Development of a WCMS-HSPF Groundwater Model Component for Underground Mine Hydrologic Impact Assessment

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Project Description and Objectives:
This project completed Phase I of a three phase development plan to add a groundwater modeling capability to the existing WCMS-HSPF (Watershed Characterization and Modeling System)-(Hydrologic Simulation Program-Fortran) system developed at West Virginia University and currently used by WVDEP (West Virginia Dept. of Environmental Protection). The groundwater modeling component is intended to upgrade WCMS-HSPF to a combined surface and subsurface hydrologic model to support analyses of probable hydrologic consequences/cumulative hydrologic impact assessments (PHC/CHIA) of past, current, and proposed underground coal mining.

Applicability to Mining and Reclamation:
The WCMS-HSPF groundwater model development project required resources and time that exceeded that available in the Applied Science Program for fiscal year 2007; therefore, the project was subdivided into three phases, with phase one to be completed during the first funding year, and phases two and three to follow in subsequent years. Phases two and three remained unfunded and subsequently the project remains with only the Phase I portion completed. If eventually completed, this project would add a groundwater modeling capability to the existing surface water modeling capability provided currently by WCMS-HSPF, which would provide a more comprehensive support of the PHC/CHIA mission.

Methodology:
The design of the WCMS-HSPF groundwater modeling structure was completed, which included a spatial subdivision of a subject watershed corresponding to the SLW (Segment Level Watershed) polygons associated with the WCMS GIS database, which includes a DEM and associated GIS data layers. The centroids of the SLW's were used to construct a TIN (Triangulated Irregular Network) of the watershed area which defined Voronoi polygons used to horizontally subdivide the groundwater model into computational elements. The groundwater flow connectivity was along the connecting links of the TIN structure using a pipe network analogy, which permitted a 2-dimensional model simulation using Darcy's Law. A single layer groundwater model algorithm was developed and tested against steady-state and unsteady flow analytical solutions. A methodology of extending the groundwater model to include a variable spatial resolution

and multiple vertical layers was completed but not implemented as a numerical algorithm.

Highlights:
The HSPF model is continuous simulation watershed model that includes all of the principal components of surface and subsurface hydrologic processes (Bicknell, et al, 2001). It focuses on the surface and soil water processes with a simple reservoir-recessionary flow model to simulate the groundwater contribution to stream flow. It cannot model the spatial interconnectivity of groundwater systems found in a typical drainage basin, and cannot model groundwater interactions with underground coal mining. This project was intended to correct this shortcoming within HSPF. The new groundwater modeling concept was completed and tested in a single layer form against steady-state and unsteady analytical solutions in Phase I of the project. Phases II and III have not been funded, or completed, but were intended to extend the Phase I work to include variable spatial resolution and multiple groundwater layers that would demonstrate the inclusion of underground mines in the modeling structure. Phases II and III were also to include the development of WCMS toolbars to permit inclusion of the combined HSPF and groundwater modeling functionality within WCMS.

Results/Findings:
This project concluded Phase I of development to extend the WCMS-HSPF surface water modeling capability to include groundwater interactions with underground coal mining. The design and testing of the basic model structure was completed in Phase I. Phase II was to add additional capability to include the representation of underground mine cavities, mine pools, and vertical fracture impacts on aquifer dewatering and stream flow, and the development of new WCMS toolbars. Phase III would have completed verification testing, user training, and installation of the combined WCMS-HSPF-groundwater modeling software on the user network at WVDEP. Phases II and III have remained unfunded at the time of this report.

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Website Information:
The final project report can be found at
http://www.osmre.gov/programs/tdt/appliedscience/projects.shtm

Figures

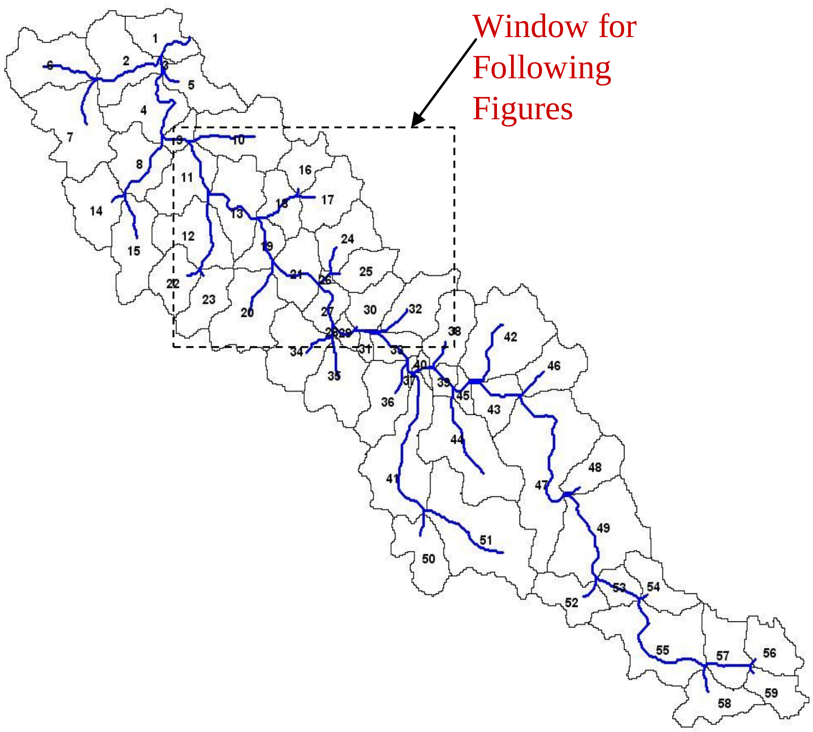

Figure 1: Segment-Level Watersheds (SLW) subdivision of example watershed (East Fork Twelve Pole Creek, WV).

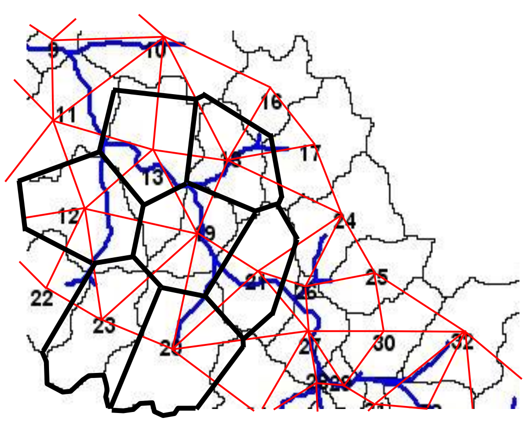

Figure 2: Method of TIN tessellation using SLW centroids and resulting Voroni Polygons used as computational elements in the groundwater model (see Figure 1 for location).