# The Interface of Simulation Modeling and Local Citizens in Two Eastern Iowa Watersheds


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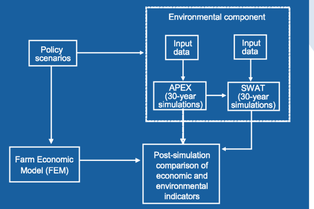
## Introduction

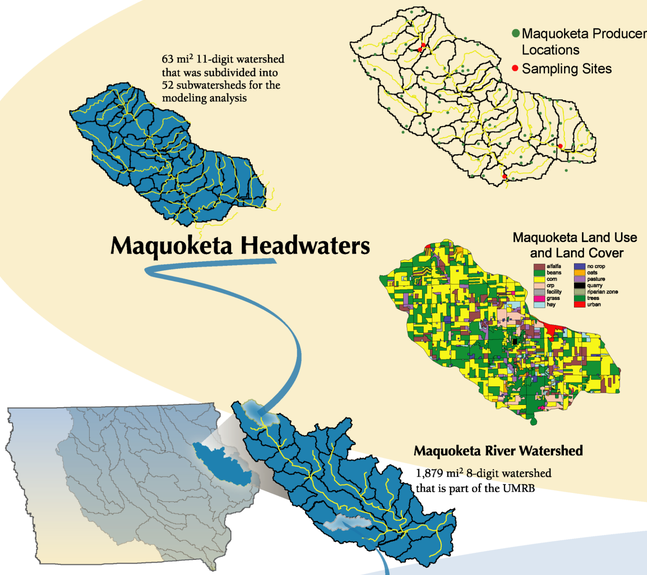
The Maquoketa River drains 1,879 square miles of predominantly agricultural land in northeastern Iowa. The 1998 Iowa Department of Natural Resources (IDNR) Unified Watershed Assessment lists the Maquoketa as a priority watershed, with the primary concern being nutrient and sediment pollutant losses from agricultural nonpoint sources. Pilot projects designed by an inter-agency task force to demonstrate new strategies for agricultural watershed protection through community-based, performance-driven environmental management have been initiated for two HUC11 subwatersheds of the Maquoketa: the Maquoketa Headwaters Watershed (MHW) and the Mineral Creek Watershed (MCW). A key component of both pilot projects is the application of an environmental and economic modeling system to provide insights into which tillage, nutrient, cropping, conservation, and other practices can provide cost effective water quality benefits. The initial application of the modeling system was performed for the MHW; a subsequent analysis is currently being conducted for the MCW. Data collection, development of model input data, and verification of model output is restricted for the MCW study due to resource constraints. Thus, to the extent possible, simulation protocols and assumptions have been transferred from the MHW to the MCW.

## Integrated Modeling System

The integrated economic and environmental modeling system consists of: (1) the Farm-level Economic Model (FEM) (Osei et al., 2000), (2) the field-level Agricultural Policy/Environmental eXtender (APEX) model (Williams et al., 1995), and (3) the watershed-level Soil and Water Assessment Tool (SWAT) model (Arnold et al., 1998). FEM is a representative farm model used to simulate farm-level economic impacts in response to different policy scenarios. APEX was developed from the Erosion Productivity Impact Calculator (EPIC) model (Williams, 1990) and is used to simulate alternative management scenarios such as variations in manure and fertilizer application rates, and adoption of structural best management practices (BMPs), for livestock operations. Edge-of-field sediment and nutrient losses simulated in APEX, coupled with losses simulated in SWAT from non-manured cropland and other land uses, are routed in SWAT through the stream system to the watershed outlet.




The integrated economic and environmental modeling system consisting of the FEM, APEX, and SWAT models.




### Maquoketa Headwaters (MHW) Livestock Operation Locations and Landuse Maps

Precise location of livestock operations, cropped fields, and other landuse in the MHW was determined primarily from reconnaissance performed by ISU Extension. Some refinement of this information occurred from discussions with producers and other people who lived in or near the watershed. Each livestock operation simulated in APEX was identified as being located in a specific SWAT subwatershed. The predicted nutrient and sediment losses from the manured fields were input into SWAT at the subwatershed outlet for subsequent routing through the stream system. Less detailed landuse data derived from the landuse map shown here was used in both APEX and SWAT; this less refined data was adequate for capturing the MHW cropping and other landuse patterns (a similar approach was used for the soil and topographic inputs to both models).

### Survey of MHW Producers

A survey instrument for the MHW was collaboratively developed by TIAER, CARD, and ISU Extension staff. Slightly over 20 percent of the 90 MHW producers, who had livestock at the time of the study, were interviewed one-on-one by ISU Extension to determine typical cropping, tillage, fertilizer and manure application, and other practices used by livestock producers in the watershed. Additional interviews were also conducted with other producers who did not have livestock. The majority of the baseline tillage, crop rotation, manure and fertilizer application rates, and timing, and other management assumptions were based on the results of these surveys. Key survey summary results for expected yields and fertilizer rates are listed in the table.

**Expected yields and fertilizer rates based on MHW survey results**

| Crop | Crop sequence | Expected yield (bu/ac) | Main N fert. appl. (lb/ac)[a] | Fall crop removal fert. appls. (lb/ac)[b] | | | |
|---|---|---|---|---|---|---|---|
| | | | | Manured fields | | Nonmanured fields | |
| | | | | N | $P_2O_5$ | N | $P_2O_5$ |
| corn | after corn | 155 | 142 | 16 | 41 | 25 | 61 |
| corn | after soybean | 160 | 114 | 9 | 23 | 25 | 61 |
| corn | after alfalfa | 158 | 89 | 9 | 23 | 25 | 61 |
| soybean | after corn | 55 | 0 | 13.7 | 35 | 25 | 61 |

[a]Same rate assumed applied to manured and nonmanured fields
[b]Applied as diammonium phosphate (DAP)

### Mineral Creek Watershed (MCW) Livestock Operation Locations and Landuse Maps

The survey developed for the MHW was modified for the MCW in consultation with the MCW Watershed Council "modeling subcommittee." The survey was mailed to producers and other land owners in the watershed, who were requested to provide information on cropping, management, and other practices, and also identify the location of their operation in one of six "watershed segments." General locations of the livestock operations and associated herd sizes within the six segments were translated into total numbers of livestock in each subwatershed, based on the survey information; ISU Extension reconnaissance; and consultations between Extension, the modeling team, and the MCW Watershed Council modeling subcommittee. Greater precision was used in identifying the livestock operations (and associated livestock distributions) located in subwatershed 8, to facilitate a Variable Rate Technology (VRT) scenario that is being developed for that subwatershed. Crop rotation distributions in each subwatershed were determined by ISU Extension in consultation with the modeling team and the council modeling subcommittee.

### Other MCW Survey Results

Similar to the MHW, the MCW baseline cropping, tillage, nutrient application, and management assumptions were based primarily on results of the returned surveys. Some modifications were made to these assumptions as a result of further input from the council modeling subcommittee. Key survey summary results for expected yields and fertilizer rates are again listed here.

**Expected yields and fertilizer rates based on MCW survey results**

| Crop | Crop sequence | Expected yield (bu/ac) | Manured fields (lb/ac) | | | Nonmanured fields (lb/ac) | | |
|---|---|---|---|---|---|---|---|---|
| | | | Main N appl. | Fall crop removal[a] | | Main N appl. | Fall crop removal[a] | |
| | | | | N | $P_2O_5$ | | N | $P_2O_5$ |
| corn | after corn | 146 | 115 | 9 | 43 | 130 | 9 | 43 |
| corn | after soybean | 146 | 92 | 0 | 0 | 107 | 0 | 0 |
| corn | after alfalfa | 146 | 74 | 9 | 43 | 89 | 9 | 43 |
| soybean | after corn | 51 | 0 | 20 | 94 | 0 | 20 | 94 |

[a]Applied as diammonium phosphate (DAP)

## Citizen Involvement

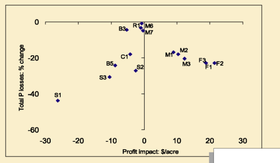
### Dissemination of MHW Simulation Results

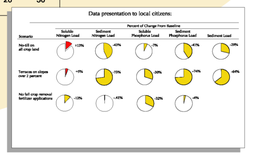
Over 20 different simulation scenarios were performed for the MHW, some of which are listed here. The final list of scenarios was arrived at by an iterative process that included input from members of the the MHW Watershed Council. Presentation of the simulation results were packaged in different formats to accommodate both local citizens (pie charts) and the scientific community in general (graphs), and were presented as percent differences relative to baseline conditions. Selected scenario results were incorporated into the goals set by the MHW Watershed Council for improving water quality. A subset of the scenario results is presented in Gassman et al. (2002); the complete set of results is discussed in Keith et al. (2000).

**Scenario codes and descriptions**

| Code | Description |
|---|---|
| Manure Application (M) | |
| M1 | Manure applied at the N rate and manure nutrient crediting[a] |
| M2 | Manure applied at the high P rate and manure nutrient crediting[a] |
| M3 | Manure applied at the low P rate and manure nutrient crediting[a] |
| M6 | Incorporation of solid manure |
| M7 | Injection of liquid manure |
| Fertilizer Application (F) | |
| F1 | Elimination of fall crop removal fertilizer applications on all cropland |
| F2 | Reduced N application on all cropland[b] |
| F3 | Reduced and split N application on all cropland[b] |
| Cropland tillage (C) | |
| C1 | No-till on all cropland |
| Soil Management (S) | |
| S1 | Terraces on cropland with slopes greater than 2 percent |
| S2 | Contouring on cropland and pastureland with slopes greater than 2 percent |
| S3 | Contour buffer strips on cropland with slopes greater than 2 percent |
| Ration Modifications (R) | |
| R1 | Phytase-supplemented rations for swine farms |
| Structural BMPs (B) | |
| B3 | Filter strips on manure application fields |
| B5 | Enhancing and developing waterways for all cropland |

[a]These scenarios also include estimation of fall crop removal fertilizer applications.

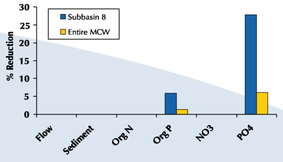


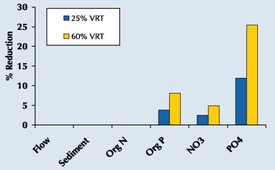

### Dissemination of MCW Simulation Results

A smaller set of scenarios has been identified for the MCW simulation applications, relative to the MHW. These scenarios were selected through a series of iterative discussions with the MCW Watershed Council. The idea for the VRT scenario originated with the council; the goal is to assess the water quality impacts of reduced phosphorus ($P_2O_5$) applications (and associated nitrogen applications) that result from application of VRT to each acre of a crop field. To date, only preliminary results have been presented to the local watershed council for the following scenarios: (1) subwatershed 8 VRT, (2) entire MCW VRT, and (3) improvement of septic nutrient discharges from the town of Center Junction. These results are again presented in terms of relative impacts as compared to baseline conditions. A final set of results for both these and other scenarios will be presented to the council in 2003.

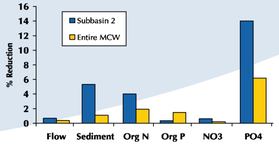
Nutrient reduction due to 50% VRT for Subbasin 8




Nutrient reduction due to 25 and 60 percent VRT for the Mineral Creek Watershed




Nutrient reductions due to eliminating septic tank sources




## Conclusions

The application of the integrated economic and environmental modeling system has proven to be very robust for capturing baseline conditions and depicting alternative scenarios, for both the MHW and MCW. The involvement of local citizens has been a key aspect of the process, especially in the configuration of the models for each watershed, the selection of simulation scenarios, and review of scenario results. The analysis of the MCW is still in progress and will be completed during calendar year 2003.

## References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