A Spatial Optimization Approach to Watershed Water Quality Management

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Introduction

There is increased interest in utilizing watershed based approaches to address excessive nutrient loading because of a lack of success in other water quality management approaches along with increasing costs of meeting water quality objectives. Local resources will have to bear an increasing share of the burden from water quality improvement programs. Consequently, the design and implementation of programs should provide community-based cost effective water quality improvements.

Goal

Address water quality management by utilizing optimization techniques and geo-spatial techniques to determine cost minimization strategies for Nitrogen (N) and Phosphorous (P) reductions to meet water quality objectives.

Objectives

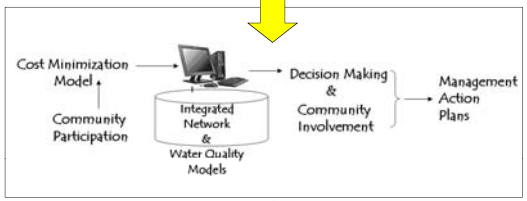
1. To develop an integrated geo-spatial optimization model for N and P pollution reduction that allows decision makers to evaluate different management alternatives.
2. Examine and recommend cost effective best management practices (BMPs).
3. Recommend strategies to improve water quality in Opequon watershed and draw policy implications from the research findings.

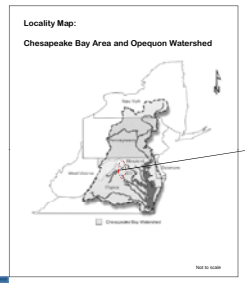
Data

Data for the study combines households and stakeholders' surveys, simulated pollution data for N and P, and conventional GIS data (land use, hydrology, infrastructure, soils and elevation).

Conceptual Model

The study adopts an integrated approach consisting of three sub-models: a cost-minimization model, GIS water quality modeling at the sub-watershed level, and a water flow network model at the watershed level.





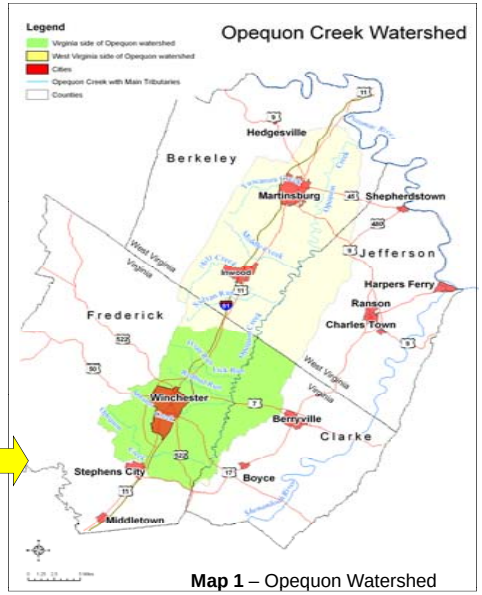
Methods

- The research analyzes sub-watershed prioritization for nutrient (N and P) pollution at minimum cost and recommend best management practices (BMPs).
- Local communities' perspectives and aspirations will be incorporated in the GIS analysis and the management of the watershed.
- Policy analysis for watershed management.

Study Area

The Opequon watershed is located in northern Virginia and the eastern panhandle of West Virginia (see Map 1). Opequon Creek drains approximately 341 square miles, with about 56% of the watershed in WV and 44% in VA.

The watershed consists of mixed land uses: urban areas, agriculture lands and a significant forest cover. Throughout the watershed, rapid growth and development is occurring causing serious strains on water quality. Bacteria, benthic and biologic impairments have resulted in several creeks in the watershed not meeting state water quality standards (WVDEP, 2005). About 18 streams in WV are impaired, including Opequon Creek.



Map 1 – Opequon Watershed

Expected Outcomes

The expected key outcome of this research will be an integrated spatial optimization model for recommending watershed nutrient reduction and management strategies.

The model can be used to develop minimum cost, total maximum daily load (TMDL) implementation strategies.

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