User's Guide for the Delaware River Basin Streamflow Estimator Tool (DRB-SET)
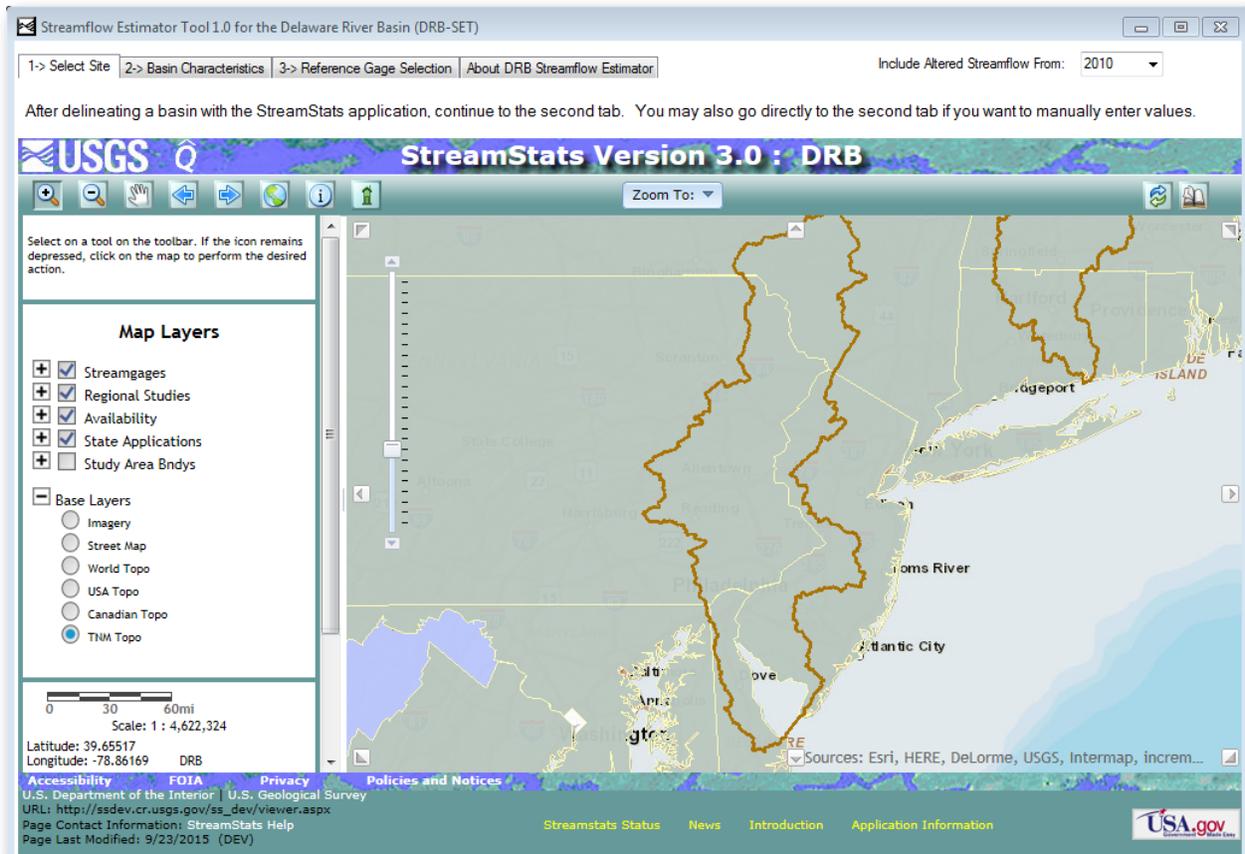
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U.S. Department of the Interior
U.S. Geological Survey

Cover.   Screen capture of the opening screen of DRB-SET.

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By Marla H. Stuckey and James E. Ulrich

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U.S. Geological Survey
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Conversion Factors

Inch/Pound to SI

Multiply	By	To obtain
Length		
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
Area		
acre	4,047	square meter (m^2)
square mile (mi^2)	259.0	hectare (ha)
square mile (mi^2)	2.590	square kilometer (km^2)
Flow rate		
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
cubic foot per second per square mile [(ft^3/s)/mi^2]	0.01093	cubic meter per second per square kilometer [(m^3/s)/km^2]
cubic foot per day (ft^3/d)	0.02832	cubic meter per second (m^3/s)
gallon per day (gal/d)	0.003785	cubic meter per day (m^3/d)
gallon per day per square mile [(gal/d)/mi^2]	1,233	cubic meter (m^3)
million gallons per day (Mgal/d)	0.001233	cubic hectometer (hm^3)
inch per hour (in/h)	0.0254	meter per hour (m/h)
inch per year (in/yr)	25.4	millimeter per year (mm/yr)
Hydraulic conductivity		
foot per day (ft/d)	0.3048	meter per day (m/d)

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

°C=(°F-32)/1.8

Vertical coordinate information is referenced to North American Vertical Datum of 1988 (NAVD 88).

Horizontal coordinate information is referenced to North American Datum of 1983 (NAD 83).

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Introduction

The Delaware River Basin Streamflow Estimator Tool (DRB-SET, v. 1.0) is a tool for the simulation of streamflow at a daily time step for an ungaged stream location in the Delaware River Basin for water years[1] 1960–2010. DRB-SET was developed by the U.S. Geological Survey (USGS) and funded through WaterSMART as part of the National Water Census, a USGS research program on national water availability and use that develops new water accounting tools and assesses water availability at regional and national scales. DRB-SET uses a QPPQ approach (Fennessey, 1994; Archfield and others, 2010; Stuckey and others, 2014), which relates probability exceedances at a gaged location to those at an ungaged stream location. Once the ungaged stream location has been identified by the user, an appropriate streamgage is automatically selected in DRB-SET using streamflow correlation (map correlation method). Alternately, the user can manually select a streamgage or use the closest streamgage. The streamgage selected, termed the "reference" streamgage, in addition to having a strong correlation with streamflow in the ungaged subbasin, needs to be representative of the ungaged basin with similar hydrologic and basin characteristics and have streamflow that is minimally altered by human activities. A report file is generated documenting the reference streamgage and ungaged stream location information, basin characteristics, any warnings, baseline (minimally altered) and altered (affected by regulation, diversion, mining, or other anthropogenic activities) daily mean streamflow, and the mean and median streamflow. The estimated daily flows for the ungaged stream location can be easily exported as a text file that can be used as input into a statistical software package to determine additional streamflow statistics, such as flow duration exceedance or streamflow frequency statistics.

Computer Requirements and Installation Instructions

An active internet connection is required to download and install DRB-SET, and to use the map selection interface. Microsoft Excel® 97-2010 (or later), Microsoft.NET Framework 4.0 (x86 and x64), and Windows Installer 3.1 are required on the machine running DRB-SET. To install DRB-SET, download the setup file from: http://paapps.er.usgs.gov/apps/drb-set/ or http://dx.doi.org/10.3133/ofr20151192. Install DRB-SET by double clicking on the downloaded "setup.exe". Administrative privileges are not typically required to install/uninstall this application, unless the .net framework is not already installed. After launching setup.exe, the program checks for prerequisites and will notify you of any problems or missing software. After successful installation, the program will be in your start menu in a folder named "USGS PA WSC," and a shortcut will be created on your desktop. The associated report by Stuckey (2016) documenting the methodology used in DRB-SET can be downloaded from the USGS Publications Warehouse.

Entering Input Data for DRB-SET

DRB-SET requires basin characteristics for the ungaged stream location to be entered before computing daily mean streamflow. The opening screen of DRB-SET displays the DRB StreamStats application (fig. 1), in which users can zoom to an ungaged stream location within the Delaware River Basin, delineate a basin, and obtain basin characteristics. Users must zoom to a scale of 1:24,000 or larger before the delineation icon is available for use (black circle with cross). Click on the delineation icon and click on the point on the stream to delineate the basin and compute basin characteristics. Do not close the StreamStats delineation box. The computed basin characteristics are automatically entered into DRB-SET Basin Characteristics table under tab 2 (fig. 2). More information on StreamStats, including instructions for

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[1] Water year (WY) is defined as a 12-month period beginning October 1 and ending September 30. The water year is designated by the calendar year in which it ends.

use, can be found at http://water.usgs.gov/osw/streamstats/ or Ries and others (2008).

Users can also go directly to tab 2 and manually enter the basin characteristics or use the StreamStats webservice. To use the StreamStats webservice, an outlet latitude and longitude in decimal degrees must be entered. Then click on the box at the top titled "Import from StreamStats Web Service." The computed basin characteristics are automatically populated in DRB-SET when utilizing this option. The delineated basin and computed basin characteristics can be downloaded as an Arc GIS geodatabase (version 10 or later) from tab 2 Basin Characteristics by clicking on the Download Basin GDB button.

The following basin characteristics are required to compute daily mean streamflow: latitude at the outlet, drainage area, mean annual precipitation, mean winter precipitation, saturated hydraulic conductivity, percentages of poorly drained soil and sand in soil, x-location in decimal degrees at the center of the basin, and y-location in decimal degrees

at the center of the basin. More information about these basin characteristics, including data sources, can be found in Stuckey (2016). The range of values for each basin characteristic used to develop the regression equations is shown in the table under tab 2. A warning message will appear if the basin characteristic value entered is outside this range, indicating the resulting flow-duration estimates determined from regression equations may not be valid. When determining the basin characteristics outside of StreamStats, it is important to use the same data source as was used to develop the regression equations for determination of the basin characteristics to maintain consistent accuracy in the regression estimates.

Text describing the ungaged watershed can be entered by clicking in the box Ungaged Site Description and entering text. This text will appear in the report file discussed in the next section "Running DRB-SET." To clear entered basin characteristics from the Basin Characteristics table under tab 2, click on the Clear Form button at the top of the page.
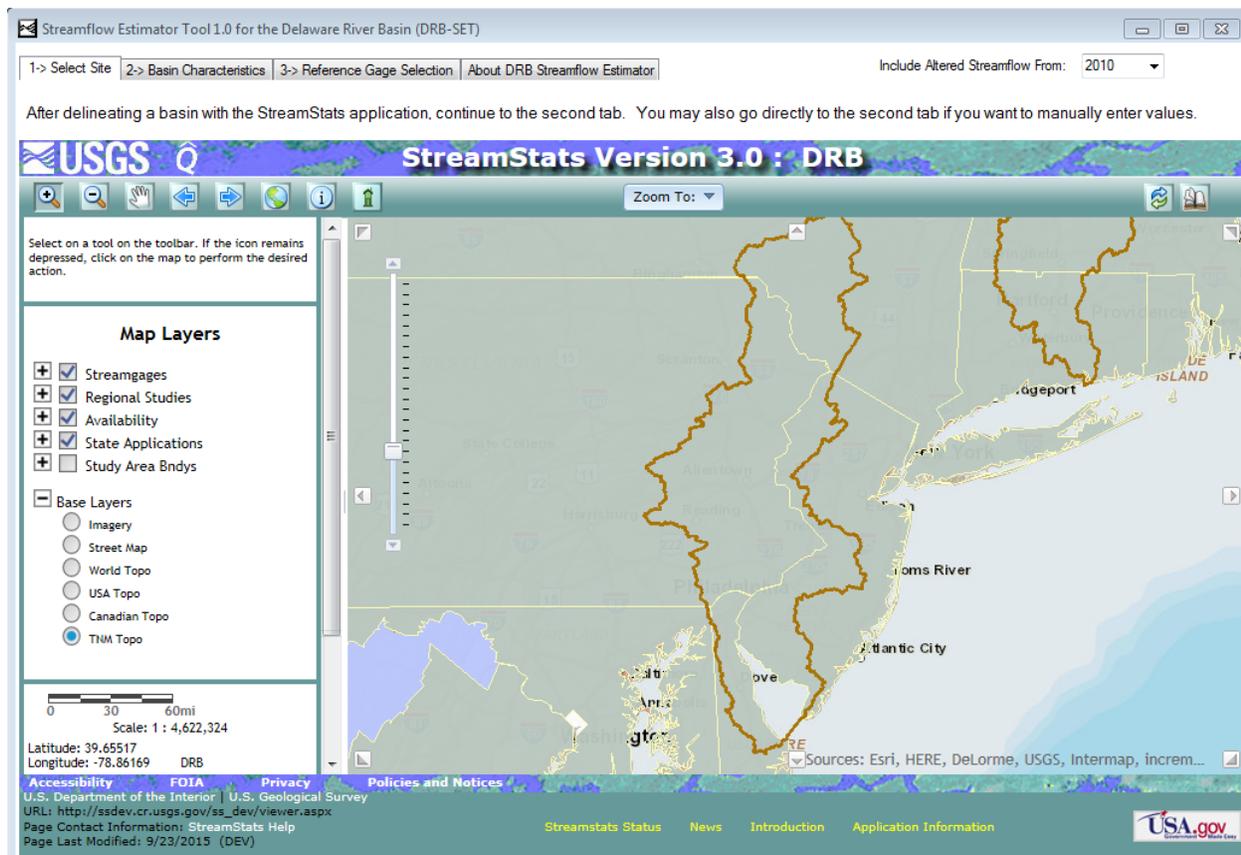

Figure 1.   The opening screen of DRB-SET.

Figure 2. Basin Characteristics table in DRB-SET.

Running DRB-SET

After basin characteristics have been entered in the Basin Characteristics table under tab 2, the reference streamgage selection method can be selected and daily mean streamflow can be computed. By default, DRB-SET uses map correlation to select an appropriate reference streamgage. If a different method is preferred, the reference streamgage selection method can be changed under tab 3 (fig. 3). To manually select the reference streamgage, uncheck the Use Map Correlation box and scroll down the list of streamgages to choose a reference streamgage. To use the closest streamgage to the ungaged stream location, click on the Use Closest Gage box.

Under tabs 1–3, at the top right corner, the year from which the water use has been compiled can be selected. Water use data include withdrawals and return flows within the selected subbasin. Currently (2015), only water use data from 2010 are available in StreamStats and DRB-SET, but the functionality exists to add other data sets in the future. Informational text can be found under the About DRB Streamflow Estimator tab at the top of the tool.

After basin characteristics have been entered for the ungaged stream location and any changes have been made

to the reference streamgage selection method, click on the Compute Daily Mean Streamflow button to compute baseline and altered daily flows. This button is found on either tab 2 Basin Characteristics or tab 3 Reference Gage Selection. The user will have to agree to the disclaimer that appears before continuing (fig. 4). The computation of daily flows will take a few minutes, depending on the computing capacity of your computer. A status bar indicates progress. When computations are completed, a window will open (may be behind other open screens) asking the user to save the resulting Microsoft Excel® file. Text in the Status Messages box in DRB-SET will alert users that the file is ready to be saved. This Microsoft Excel® file is the output from the tool. After saving the file, close the file before attempting to run DRB-SET for another location. DRB-SET may not function properly when this file is open.

The output Microsoft Excel® file contains worksheets titled BasinCharacteristics, ReferenceGageSelection, ContinuousFlowDuration, ContinuousDailyFlow, Report, and WaterUse. The BasinCharacteristics worksheet is a copy of the Basin Characteristics table from tab 2 in DRB-SET. The ReferenceGageSelection worksheet lists information about the reference streamgage selected and four other reference
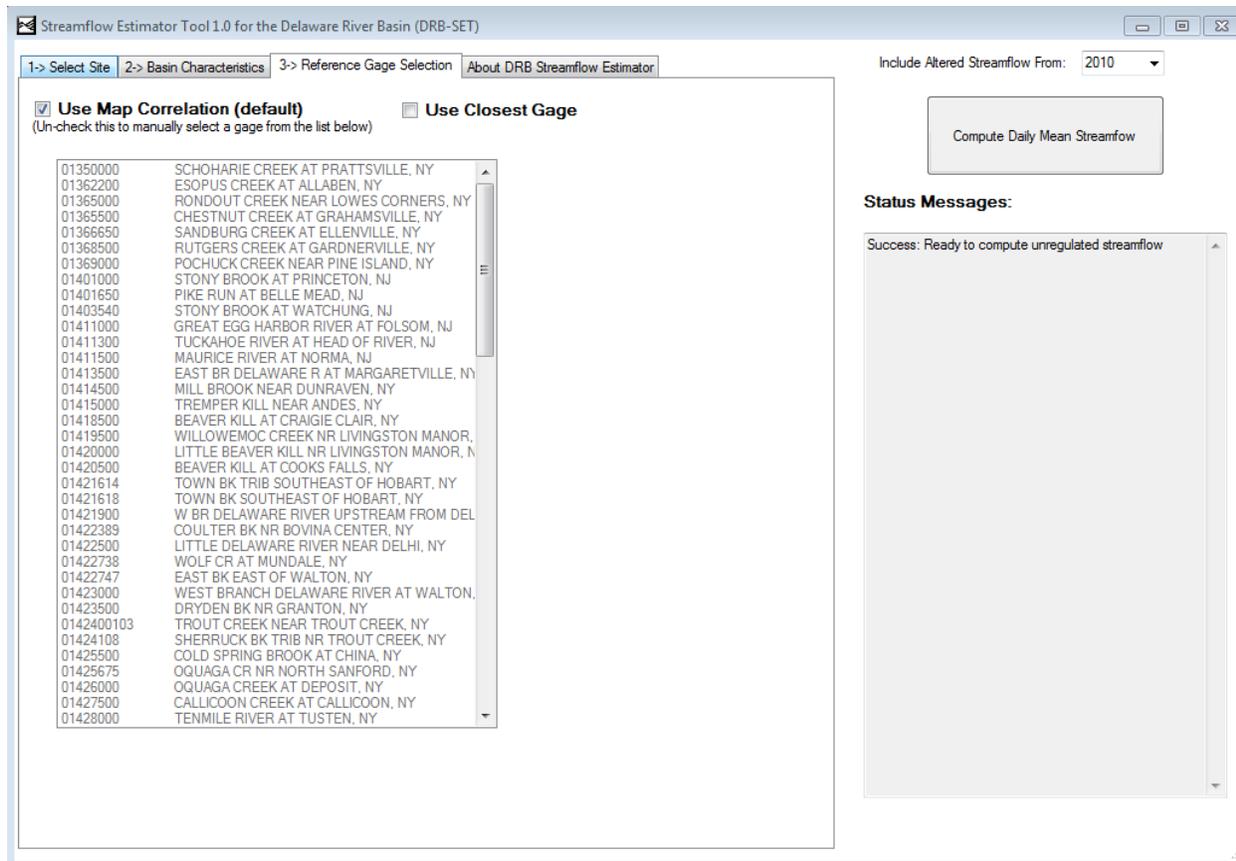
Figure 3.   Reference Gage Selection tab in DRB-SET.
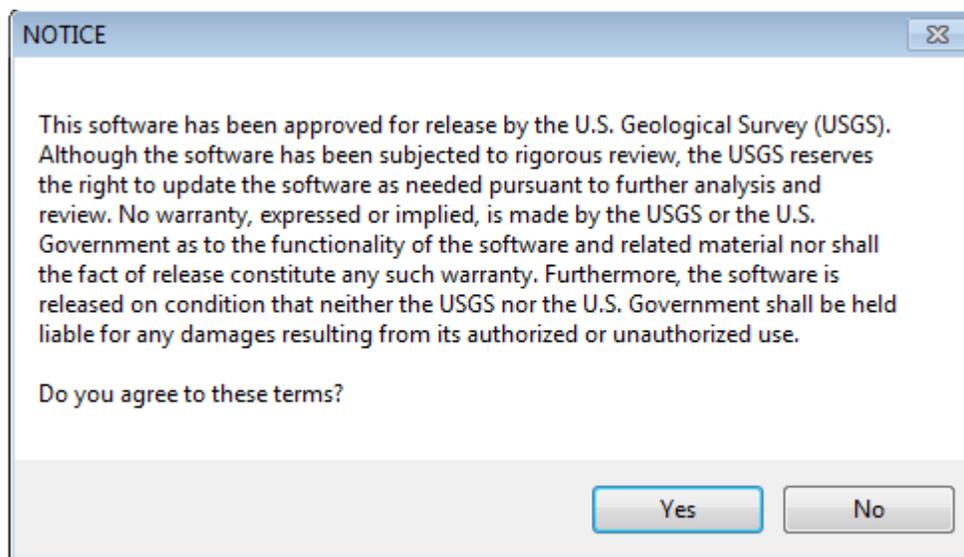

Figure 4.   Disclaimer from DRB-SET.

streamgages with the highest correlations (Spearman's rho) to the ungaged stream location. The distances between the ungaged stream location and reference streamgages are listed in the table and can be used to evaluate the appropriateness of the selected streamgage. If the Use Closest Gage was selected in order to choose the reference streamgage, the five closest streamgages will be listed. The exceedance probabilities for the reference streamgage and ungaged stream location will be listed in the ContinuousFlowDuration worksheet. The daily mean streamflow for the reference streamgage and the estimated streamflow (both baseline and altered) for the ungaged stream location will be listed in the ContinuousDailyFlow worksheet.

The Report worksheet (fig. 5) lists the basin characteristics for the reference streamgage and ungaged stream location and the mean and median streamflow for the period 10/1/1959–09/30/2010 (water years 1960–2010). The Report worksheet plots the flow duration curve and hydrograph for the ungaged location. To save the estimated baseline and altered daily flows and dates for the ungaged stream location as a text file, click on the Export Daily Values button on the Report worksheet. Macros need to be enabled to use this feature. To enable macros, click on Enable Content from the

message bar or under File, Info, Security Warning, Enable Content, select Enable All Content.

The WaterUse worksheet (fig. 6) lists the water use (both withdrawal and returns) in the ungaged basin. Return flows are listed annually and by month. Withdrawals are listed annually, monthly, and by water-use categories. Withdrawal categories include water supply, self-supplied domestic, industrial, irrigation, livestock, mining, power/hydroelectric, remediation, sewage treatment, thermoelectric, aquaculture, and commercial. More information about the categories and water use compilation can be found in Hutson and others (in press). The mean and median altered streamflow at the ungaged stream location for the period from 10/1/1959–09/30/2010 (water years 1960–2010) are listed, and plots of the flow duration curve and hydrograph, both baseline and altered, for the ungaged stream location are shown. To save the estimated altered daily flows and dates for the ungaged stream location as a text file, click on the Export Daily Values button on the Report worksheet. Macros need to be enabled to use this feature. To enable macros, click on Enable Content from the message bar or under File, Info, Security Warning, Enable Content, select Enable All Content.

USGS DRB Streamflow Estimator Tool

Summary Report by: mstuckey   Date: 5/16/16 3:05 PM

Ungaged Site Description:

Reference streamgage: 01472157 French Creek near Phoenixville, Pa. 1969-2008

Correlation coefficient: 0.85

Distance, in miles: 33.67   Streamflow estimates may not be valid for distances > 75 miles

Basin characteristics	Reference streamgage	Ungaged site	Range*	Units	Percent difference from reference gage
Outlet latitude	40.15	40.15	38.638861 - 42.450968	decimal degrees	---
Outlet longitude	---	-74.92		decimal degrees	---
Drainage Area	59.04	217.00	.61 - 2235	miles squared	267.55
Poorly drained soil	10.75	12.60	0 - 47.8	percent	17.19
Sand in soil	35.20	23.20	17.6 - 86.5	percent	-34.10
Mean annual precipitation	46.27	47.90	42.6 - 59.2	inches	3.51
Mean winter precipitation	3.29	3.36	2.69 - 4.29	inches	1.99
Saturated Hydraulic Conductivity	19.84	13.20	3.5 - 120.9	micrometers per second	-33.48
X-location at the center of the basin	1698846.64	1748381.40		Albers meters	---
Y-location at the center of the basin	2087234.54	2109216.40		Albers meters	---

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

Baseline streamflow statistics for ungaged site

Mean daily streamflow	343.65 cubic ft per second (ft³/s)
Median daily streamflow	192.32 cubic ft per second (ft³/s)

Figure 1. Flow-duration curve in cubic feet per second for ungaged site under baseline flow conditions.

Figure 2. Baseline hydrograph in cubic feet per second for ungaged site.

Figure 5. Report worksheet from DRB-SET.

USGS DRB Streamflow Estimator Tool
Water Use Data: 2010

	Annual Daily Average Return (Mgal/D)	Annual Daily Average Withdrawal (Mgal/D)	
	Total		WS = Water Supply
			DO = self-supplied DOmestic
	31.0965	39.9230	IN = INdustrial
	Groundwater		IR = IRrigation
			LV = LiVestock
	--	12.4694	MI = MIning
	Surface Water		PH = Power, Hydroelectric
			RM = ReMediation
	--	27.4536	ST = Sewage Treatment
			TE = ThermoElectric
			AQ = AQuaculture
			CO = COmmercial

Month	Total Return (Mgal/D)	Total Withdrawal (Mgal/D)	Withdrawal by Category (Mgal/D)											
			WS	DO	IN	IR	LV	MI	PH	RM	ST	TE	AQ	CO
January	20.4322	36.01522	34.225	0	0.0549	0	0	1.5796	0	0	0	0	0	0.1554
February	22.412	36.84442	34.742	0	0.0578	0	0	1.8639	0	0	0	0	0	0.1804
March	42.8609	37.97462	35.059	0	0.0665	0	0	2.6815	0	0	0	0	0	0.1676
April	23.4734	38.45602	35.982	0	0.0531	0.0748	0	2.2044	0	0	0	0	0	0.142
May	39.4296	40.15662	38.725	0	0.0533	0.2803	0	0.9512	0	0	0	0	0	0.1472
June	42.7385	44.26495	42.774	0	0.0796	0.4658	0	0.8048	0	0	0	0	0	0.1404
July	41.9428	44.33392	42.863	0	0.0732	0.4701	0	0.7598	0	0	0	0	0	0.1678
August	34.9733	43.12852	41.617	0	0.071	0.6793	0	0.6198	0	0	0	0	0	0.1412
September	37.9796	42.47635	40.965	0	0.0553	0.6269	0	0.6636	0	0	0	0	0	0.166
October	22.8949	40.00652	35.488	0	0.0484	0.141	0	4.1933	0	0	0	0	0	0.1356
November	21.4032	37.65173	34.688	0	0.0528	0.0022	0	2.7534	0	0	0	0	0	0.1552
December	21.8164	37.57112	35.354	0	0.053	0	0	2.0335	0	0	0	0	0	0.1308

Altered* Streamflow statistics for ungaged site (ft³/s)

Mean daily streamflow	330.00
Median daily streamflow	178.22

*Altered conditions incorporate water use in the watershed

Figure 1. Flow-duration curve in cubic feet per second for ungaged site under baseline and altered flow conditions.

Figure 2. Baseline and altered hydrograph in cubic feet per second for ungaged site.
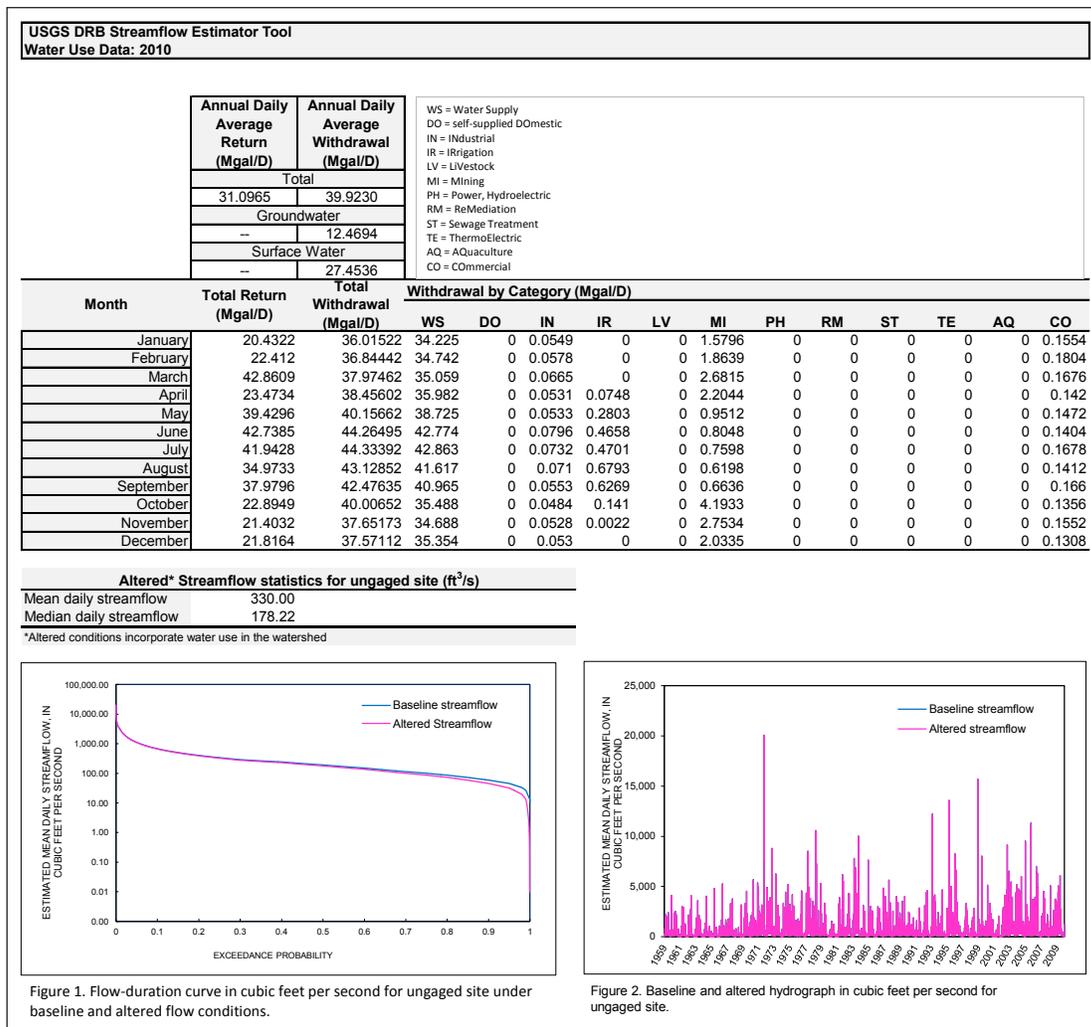
Figure 6.   WaterUse worksheet from DRB-SET.

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