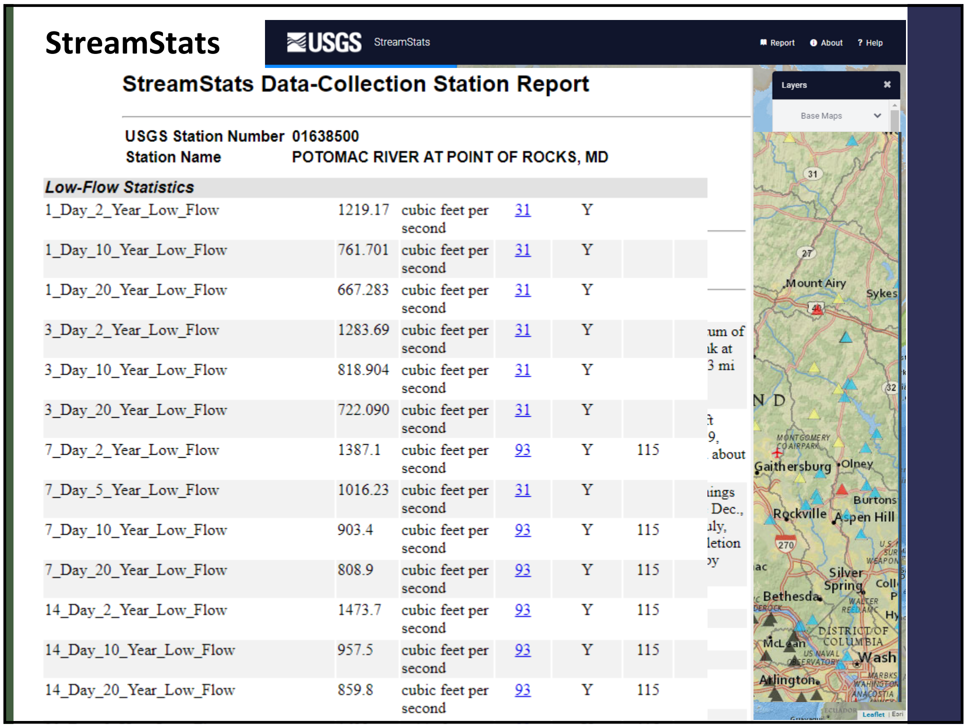
For additional info (upcoming)

Publication: *Bulletin 17C Guidelines for Determining Flood Flow Frequency*

USGS software: PeakFQ

Key takeaway:

SWToolbox is NOT for flood frequency analysis.



StreamStats

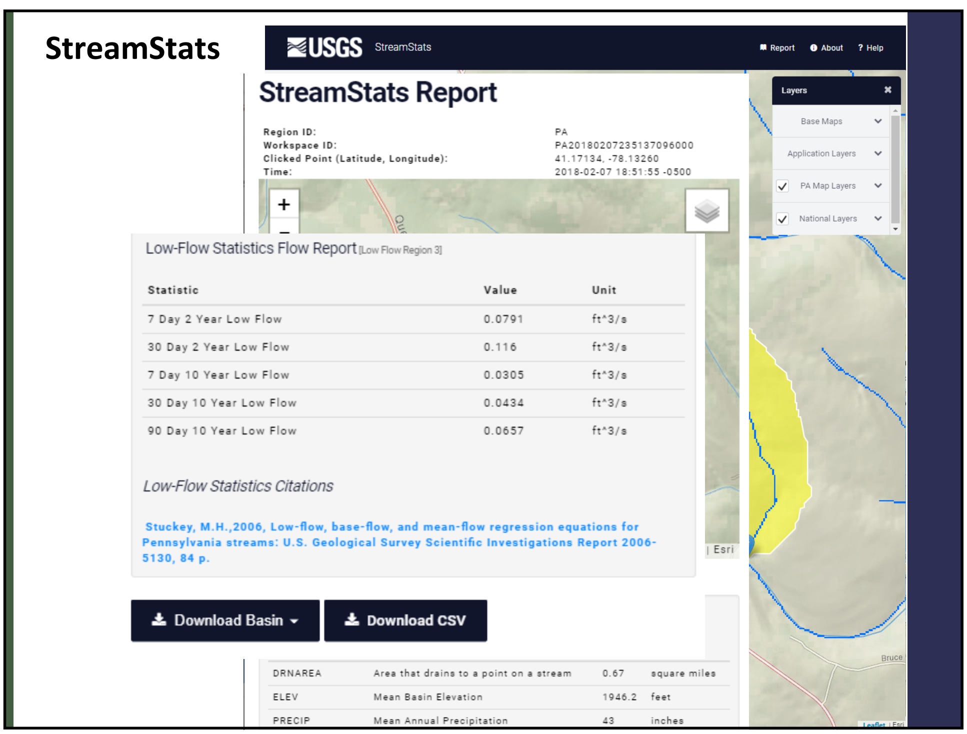
USGS StreamStats Report About Help

StreamStats Data-Collection Station Report

USGS Station Number 01638500
Station Name POTOMAC RIVER AT POINT OF ROCKS, MD

Low-Flow Statistics

1_Day_2_Year_Low_Flow	1219.17	cubic feet per second	31	Y	
1_Day_10_Year_Low_Flow	761.701	cubic feet per second	31	Y	
1_Day_20_Year_Low_Flow	667.283	cubic feet per second	31	Y	
3_Day_2_Year_Low_Flow	1283.69	cubic feet per second	31	Y	
3_Day_10_Year_Low_Flow	818.904	cubic feet per second	31	Y	
3_Day_20_Year_Low_Flow	722.090	cubic feet per second	31	Y	
7_Day_2_Year_Low_Flow	1387.1	cubic feet per second	93	Y	115
7_Day_5_Year_Low_Flow	1016.23	cubic feet per second	31	Y	
7_Day_10_Year_Low_Flow	903.4	cubic feet per second	93	Y	115
7_Day_20_Year_Low_Flow	808.9	cubic feet per second	93	Y	115
14_Day_2_Year_Low_Flow	1473.7	cubic feet per second	93	Y	115
14_Day_10_Year_Low_Flow	957.5	cubic feet per second	93	Y	115
14_Day_20_Year_Low_Flow	859.8	cubic feet per second	93	Y	115



StreamStats

USGS StreamStats Report About Help

StreamStats Report

Region ID:	PA
Workspace ID:	PA20180207235137096000
Clicked Point (Latitude, Longitude):	41.17134, -78.13260
Time:	2018-02-07 18:51:55 -0500

Low-Flow Statistics Flow Report [Low Flow Region 3]

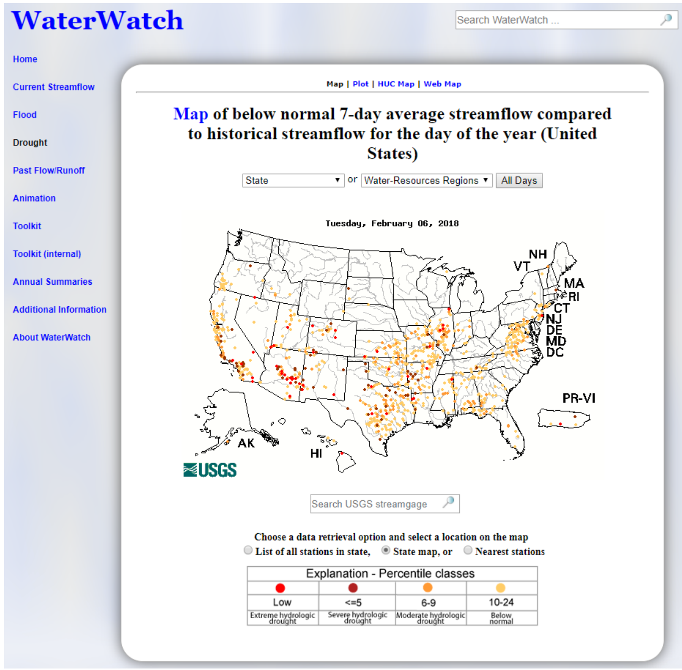
Statistic	Value	Unit
7 Day 2 Year Low Flow	0.0791	ft^3/s
30 Day 2 Year Low Flow	0.116	ft^3/s
7 Day 10 Year Low Flow	0.0305	ft^3/s
30 Day 10 Year Low Flow	0.0434	ft^3/s
90 Day 10 Year Low Flow	0.0657	ft^3/s

Low-Flow Statistics Citations

Stuckey, M.H.,2006, Low-flow, base-flow, and mean-flow regression equations for Pennsylvania streams: U.S. Geological Survey Scientific Investigations Report 2006-5130, 84 p.

Download Basin | Download CSV

DRNAREA	Area that drains to a point on a stream	0.67	square miles
ELEV	Mean Basin Elevation	1946.2	feet
PRECIP	Mean Annual Precipitation	43	inches



waterwatch.usgs.gov → Drought → 7-day Below Normal Streamflow

BIOLOGICALLY-BASED FLOWS: 1B3 (AND FRIENDS)

Biologically-based flows

Developed by U.S. EPA ORD

Determined by computing the frequency of excursions below the design-flow threshold.

- Different averaging periods
  Examples: 1-day, 4-day, 30-day
- Average frequency of excursions allowed
  Example: once every 3 years

1B3: 1-day averaging, excursions once every 3 years

4B3: 4-day averaging, excursions once every 3 years

Additional details in EPA docs.

Harmonic mean

Recipricol of the mean of the recipricols

$$H = \frac{n}{\frac{1}{x_1} + \frac{1}{x_2} + \cdots \frac{1}{x_n}}$$

Where:

n is the number of data points

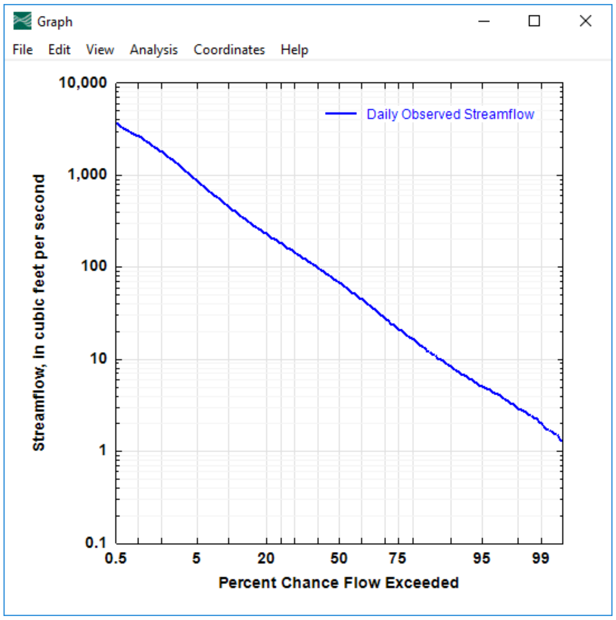
x_1 through x_n are the data points.

FLOW DURATION CURVE (AND FRIENDS)

Flow Duration Curve

- Flow duration values: percentage of time a given flow is equaled or exceeded.
- Flow duration curve: Graphical representation of the flow-duration values for a station, usually plotted as log-probability graph
- Can be computed from daily, weekly, monthly, seasonal, annual, or other values from:
  - The entire period of record
  - A portion of the period of record selected to represent a particular condition

Flow Duration Curve



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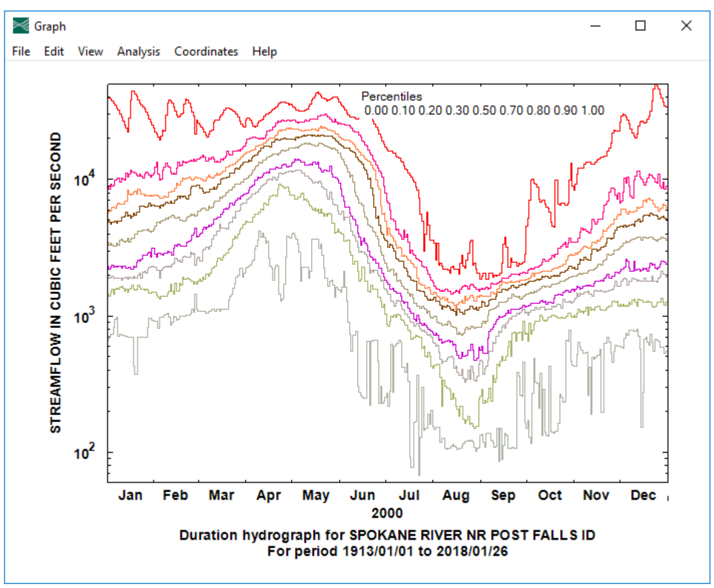
FLOW-DURATION CURVE

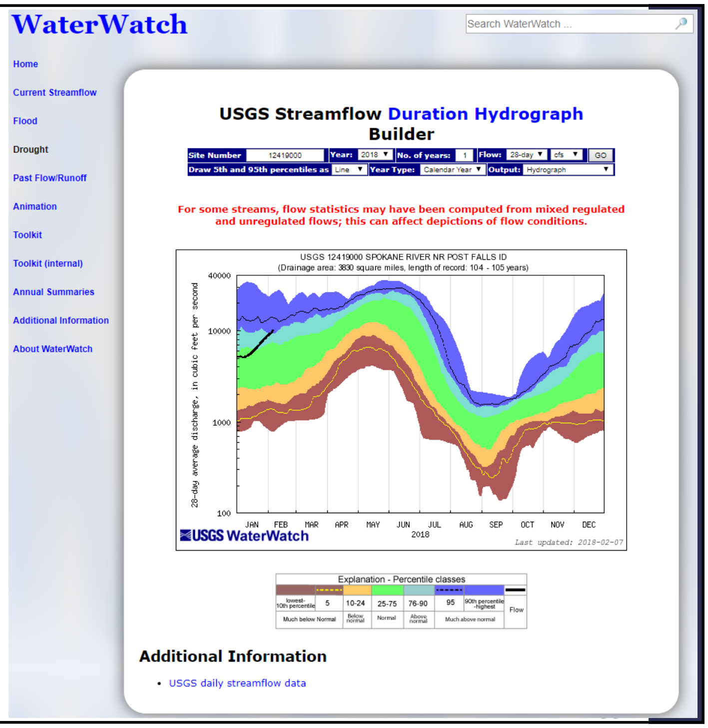
Duration Hydrograph



Shows flow percentiles for each day of the year.

FLOW-DURATION CURVE

waterwatch.usgs.gov
→ Drought (or Toolkit)
→ Site Duration Hydrograph



SWTOOLBOX

Surface Water Toolbox (SWToolbox)

- USGS SWSTAT
- EPA DFLOW

} SWTOOLBOX

- Primary functions:
  - Critical low flow computation
  - Flow duration computation
- Built in EPA BASINS (MapWindows) environment
  - USGS Ground Water Toolbox – same environment (http://water.usgs.gov/ogw/gwtoolbox/)

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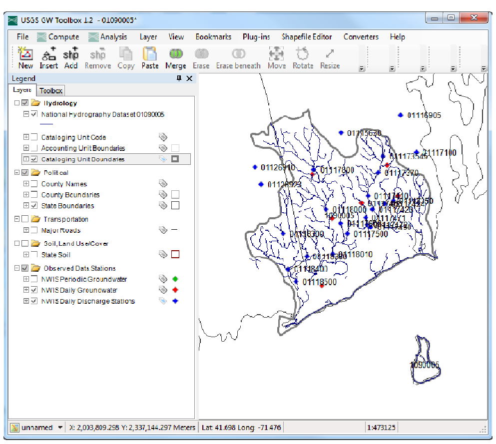
USGS Groundwater Toolbox (GWToolbox)



- Initial release January 2015
- NWISWeb:
  - Daily Discharge
  - Daily Groundwater levels
  - Periodic Groundwater levels
- Hydrograph Separation
  - PART
  - HYSEP
  - BFI
  - Digital Filters (SWAT Bflow, Eckhardt)
- Recession Constants
  - RECESS
  - Correlation method
- Recharge Estimation
  - RORA

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SWToolbox

- Others who have contributed to software development:
  - Kate Flynn (retired, USGS)
  - Greg Granato (USGS New England WSC)
  - RESPEC consultants, particularly Paul Hummel and Tong Zhai
  - Software testers, many from EPA.

Enhancements over previous SWSTAT and DFLOW

- CONSISTENCY between two agency programs
- Better graphics
- Output reports to document analysis
- Screening tools for time series
- More flexibility (data sources)

Timeline

<u>User Manual</u>

- Initial layout done.
- Will have copy for review next week.

<u>Software Release</u>

- Working out problem with R scripting (works on some computers, not others)
- Doing final testing of latest build (from last week)

Release both by end of month.

2/16/2018

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Getting Started – build project

- Similar to EPA BASINS
- Select region of interest and Build project
- A number of coverages are downloaded
  - NWIS Daily Discharge Stations – automatic
- Select stations and use File/Data Download option to retrieve the USGS discharge data

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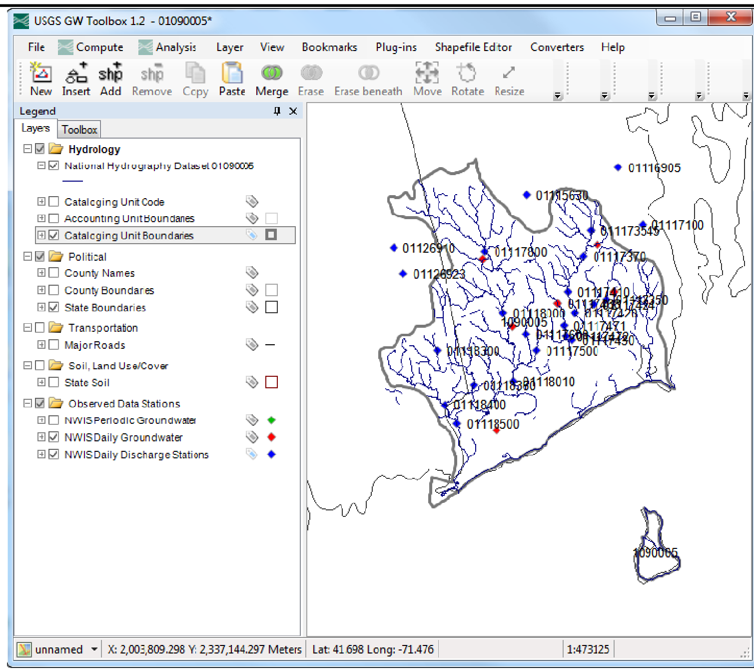
USGS GW Toolbox 1.2 - 01090005*
File
Compute
Analysis
Layer
View
Bookmarks
Plug-ins
Shapefile Editor
Converters
Help
New
Insert
Add
Remove
Copy
Paste
Merge
Erase
Erase beneath
Move
Rotate
Resize
Legend
Layers
Toolbox
Hydrology
National Hydrography Dataset 01090005
Cataloging Unit Code
Accounting Unit Boundaries
Cataloging Unit Boundaries
Political
County Names
County Boundaries
State Boundaries
Transportation
Major Roads
Soil, Land Use/Cover
State Soil
Observed Data Stations
NWIS Periodic Groundwater
NWIS Daily Groundwater
NWIS Daily Discharge Stations
unnamed
X: 2,003,809.298 Y: 2,337,144.297 Meters
Lat: 41.698 Long: -71.476
1:473125

LAUNCH DEMO…

QUESTIONS?

SWToolboxTesting@usgs.gov

Questions?

- Please use the “Questions” box on the right slide of your screen.
- Time permitting, we will answer as many questions as we can.

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Speaker Contact Information

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Next Watershed Academy Webcast

Check back with us at www.epa.gov/watershedacademy for more details!

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Participation Certificate

https://www.epa.gov/sites/production/files/2018-02/documents/watershed_acad_webcast_certificate_020818_508.pdf

You may also download it from the "Downloads" pod.

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Thank You!

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