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

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.

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Use of SW Toolbox for NPDES Permitting

By Brian Nickel
EPA Region 10
NPDES Permits Unit

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.
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).

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).
Background on Critical Flows

  - Aquatic Life (Appendix D):
    - Hydrologically-based
      - 1Q10 for criterion maximum concentration (CMC or acute criteria)
      - 7Q10 for criterion continuous concentration (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)

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
Further Reading


  https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P100BK6P.txt

  https://www.federalregister.gov/d/00-27924/p-166

USGS-EPA SWTOOLBOX
Overview and Demo February 8, 2018

Julie Kiang, USGS
Brian Nickel, EPA
Jenny Molloy, EPA
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
HYDROLOGICALLY-BASED FLOWS: 7Q10 (AND FRIENDS)

7Q10 Computation (part 1)

Procedure:
• 7-day averaging window.
• Window moved to next consecutive day. All values recorded.
• Smallest value chosen to represent that climatic year.
7Q10 Computation (part 2)

Procedure (cont.):
- Inspect time series
  - Obvious problems?
  - Trends?

7Q10 Computation (part 3)

Procedure (cont.):
- Fit statistical distribution (Log-Pearson Type III)
- Based on mean, standard deviation and skew
- Conditional probability adjustment required for zero flows
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 Data-Collection Station Report

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

<table>
<thead>
<tr>
<th>Low-Flow Statistics</th>
<th>Value</th>
<th>Unit</th>
</tr>
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<tbody>
<tr>
<td>1_day_2_Year_Low_Flow</td>
<td>1219.17</td>
<td>cubic feet per second</td>
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<tr>
<td>1_day_10_Year_Low_Flow</td>
<td>761.701</td>
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<tr>
<td>1_day_20_Year_Low_Flow</td>
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<td>3_day_2_Year_Low_Flow</td>
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<tr>
<td>14_day_30_Year_Low_Flow</td>
<td>859.8</td>
<td>cubic feet per second</td>
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</tbody>
</table>

**StreamStats Report**

**Region ID**:  
**Station ID**:  
**Gauge Point (Latitude, Longitude)**:  
**Time**:  
**Reference**: Pa.  
**Phone**: 800-654-3627  
**Date Range**: December 16-17, 2009

**Low-Flow Statistics Flow Report**

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 day 2 year low flow</td>
<td>0.0791</td>
<td>ft³/s</td>
</tr>
<tr>
<td>30 day 2 year low flow</td>
<td>0.116</td>
<td>ft³/s</td>
</tr>
<tr>
<td>7 day 10 year low flow</td>
<td>0.0305</td>
<td>ft³/s</td>
</tr>
<tr>
<td>90 day 10 year low flow</td>
<td>0.0484</td>
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</tr>
<tr>
<td>40 day 10 year low flow</td>
<td>0.0557</td>
<td>ft³/s</td>
</tr>
</tbody>
</table>

**Low-Flow Statistics Citations**

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

Reciprocal of the mean of the reciprocals

\[ H = \frac{n}{\frac{1}{x_1} + \frac{1}{x_2} + \ldots + \frac{1}{x_n}} \]

Where:

- \( n \) is the number of data points
- \( x_1 \) through \( x_n \) are the data points.
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 a 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

Shows flow percentiles for each day of the year.
For some streams, flow statistics may have been computed from unregulated and unregulated flows; this can affect perceptions of flow conditions.

**Additional Information**
- USGS data streamflow data.
Surface Water Toolbox (SWToolbox)

- USGS SWSTAT
- EPA DFLOW

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/)

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
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)
User Manual
• Initial layout done.
• Will have copy for review next week.

Software Release
• 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.

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
LAUNCH DEMO...
Questions?

• Please use the “Questions” box on the right slide of your screen.

• Time permitting, we will answer as many questions as we can.

QUESTIONS?

SWToolboxTesting@usgs.gov
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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!

Participation Certificate


You may also download it from the “Downloads” pod.
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Thank You!