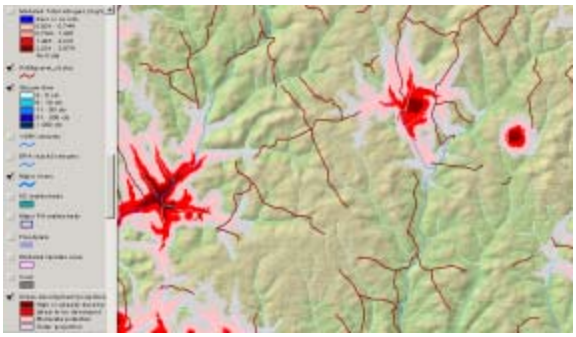
GIS has Allowed a New View of Land Use Changes on Stream Water Quality

BACKGROUND

The non-profit Conemaugh Valley Conservancy (CVC) developed a watershed Geographic Information System (GIS) model to assist in remediation planning for acid mine drainage (AMD) sites. This led to the Kiski-Conemaugh Watershed Modeling System (KCWMS), which was developed to evaluate, identify, and recommend treatment or best management practices (BMPs) in watersheds that are affected by point and non-point source pollution. The model is based on ESRI Arc View interface that combines a wide variety of spatial data layers and water quality modeling components for meeting common watershed analysis tasks.

With a USDA Forest Service grant the CVC will be able to expand this model allowing them to predict inputs from some of the leading causes of pollution in the Kiski-Conemaugh (KC) Watershed. The ability to change land use and land cover classes in the models, and visualize the effects on stream and watershed health will be examined. Also the ability to predict stream water quality effects of existing and/or future clear-cuts, strip mines, dirt/gravel roads, or agriculture will prove to be a valuable analysis tool for planners and resource managers.



The gravel roads, shown as brown lines, need maintenance to prevent erosion.

LOCATION

The Kiski-Conemaugh Watershed covers 1,887 square miles in Southwestern Pennsylvania. The watershed lies within Armstrong, Cambria, Indiana, Somerset, and Westmoreland Counties. Six major sub-basins within the watershed include: Blacklick Creek, Little Conemaugh River, Stonycreek River, Conemaugh River, Loyalhanna Creek, and Kiskiminetas River.

ISSUES BEING ADDRESSED

Control of soil erosion and associated stream sedimentation has been identified as a critical need within the KC Watershed. Increased erosion contributes to flooding, reduces the storage capacity of reservoirs, and transports contaminants downstream. Although some of the erosion occurs naturally because of the steep topography, other activities or disturbances within the watershed contribute to the overall problem. These include:

- Acid mine drainage remains the number one problem in the basin with 1,500 AMD discharges in six waterways.
- Non-point source pollution includes agricultural and urban runoff, nitrogen, and other sources. This is the second leading cause of pollution in the watershed.
- Dirt and gravel roads.

GOALS

- Develop an interactive geographic information system (GIS) model, which will allow users to perform “what if” scenarios on the landscape within the KC Watershed.
- Provide solution-oriented information to environmental managers for making strategic decisions in addressing water quality issues in the KC Watershed.
- Be able to:
  - Focus on water quality sampling.
  - Find the seasonal flow.
  - Identify the most severely affected streams.
  - Identify which sub-watershed or tributaries contribute the most to loading of the main-stem river.
  - Determine the effect BMPs have on water quality.

WHAT THE GIS MODEL DOES

The GIS model will perform “what if” scenarios such as:

- What if land cover changes from forestland to agriculture?
- What would happen to total suspended solids if a new dirt and gravel road was constructed in a particular location in a watershed?
- How would a vegetated buffer improve water quality in a watershed?

These questions require an understanding of the interactions between the landscape, land use patterns, and water quality of receiving streams.

Since 1999, the Northeastern Area and the Northeastern Area Association of State Foresters have sponsored a cooperative challenge grants program to promote watershed health and restoration through the conservation, restoration, and sound stewardship of trees and forests.

This modeling approach has three steps:

1. Evaluate the current existing conditions.
2. Evaluate how specific recommended changes can result in better water quality.
3. Develop scenarios in which land use patterns change or BMPs are implemented and predict the results.

In other words, the user can determine the scenario and run the model. The model then produces a map highlighting changes in landscapes or shows streams that are impacted by the scenarios. For example, a user chooses a stream that is impaired by a pollutant, such as phosphorus. The user selects BMPs to correct the problem and runs the model. The model digitally illustrates the potential improvements if "X" amount of pollution sources are removed by the BMPs.

METHODOLOGY

To answer scenario questions, KVC will complete several phases of analysis for the KC Watershed.

- Track the surface runoff from potential pollution sources and identify where pollutants enter a stream.
- Make flow estimates for all streams in the KC Watershed to calculate pollution loadings.
- Use water quality data from sampling sites to model in-stream concentrations.
- Delineate sub-watersheds for all pollution-contributing tributaries and rank the areas based on the loading to the main stem of the river. As a ranking tool, it will guide where to start restoration in the KC Watershed.
- Use the results from Phase 4, choose a high-ranking sub-watershed, and analyze the effects of BMPs.

OUTCOMES/ACCOMPLISHMENTS

- Expanded baseline data and developed a predictive GIS model that identifies high priority dirt and gravel roads that will best benefit from maintenance funding.
- Evaluated current land use conditions and land cover classes using digital ortho-photo quads.
- Determined flow conditions over different times of the year, severely affected streams, and which sub watersheds contribute to pollution loads.
- Hosted training workshops for county planners and resource management for the GIS program.

PARTNERS

- Allegheny Heritage Development Corporation (AHDC) – a regional nine-county non-profit organization
- U.S. Fish and Wildlife Service
- AmeriCorps National Service Project
- Five county Conservation Districts and two RC&D Councils
- Kiski-Conemaugh Stream Team
- Pennsylvania State University School of Forest Resources
- USDA Forest Service
- PA Urban and Community Forestry Council
- Over 100 municipalities within the KC watershed
- National Park Service

FUTURE PLANS

The GIS model will be a universal tool for public use. After completion of the model, it will be available in CD format to anyone who wants to use it as an analysis tool. This tool has been designed to be easier and take less time to use than standard GIS. However, because some of the data is specific to the KC Watershed, users outside the area will need to make adjustments or include their own data.

The Dirt and Gravel Road Task Force and the PA Conservation Commission have completed baseline GIS of all dirt and gravel roads in PA. Once the model is complete, KVC will make the results of the gravel road scenario available to the Task Force. The Task Force will then decide which roads need repairs to prevent further sedimentation from reaching stream segments.

Reclassification of 1990 land use imagery has been necessary because of inconsistencies with the data. CVC will continue the modeling after this imagery is corrected and digitized.

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Project Grant: $58,000.00