This is not a peer-reviewed article.
Pp. 532-535 in Total Maximum Daily Load (TMDL) Environmental Regulations: Proceedings of the March 11-13, 2002 Conference, (Fort Worth, Texas, USA) Publication Date March 11, 2002.
ASAE Publication Number 701P0102, ed. Ali Saleh.

VFSMOD-W a graphical Windows system for the evaluation and design of vegetative filter strips for sediment trapping[1]

Abstract

Design of vegetative filter strips for trapping sediment and sediment-borne chemicals can be done on a storm-event basis using VFSMOD. This approach requires confidence in a number of input parameters such as soil infiltration characteristics, surface topography, vegetative composition and roughness, and incoming sediment load and particle size distribution. We have developed a simple program, UH, to estimate runoff hydrographs and sediment transport from a source area based on the NRCS Unit Hydrograph Method and the Modified Universal Soil Loss Equation (MUSLE). VFSMOD uses this information from the source area to predict the amount of sediment trapped in the filter strip. UH and VFSMOD have been integrated into one system using a graphical user interface program, VFSMOD-W. The integrated system allows the user to develop input data sets and perform complex modeling analyses such as sensitivity and uncertainty analyses.

Keywords: vegetative filter strips. modeling, TMDL, sediment, design, computer program

---

[1] The authors are: John E. Parsons, Associate Professor, Biological and Agricultural Engineering, North Carolina State University, Raleigh, NC 27695, john_parsons@ncsu.edu and Rafael Muñoz-Carpena, Assistant Professor, IFAS-TREC, University of Florida, Homestead, FL 33031-3314, carpena@mail.ifas.ufl.edu

This research was supported in part by North Carolina Agricultural Research Service, USDA-CREES, Southern Region Project Number S274, Florida Agricultural Experiment Station, and Instituto Nacional de Investigaciones Agrarias y Alimentaria of Spain.

Introduction

Model development and testing are important activities in hydrology and water quality. These represent major undertakings that help users to develop confidence in model use and applicability. Graphical user interfaces for many models are not available making application difficult. Models with integrated graphical user interfaces usually include setup and editing of input datasets along with integrated help. Some provide additional features such as analysis of modeling results, integration features to enable multiple simulations and analyses.

In this work, we have an integrated modeling system that facilitates the modeling and design process of a common BMP, vegetative filter strips, to control runoff and sediment outflow from upslope disturbed areas. This paper discusses the VFSMOD-W window interface.

Models and User Interface Program

The vegetative filter strip, VFS, modeling system consists of a front-end graphical user interface program, VFSMOD-W, the source area program, UH, and the vegetative filter strip model, VFSMOD. The front-end graphical interface program was developed in 2000 to provide an integrated environment for users to evaluate potential designs of vegetative filter strips for trapping sediment from upslope source areas. The program enables users to develop input datasets for the source area program, UH, and for the vegetative filter strip model, VFSMOD, for evaluating potential vegetative filter strip designs for trapping sediment from upslope source areas.

The source area program, UH, allows the user to estimate runoff hydrographs and sediment losses from upslope source areas for a storm event. For each storm event, a rainfall hyetograph is generated as described by Haan et al. (1994). Based on land use and topography of the source area, runoff is determined using the NRCS curve number methods and a runoff hydrograph is generated using the NRCS unit hydrograph method (USDA NRCS, 1986). Sediment losses are estimated using the Modified Soil Loss Equation (Wischmeier and Smith, 1978; Williams, 1975). These are output formatted for use in VFSMOD. Suwandono et al. (1999) presented detailed descriptions of the procedures.

The vegetative filter strip model, VFSMOD, was developed and tested in North Carolina in 1993 (Muñoz Carpena and Parsons, 1999). VFSMOD is a field scale, mechanistic, storm-based model developed to route incoming hydrographs and sedimentographs from an adjacent field through VFS. Outputs from VFSMOD include surface runoff from the VFS, infiltration in the VFS, and sediment trapping efficiency of the VFS. The model handles time dependent hyetographs and runoff hydrographs, space distributed filter parameters (vegetation roughness or density, slope, infiltration characteristics) and varying particle sizes of incoming sediment. In addition, the model has been successfully tested under experimental conditions in Canada (Abu-Zreig, 2001). The combination of VFSMOD and UH is intended as a powerful design tool to evaluate offsite sediment losses from a source area – VFS combination as demonstrated by Suwandono et al. (1999) using an example from the North Carolina Piedmont region. A design application case is discussed by Muñoz Carpena and Parsons (2002).

Input and output files for UH and VFSMOD are managed using project files. Examples of the project files are shown in Figure 1. From these the user can edit input parameters for UH and VFSMOD. Examples of the screens for editing input parameters are given in Figure 2.

VFSMOD-W has a number of options for managing and analyzing output data. An output file viewer is integrated into the program (Figure 3). Graphs of the runoff and sediment balances can also be viewed within VFSMOD-W.

In 2001, the graphical user interface, VFSMOD-W, was modified to incorporate both sensitivity and uncertainty analysis in the VFS design system (Parsons and Muñoz-Carpena, 2001). A number of input parameters were identified as candidates for inclusion in the graphical user interface program. These were identified based on previous detailed sensitivity analysis with VFSMOD (Muñoz-Carpena, 1993; Muñoz-Carpena et al., 1999) and literature suggestions for the procedures used in the UH program.

VFSMOD parameters for inclusion in the sensitivity and uncertainty analyses were selected based on the initial model testing and sensitivity analysis (Muñoz-Carpena, 1993; Muñoz-Carpena et al., 1999). This was used to guide selection of the candidates for inclusion. From this analysis, the input parameters selected include the saturated hydraulic conductivity, initial soil water content in the buffer strip, the average soil particle diameter of the sediment from the source area, and the average vegetation stem spacing.

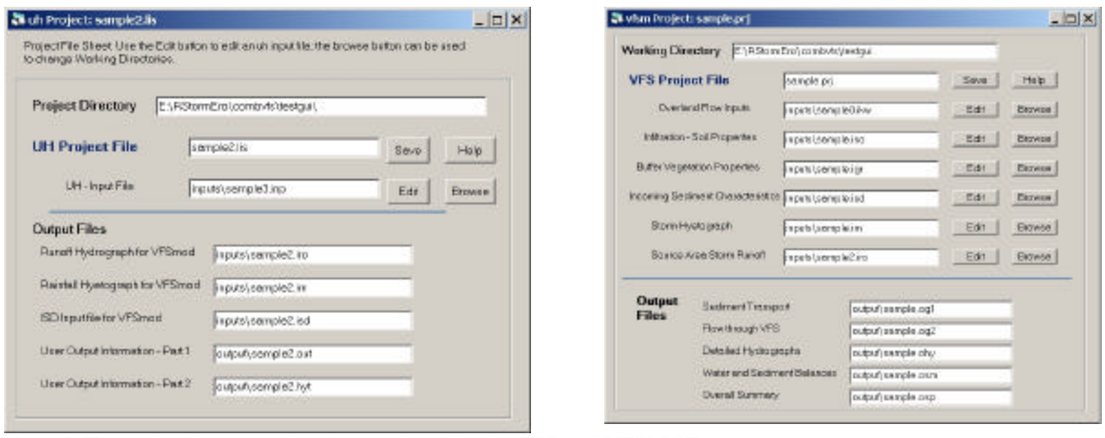

Figure 1. Example of screens showing project files for UH and VFSMOD.

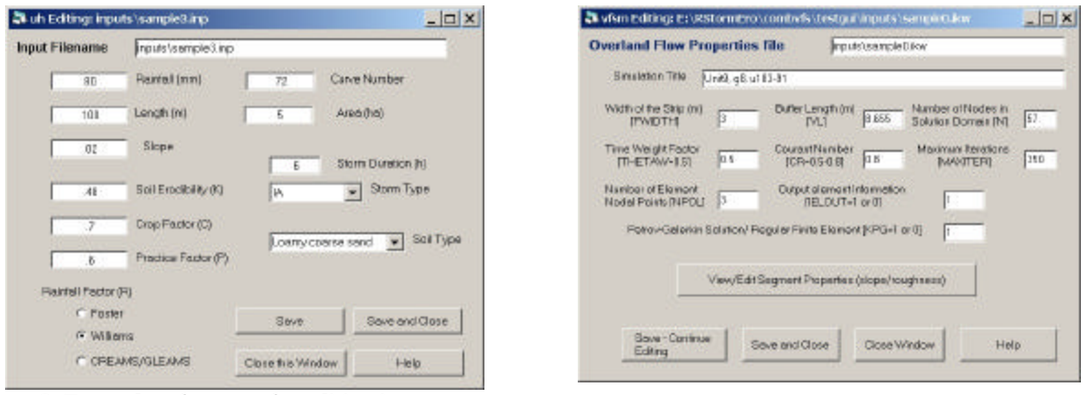

Figure 2. Examples of screens for editing input parameters.

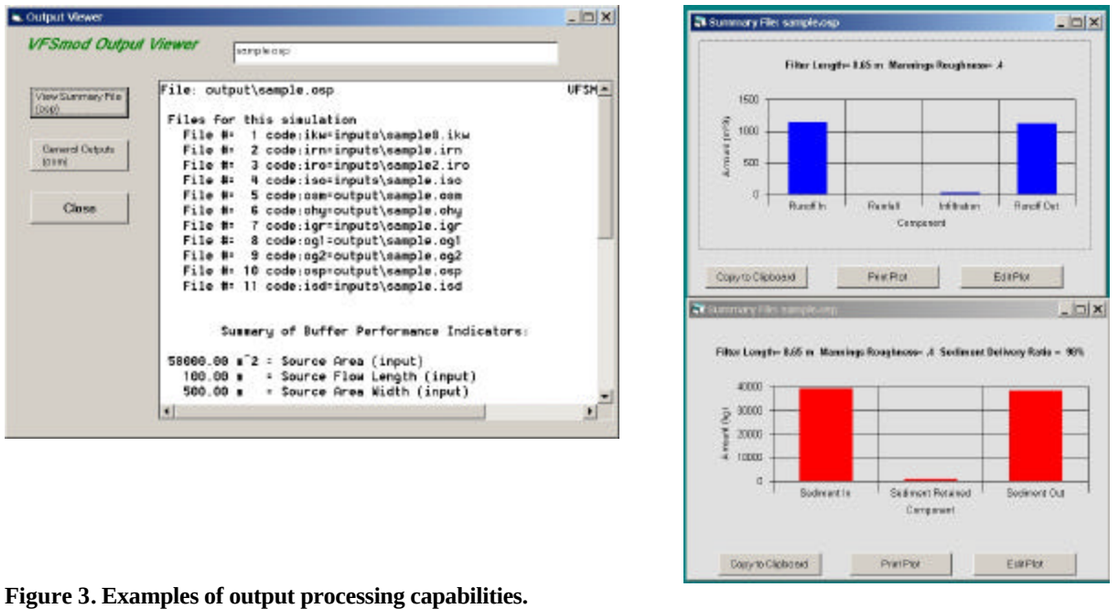

Figure 3. Examples of output processing capabilities.

The user first selects a base set of inputs for UH and VFSMOD. These inputs provide base values for performing the sensitivity or uncertainty analyses. In the sensitivity analysis section, the user selects the minimum and maximum value and an increment for varying the input parameter. Next, the simulations are done and the user can view the results. Simple statistics are computed along with graphs of the relationships. The data is stored in a dataset compatible with other programs for further analyses.

The uncertainty analysis section enables the user to do MCS and investigate the interaction between input parameters to assess the uncertainty of design outputs. For each parameter, VFSMOD-W includes a selection of

possible input distributions. The input distributions include the normal, lognormal, triangular and uniform along with parameters to define the distribution. Figure 4 shows selecting the distribution and parameters in VFSMOD-W.

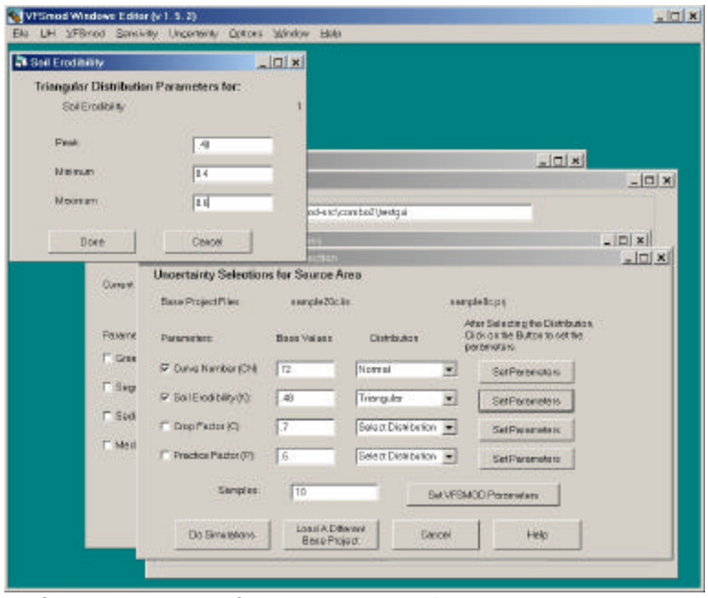

Figure 4. Selection of Input Parameters for Uncertainty Analysis

Summary and Conclusions

The vegetative modeling system consists of a graphical user interface program, VFSMOD-W, along with the programs UH and VFSMOD for evaluating the effectiveness of vegetative filter strips for trapping sediment from upslope source areas. The UH program generates storm hyetographs, runoff hydrographs, and erosion estimates from the source area in a format compatible as inputs for VFSMOD. VFSMOD simulates transport and fate of sediment through a VFS. VFSMOD-W integrates the development of input data sets for UH and VFSMOD in to an easy to use graphical interface program. Other features including the integration of sensitivity and uncertainty analysis for a given design scenario make VFSMOD-W a flexible modeling system.

References

Abu-Zreig, M., R. P. Rudra, and H. R. Whiteley. 2001. Validation of a vegetated filter strip model (VFSMOD). Hydrol. Process. 15:729-742.

Haan, C. T., B. J. Barfield and J. C. Hayes. 1994. Design Hydrology and Sedimentology for Small Catchments. San Diego: Academic Press.

Muñoz-Carpena, R. 1993. Modeling hydrology and sediment transport on vegetative filter strips. Ph.D. dissertation, North Carolina State Univ., Raleigh, NC.

Muñoz-Carpena, R. and J. E. Parsons. 2001. VFSMOD Vegetative Filter Strips Hydrology and Sediment Transport Model, Model Documentation and Users Manual (version 1.05). 2001. URL: http://www3.bae.ncsu.edu/vfsmod/. 99 pp.

Muñoz-Carpena, R., J. E. Parsons, and J. W. Gilliam, 1999. Modeling hydrology and sediment transport in vegetative filter strips. Journal of Hydrology 214 (1999) 111 – 219.

Muñoz-Carpena, R and J.E. Parsons. 2002. A normalized design procedure to meet sediment TMDL with vegetative filter strips (In this Proceedings).

Parsons, J. E. and R. Muñoz-Carpena. 2001. Impact of Uncertainty on the Design of Vegetative Filter Strips. In the Proceedings for the Mini Symposium: Statistical Methods in Hydrology held in conjunction with the 2001 ASAE Annual International Meeting, Sacramento, CA, July 30 – August 1, 2001. (Paper Number 01-2214).

Suwandono, L, J. E. Parsons and R. Muñoz-Carpena. 1999. Design Guide for Vegetative Filter Strips Using VFSMOD. ASAE Paper No. 99-2147. St. Joseph, MI 49085-9659.

Williams, J. R. 1975. Sediment-yield prediction with the Universal equation using runoff energy factor. In: Present and prospective technology for predicting sediment yields and sources. ARS-S-40. USDA-Agricultural Research Service, pp. 244-252.

Wischmeier, W. H. and D. D. Smith. 1978. Predicting rainfall erosion losses - a guide to conservation planning. Agriculture Handbook No. 537, USDA, Washington, DC, 58 pp.