User Manual

Decision Support Tool for Risk-based Watershed Health Management

Development Team

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Abstract

In the United States several federal and state agencies are involved in collecting water quality data from stream networks and performing impact analyses at different spatial and temporal scales. These measurements are then compared to established standards (US EPA, 2009) to determine if violations have occurred. Hoque et al. (2012) used the frequency and severity of water quality violations in a risk-based framework to compute reliability, resilience, and vulnerability (R-R-V) measures that were then used to assess watershed health and ecological risk. A web-based interface has been developed with the aim of helping decision makers, scientific community, and the general public to make risk-based assessments of different areas draining to stream gauges with respect to several water quality parameters measured at these stations. In addition to providing R-R-V measures, the tool enables the user to view and download plots of reconstructed water quality loads and other statistical measures. The tool is designed to be upgraded in the future to enable identification of critical source areas for different water quality constituents, and also quantify trends in R-R-V measures over time and their distribution in space. This web-based product will serve as a first stop for the scientific community, regulators, and decision makers to identify areas that need special attention to reduce ecologic and hydrologic risk, and develop programs to implement better management practices.

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Study Area

The web-based decision support tool (DST) provides measures of reliability, resilience, and vulnerability (Hoque et al., 2012) using stream water quality data for the Upper Mississippi River Basin (UMRB), the Ohio River Basin (ORB), and the Maumee River Basin (MRB). A total of 214 USGS stations (see Figure 1) - 57 stations in UMRB, 99 stations in ORB, and 58 stations in MRB with available water quality (WQ) data were identified over these study areas. The U. S. Environmental Protection Agency (U.S. EPA) along with other task forces within these states are responsible for enhancing interstate cooperation in Clean Water Act implementation.

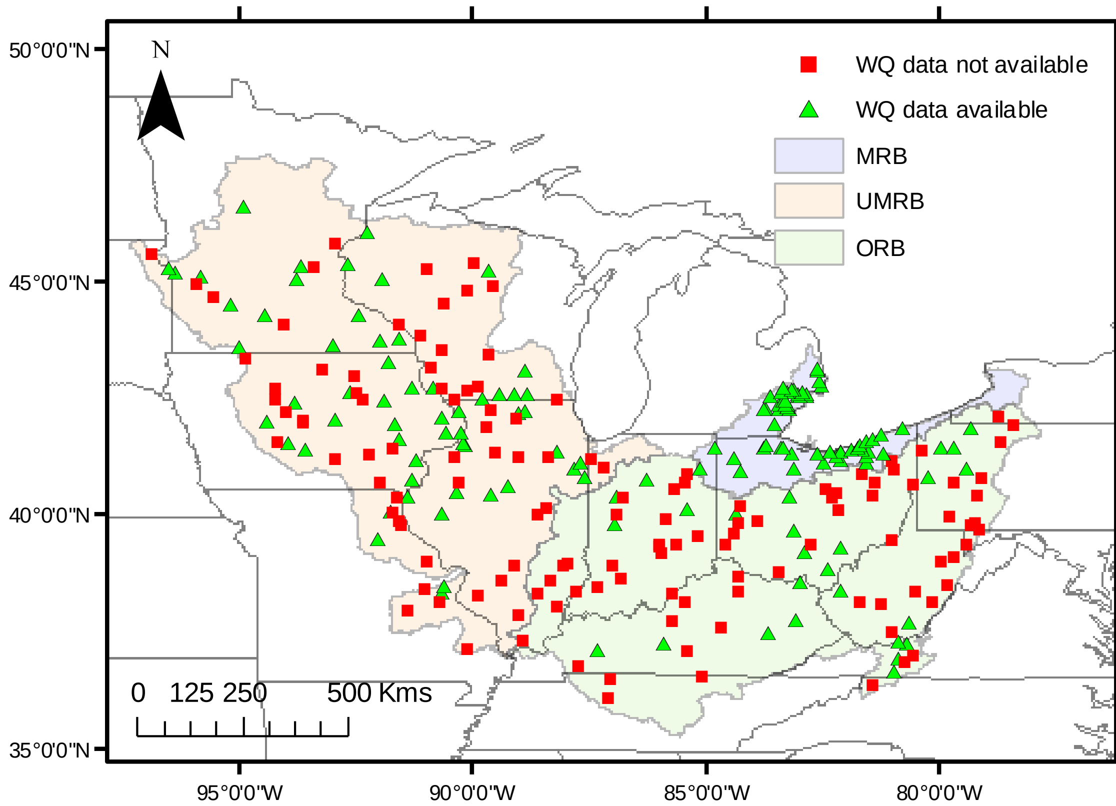


Figure 1: Study area showing USGS stations. Green markers denote stations where water quality data are available.

In addition, USGS National Water-Quality Assessment (NAWQA) data warehouse was used to collect chemical, biological and physical water quality data for the study area where available. Missing data were reconstructed according to Hoque et al. (2012) before computing the R-R-V measures at the gauging stations within the study area.

Decision Support Tool

Introduction: Watershed Risk-Assessment Decision Support Tool

The decision support tool (DST) can be accessed by users through a *web browser*. The decision support tool provides measures of reliability, resilience, vulnerability (R-R-V; Hoque et al., 2012) and watershed health using stream water quality data for the Upper Mississippi River Basin (UMRB), the Ohio River Basin (ORB), and the Maumee River Basin (MRB). Stream flow data from the U. S. Geological Survey (USGS), and chemical, biological and physical water quality data water quality data from the USGS daily water quality dataset and the National Water-Quality Assessment (NAWQA) data warehouse are used for the analysis. Missing data are reconstructed according to Hoque et al. (2012) before computing the R-R-V and watershed health measures at the gauging stations within the study area. For visualizing the R-R-V and watershed health results at any station, the user is asked to enter relevant information such as the choice of water quality parameters, start and end dates, water quality standard, and choice of regression equation to fill in any missing water quality parameter values. When the user submits the request, a MATLAB program executes on the web server to process the results using the user-input information. The RRV results can be viewed on the web browser in the form of tables and charts, once the MATLAB execution is complete.

System Requirements

- An active internet connection is required for using the DST.
- A web browser (e.g. Chrome, Firefox, Internet Explorer) to access the DST website.

Accessing the DST

Users can access the tool from the URL (https://engineering.purdue.edu/WaterDST/) as shown in Figure 2.

Figure 2: Entering the URL in the web browser.

DST User Interface

This will load the DST user interface (see Figure 3). A Google map of the study area along with markers (shown in green), denoting stations where stream flow and water quality data are available, is displayed. The Google maps interface provides the zoom-in (double click the left mouse button) and zoom-out (double click the right mouse button) tool on the bottom right-hand side of the map. The user can pan the map using the arrow keys available on the keyboard or by simultaneously clicking the left mouse button and moving the mouse.

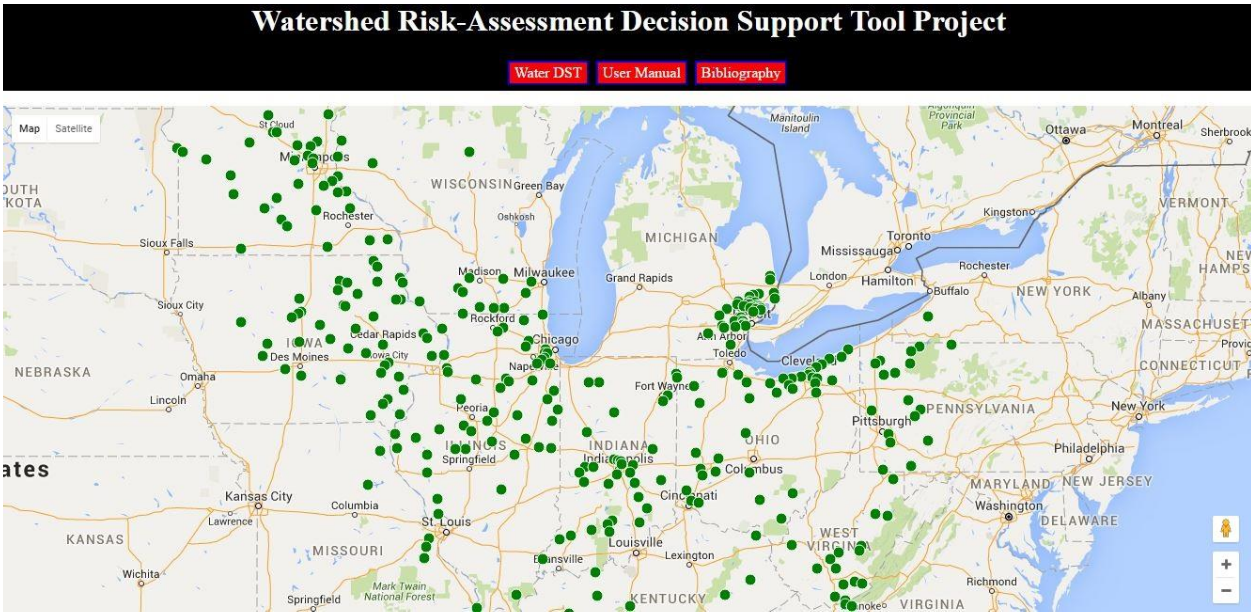


Figure 3: DST loading page. Markers represent stations where stream flow and water quality data are available.

Navigation tabs are located in the header section of the web page. Clicking the *Water DST* tab reloads the DST tool. The *User Manual* tab allows the user to download a PDF version of the user manual. The *Bibliography* tab opens a new web page containing the relevant citations used in developing the DST.

Station Metadata

To compute the R-R-V and the watershed health measure at a station, users should first zoom-in to that station as described above, and click on the marker representing the station. This opens an info-window for this station (Figure 4). The info-window shows details such as station number, station name, metadata for the water quality parameters available at the selected station, and several user input fields.

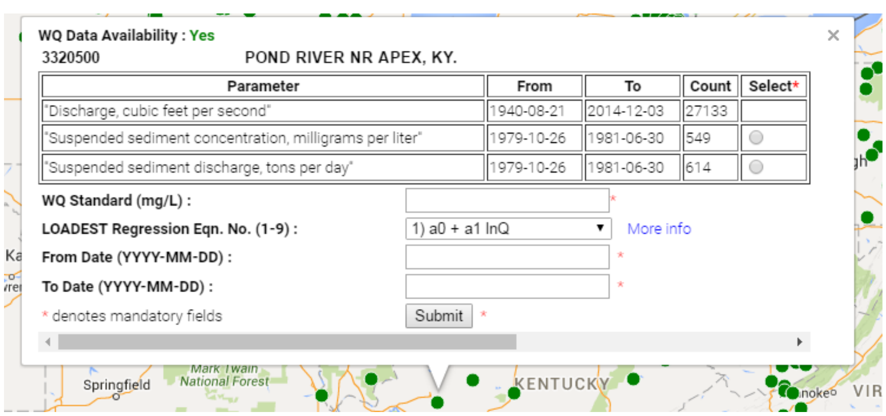


Figure 4: Info-window popup upon clicking a station marker.

User Inputs to the DST

The user can now select the radio button against the water quality parameter for which the R-R-V measures need to be computed. The user has to then provide a *water quality (WQ) standard value*. This will preferably be a U.S. EPA or some other regulatory agency suggested standard (US EPA, 2015) for the water quality parameter being examined by the user, and the units must be in ***mg/L***. Using the drop-down menu, the user selects the *LOADEST regression equation* to be used for filling any missing values in the water quality data. The date range for the analysis needs to be entered in *YYYY-MM-DD* format using the *From Date* and *To Date* input fields (see Figure 5). Once all the data are entered, the user has to click the *Submit* button.

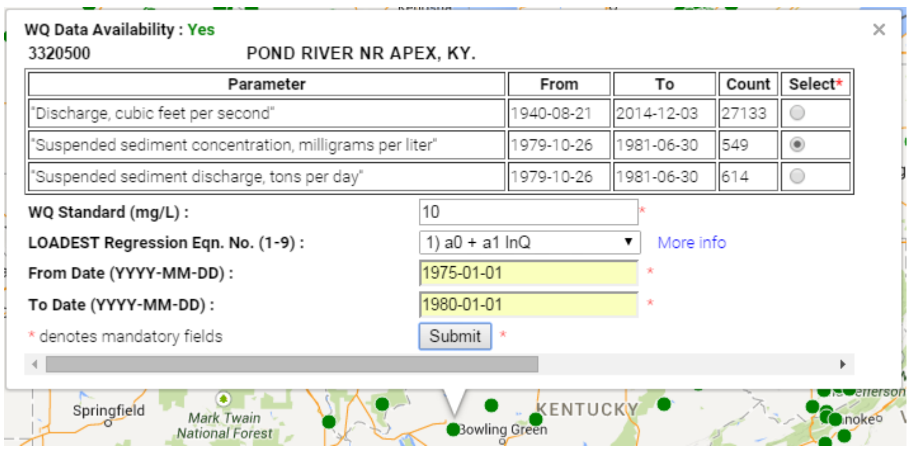


Figure 5: Info-window with user input data.

Upon clicking the submit button, a message with a busy wheel is displayed until the MATLAB computations are completed on the server. The user has the option to cancel a MATLAB job by clicking the *Cancel Matlab Computation* button (Figure 6).

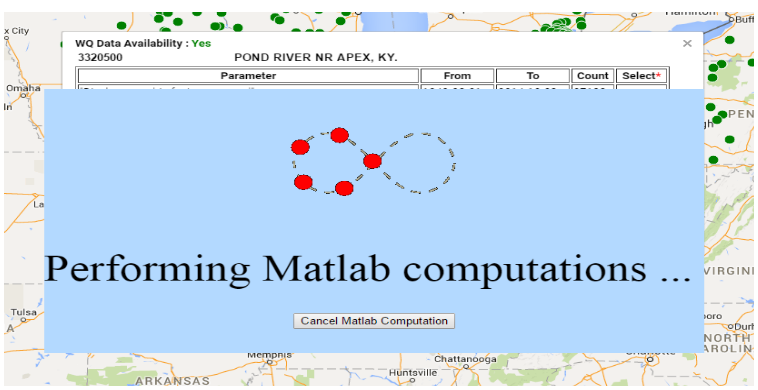


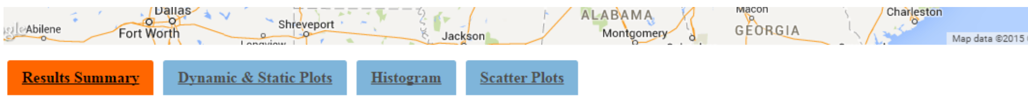
Figure 6: Message box showing status of MATLAB computation along with a *Cancel* button.

Visualize Results in the DST

Once the MATLAB computations are complete the message box (Figure 6) closes automatically, and the results are now available on the web browser for visualization. Upon scrolling down the web page, four tabs named as *Results Summary*, *Dynamic & Static plots, Histogram,* and *Scatter Plots* are visible to the user. The current active tab has an orange background color, while the dormant tabs have a blue background (see Figure 7). The user can switch between tabs by clicking on them.

Results Summary Table

The *Results Summary* tab (Figure 7) displays the mean and standard deviation of the R-R-V measures in a tabular format. A table showing the goodness of fit metrics, adjusted R^2 and Nash-Sutcliffe coefficient, for all regression models are also shown.



RRV Summary

Statistic	Reliability	Resilience	Vulnerability	Watershed Health
Mean	0.222241	0.222487	0.914067	0.161917
Std. Deviation	0.009608	0.010839	0.001815	0.004946

Goodness of fit metric for all models

Goodness of Fit Measure	Model – 1	Model – 2	Model – 3	Model – 4	Model – 5	Model – 6	Model – 7	Model – 8	Model – 9
Adjusted R2	0.909566	0.919821	0.910002	0.943334	0.920588	0.952468	0.944998	0.953883	0.954859
Nash-Sutcliffe	0.909739	0.920128	0.910346	0.943659	0.921044	0.952832	0.945418	0.954324	0.955377

Figure 7: Results Summary tab. Tab with orange background is active while the tabs with blue background are dormant.

Dynamic and Static Plots

The user can then select the *Dynamic & Static Plots* tab to visualize the graphs (Figure 8). A dynamic chart showing the time-series of water quality standard and reconstructed water quality load are shown as line plots. The water quality observations (if any during the user specified time period) are shown as markers.

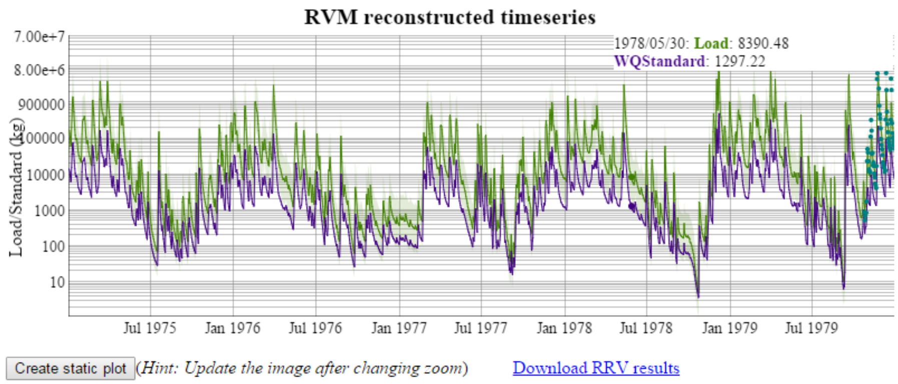


Figure 8: Dynamic time-series plot of the load and water quality standard for the user defined time period. Static plot button and a link to download the RRV results are shown.

The user can zoom in to any section of the plot by simultaneously clicking the left mouse button, dragging the pointer across the area of interest (in the chart) and releasing the mouse button. At any time, the user can double click the left mouse button to return to full chart view. The dynamic chart provides a legend box in the upper right hand corner with current values of the variables plotted, as the cursor hovers across the chart.

Upon clicking the *Create static plot* button, a static image (which can be saved by the user by right clicking the mouse button and selecting *Save image as* option) of the current dynamic plot extent is created in the bottom panel. By clicking the *Download RRV results* link, the user can download a text file containing results (Figure 9). The text file contains the summary of R-R-V results along with the data used for creating the dynamic plot.

```
RRV Calculation Summary
************************

Approximate code execution time (seconds) : 2.648127
Station Number : 3320500
WQ Parameter chosen by the user : 80154_00003
WQ Standard defined by the user : 10
Regression equation number : 1
Date range : 1975-01-01 to 1980-01-01


Reliability Resilience  Vulnerability   Watershed Health
0.222260    0.222517    0.914113    0.161899


Date     Load(kg)     Load Variance(kg^2) WQStandard(kg)  Observations(kg)
1975/01/01  181410.949023   102462538037.445070 14734.504249    NaN
1975/01/02  177607.626477   98204817426.305283  14489.745042    NaN
1975/01/03  164804.644617   84537479071.925110  13657.563739    NaN
1975/01/04  161449.571891   81125497848.830933  13437.280453    NaN
1975/01/05  139102.201310   60195364122.327354  11944.249292    NaN
1975/01/06  95337.128065    28247902389.994164  8860.283286 NaN
1975/01/07  61204.599767    11630672150.092310  6241.359773 NaN
1975/01/08  67338.487427    14081455226.755592  6730.878187 NaN
1975/01/09  200285.971782   124932444442.749760 15933.824363    NaN
1975/01/10  585418.432904   1071681794107.099900    37203.399433    NaN
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Figure 9: R-R-V results output to a text file

Histograms of Monte-Carlo Simulations

The *Histogram* tab allows the user to visualize the plots from the Monte-Carlo simulations for different R-R-V measures (Figure 10). The variables can be chosen using the drop-down menu provided below the histogram plot.

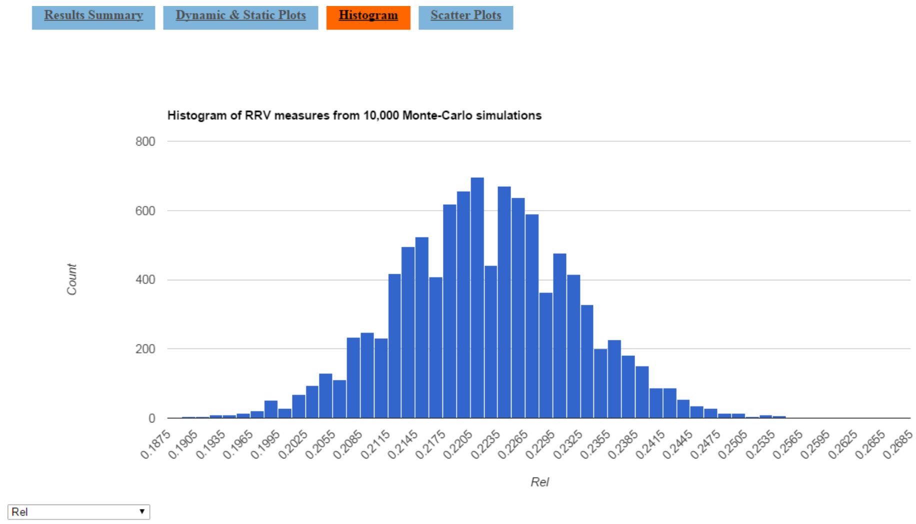

Figure 10: Histogram plot of Monte-Carlo simulations for R-R-V measures. The drop-down menu allows the user to switch between variables.

Scatter Plots of Observed WQ v/s Model Predicted WQ

The *Scatter Plots* tab enables the user to visualize the fit between the output of all the regression models and the observed values for the water quality parameter. The plot (see Figure 11) displays the best fit line and its equation, along with the R^2 value. A drop-down menu below the plot allows the user to switch between different regression models.

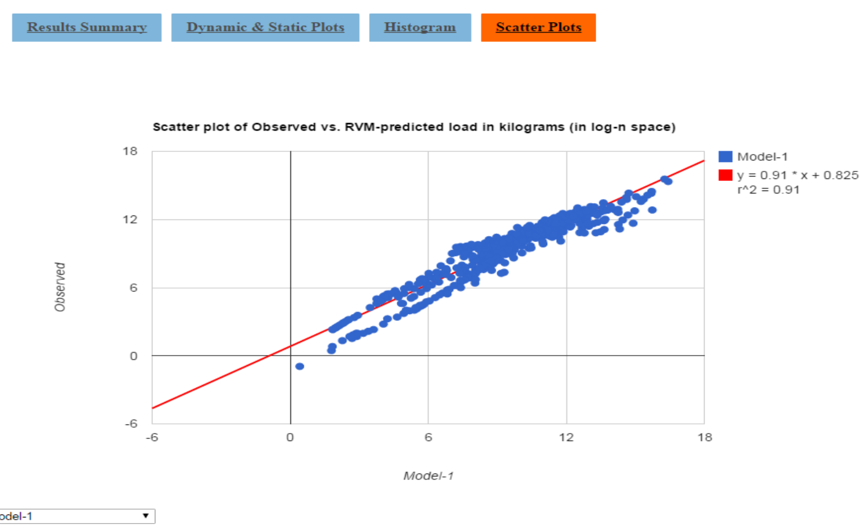

Figure 11: Scatter plot between the output of regression model and the water quality observations. Drop-down menu below the plot allows the use to switch between different models.

References

Hoque, Yamen M., Shivam Tripathi, Mohamed M. Hantush, and Rao S. Govindaraju. 2012. "Watershed Reliability, Resilience and Vulnerability Analysis under Uncertainty Using Water Quality Data." *Journal of Environmental Management* 109 (0): 101–12. doi:10.1016/j.jenvman.2012.05.010.

US EPA. 2009. "National Recommended Water Quality Criteria." http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm.

———. 2015. "Quality Criteria for Water 1986 [The Gold Book]| US EPA." Accessed June 16. http://yosemite.epa.gov/water/owrccatalog.nsf/9da204a4b4406ef885256ae0007a79c7/18888fcb7d1b9dc285256b0600724b5f!OpenDocument.

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