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Development of a Calibrated Watershed Model, Potomac River Basin

A Cooperative Project between the U.S. Geological Survey (USGS),
the Interstate Commission on the Potomac River Basin (ICPRB),
the Maryland Department of the Environment (MDE), and the
U.S. Environmental Protection Agency Chesapeake Bay Program Office (CBP)

Progress Report July 1–September 30, 2002

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Project Description

Problem. Work performed by the National Water-Quality Assessment (NAWQA) Program Potomac River Basin study unit (1992-95) indicated that elevated concentrations of nutrients in surface and ground water in the basin often result from human activities such as manure and fertilizer application. A watershed model of the basin is needed to assess the effects of point and nonpoint nutrient and sediment sources on water quality in the Potomac River and its tributaries.

Objectives. The USGS is responsible for the following objectives: 1) compile necessary data for simulation of Potomac watershed processes, using the Hydrologic Simulation Program-FORTRAN (HSPF); 2) create necessary control files for HSPF simulation of the Potomac River Basin, following the framework developed by CBP for Phase 5 of the Chesapeake Bay Watershed Model (CBWM); 3) develop and implement innovative calibration procedures to improve HSPF model calibration; 4) calibrate an HSPF model for the Potomac River Basin; and 5) prepare reports on calibration and analysis of model results.

Benefits and relevance. The calibrated Potomac Watershed Model will allow resource managers to simulate the effects of land-use changes and best management practices on water quality and evaluate alternative approaches for correcting existing water-quality and water-quantity problems within the Potomac River Basin. The proposed study also meets several goals of the USGS Water Resources Division (WRD).

Approach and methods. The proposed study will involve the following tasks: 1) compilation of existing input data, development of model segmentation and network, processing of time-series data, and compilation of ancillary data and observational data for model calibration; 2) development of a model calibration strategy through implementation of existing software for general inversion and calibration of multi-parameter hydrological models; 3) calibration of hydrological and water-quality model (sediment and nutrients); 4) analysis of model results, including consideration of specific study questions; and 5) dissemination of calibrated model and preparation of final reports analyzing the model results.

USGS will be responsible for development and calibration of the Potomac Watershed Model. CBP will be responsible for parallel development of the CBWM (Phase 5); the Potomac Watershed Model developed by USGS will be one major basin nested within the CBWM. ICPRB will be responsible for all aspects of outreach and inter-agency coordination, and prepare reports for MDE on model aspects relevant to Total Maximum Daily Loads (TMDL) needs.

Timeline and personnel. The project will run from July 1, 2001 through June 30, 2004. The primary product from the project will be a calibrated model of the Potomac River Basin for hydrology, suspended sediment, and nutrients. The completed model will be delivered to ICPRB by October 1, 2003. Intermediate provisional data sets and model results will be disseminated as completed. Progress will be reported by the USGS quarterly; final reports describing the model development and analysis and documenting calibration methods and calibrated parameters will also be prepared by the USGS. Project personnel include a project chief and one other modeler, as well as part-time GIS and database support.

Progress During Reporting Period

During the past 3 months, the following tasks were completed by the USGS:

1. Collection of cross-sectional information for the generation of F-TABLES was completed for the Patuxent and Potomac Basins. This information was used to develop preliminary regressions to estimate cross-sectional parameters in ungaged basins.

2. The Directory Structure for the Phase 5 Chesapeake Bay Watershed model was reviewed and modified as needed and debugging was initiated for the Patuxent watershed.

3. Software was updated for the parameter estimator PEST (TSPROC utility).

Generation of F-TABLES

In order to route water and chemicals through individual stream reaches, HSPF uses simple convex routing that requires designation of the relations among stream cross-sectional area, depth, velocity, and reach volume. These relations are provided in the form of F-tables that require (where available) measurements of stream cross-sections, velocities, and depths.

Collection of cross sections information for the generation of F-TABLES was completed for the Patuxent and Potomac Basin. Information came from the indirect measurements USGS files, MDE data, and the report "Maryland Stream Survey: Bankfull Discharge and Channel Characteristics of Streams in the Piedmont Hydrologic Region", March 2002, US Fish & Wildlife Service, CBFO-S02-01. This information was used to produce preliminary regressions on the following parameters as a function of the drainage area: (1) bankfull width (Figure 1), (2) bankfull height (Figure 2) (3) bottom width (Figure 3). This work is being undertaken by Mick Senus (USGS, Baltimore) and Doug Moyer (USGS, Richmond). For the development of these regressions a trapezoidal channel was assumed as the shape of the cross section. The next step is to use these equations to establish the regressed parameters in ungaged basins.

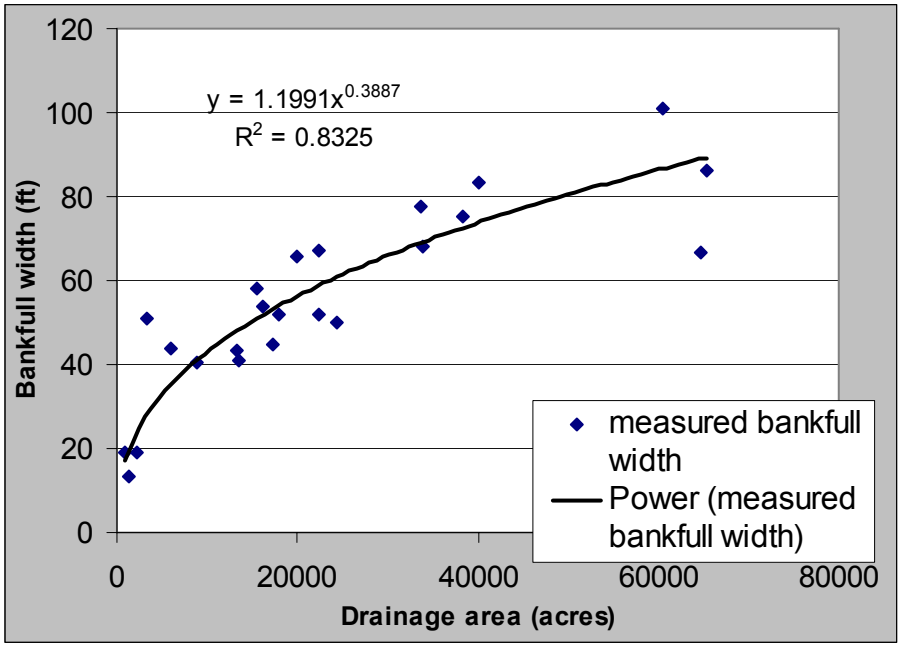

Figure 1. Bankfull width as a function of the drainage area.

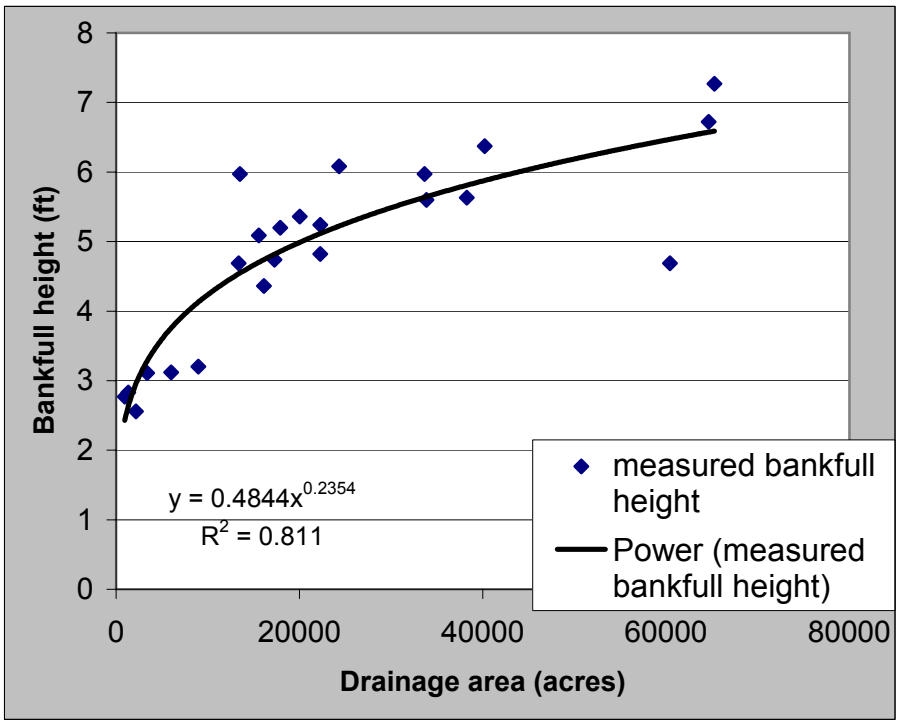

Figure 2. Bankfull height as a function of the drainage area.

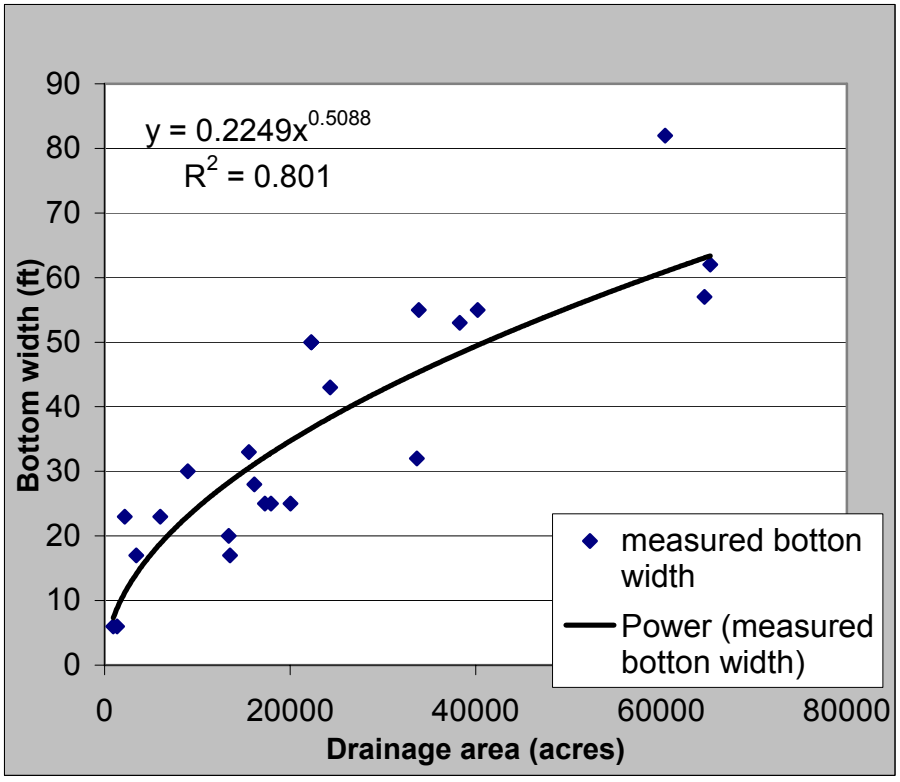

Figure 3. Bottom width as a function of the drainage area.

Directory Structure for the Watershed Model
The Directory Structure (Table 1) for the Watershed model was reviewed and modified as needed, while software code debugging was initiated for the Patuxent watershed.

Table 1. Directory structure for the Chesapeake Bay Watershed Model.

/work/p50X/output/	*- All output files*
./pp/	*- Source code for all processors, all scenario input data, control files for the scenarios, and parameters to make the model run*
./run/	*-All scripts used to run the model*
./uci/	*-All river and land UCI files for scenario*
./wdm/	*-All land, river input, and river output WDM files for scenario*
/working/temp/	*-Temporary files generated during HSPF or ETM runs*
/wdm/	*-All input WDMs (i.e., meteorological data, precipitation and atmospheric deposition, and point sources and diversions) and blank WDMs (populated during model run)*

As part of the training and preparation to run the Chesapeake Bay Watershed Model version 5.0X, a two-day workshop was conducted between staff from the CBPO and the USGS offices of Virginia and Maryland. During these two days, Gary Shenk provided information about the steps needed to run the version 5 model, and indicated that several data files will need to be populated before any run can be achieved. These tasks were assigned to the participants and members of the CBPO and USGS offices. The steps for running the model are shown below:

Steps in Running the Chesapeake Bay Watershed Model Version 5.0X
The directory /work/p50X/run/ *contains all scripts used to run the model. These are the steps:*

1) **run_lug.com [*scenario name*]**
This script builds the UCI files for each land segment and land use. The script includes a line where segments to be run are specified. It is therefore possible to set up individual run_lug.com scripts for each basin.

2) **run_land.com [*scenario name*]**
This script runs HSPF for all PERLNDs and IMPLNDs for the segments specified in the script (which should be the same as those specified in run_lug.com).

3) **run_etm.com [*scenario name*]**
This script runs the external transfer module.

4) **run_rug.com [*scenario name*]**
This script creates the river UCI files.

5) run_river./com [scenario name]
This script runs HSPF for the rivers.

Software update for the parameter estimator PEST (TSPROC utility)
Significant updates were implemented during the testing period on the utility TSPROC. Functions of arbitrary complexity calculated on the basis of one or more measured or modeled time series can be now included in the calibration process.

Two digital filters are now part of the TSPROC utility. The "Butterworth" filter which remove high and low frequency components, and the "Base flow separation" which allows the extraction of quick response from a flow time series. This particular update can be only used for the calibration of hydrology, since the sample interval needs to be constant.

Plans for Next Quarter

1. Extend the calculation of flood plain slope for each USGS stream-gaging station from stream cross sections for the rest of the Potomac Basin.

2. Complete regional geomorphic regression analysis and estimate channel characteristics for ungaged reaches; complete F-tables for reaches within the Patuxent and Potomac Basins.

3. Run new generalized precipitation model being developed by Lauren Hay (USGS, Denver); develop models for different hourly disaggregation schemes and test them.

4. Complete initial Patuxent Basin simulation using complete Phase 5 Chesapeake Bay Watershed Model software and segmentation.

5. Begin investigation of implementation of PEST (Parameter ESTimation) software for parameter estimation.

References

Tamara L. McCandless and Richard A. Everett, "Maryland Stream Survey: Bankfull Discharge and Channel Characteristics of Streams in the Piedmont Hydrologic Region", March 2002, US Fish & Wildlife Service, CBFO-S02-01.