An Alternative Approach for Analyzing Wetlands in SWAT for the Boone River Watershed in North Central Iowa

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Overview

1) Iowa Agricultural Production and water quality issues

2) Description of Boone River Watershed

3) Simulation framework, input assumptions, & current baseline results

4) Wetland scenario description/intial findings - “alternative” refers to delineation scheme
2002 Iowa Landuse Map

- **Com**
- **Soybeans**
- **Alfalfa, pasture, and other grassland**
- **Forest**
- **Urban**
- **Water and wetland**
20% of the N load to the Gulf of Mexico
Boone River Watershed

• ~237,000 ha in parts of six counties

• Des Moines Lobe; part of central North American Prairie Pothole region

• Mulch tillage widely used; very few structural conservation practices

• Dominated by crop production; ~85% in corn-soybean rotation
2005 Land Use Determined from Field-level Survey
Locations of Hydric (Wet) Soils in Iowa
Distribution of Tillage in the Boone River Watershed Determined from Field-Level Survey
# CAFOs

<table>
<thead>
<tr>
<th>Type</th>
<th>Total operations</th>
<th>Total head</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swine</td>
<td>109</td>
<td>481,448</td>
</tr>
<tr>
<td>Cattle</td>
<td>13</td>
<td>4,265</td>
</tr>
<tr>
<td>Layers</td>
<td>6</td>
<td>6,962,112</td>
</tr>
</tbody>
</table>

Source: 2005 IDNR CAFO data
SWAT2005: several improvements including enhanced tile drainage routine
  – Du et al., 2005; Green et al., 2006 (Trans. ASABE)

- AVSWATX: ArcView SWAT interface
  - supports SWAT2005
  - SSURGO soils
  - other enhancements

- ArcSWAT: ArcGIS SWAT interface
SWAT Hydrologic Calibration

- 34-year simulation: 1971-2004
  - calibration: 1989-2003
  - validation: 1974-1988

- Calibration steps:
  - curve numbers reduced by 8 (e.g., 78→70)
  - all cropland assumed tiled
  - Hargreaves ET option
  - other parameter adjustments (minor effects)
34-Year Hydrologic Balance

<table>
<thead>
<tr>
<th>Component</th>
<th>Depth (mm)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precipitation</td>
<td>793.7</td>
<td>average annual precip.</td>
</tr>
<tr>
<td>Snowmelt</td>
<td>94.1</td>
<td></td>
</tr>
<tr>
<td>Surface runoff</td>
<td>122.6</td>
<td>~50% of water yield</td>
</tr>
<tr>
<td>Tile flow</td>
<td>114.6</td>
<td>Baseflow (tile, groundwater, &amp; lateral): ~50% of water yield</td>
</tr>
<tr>
<td>Groundwater &amp; lateral subsurf. Q</td>
<td>9.2</td>
<td></td>
</tr>
<tr>
<td>ET</td>
<td>544.3</td>
<td>~69% of precipitation</td>
</tr>
<tr>
<td>Stream flow</td>
<td>246.4</td>
<td>total flow (watershed outlet)</td>
</tr>
</tbody>
</table>
Nitrogen Inputs

• N fertilizer rates: Primarily based on ISA data
  - corn after soybean:
    - spring: 172 kg/ha (100)
    - fall: 183 kg/ha (21)
  - corn after corn: 196 kg/ha

• Manure assumptions less straightforward
  - 80% applied on corn & 20% on soybean
  - N rate: ~210 kg/ha
  - simulation 1: 50% of manured corn also fertilized
  - simulation 2: no additional fertilizer
SWAT Nitrogen Calibration

• 5-year comparison: 2000-2004
  - ~80% of measured nitrogen is nitrate

• Loads estimated with USGS LOADEST program
  - $f$(monthly grab samples and streamflow)

• Calibration steps:
  - N percolation coefficient: .2
  - adjusted four in-stream kinetic parameters
Initial Nitrate Load Comparisons at Outlet

Nitrate (million kg)
Effects of Tile Drainage on Soil Water

Iowa Conservation Reserve Enhancement Program

Nitrate Removal Wetlands

Source: Iowa Department of Agriculture and Land Stewardship, Division of Soil Conservation, Des Moines, Iowa; http://www.agriculture.state.ia.us/CREP.htm
SWAT Wetland Limitations

• Only one wetland at subwatershed outlet can be simulated
  - Identify % of subwatershed that drains to the wetland

• Proxy approach must be used for 30 subwatershed configuration

• Nutrient transformations are limited to nutrient removal by settling
  - e.g., no transformation between nitrogen pools
Constructed Wetland Scenario

• Iowa Conservation Reserve Enhancement Project (CREP)
  - 36 north central counties (Des Moines Lobe)

• CREP wetland criteria:
  - intercept tile drain flows and pollutants
  - wetlands: 0.5 to 2.0% of drainage area
  - drainage area > 500 acres
  - quasi-criteria: x% identified as hydric soils
    - 60% used for example shown here
Alternative approach: 405 subwatersheds

Suitable subwatersheds (meet all 3 criteria) highlighted in blue

More realistic approach than assuming large aggregated single wetland at outlet of larger subwatersheds
## Subwatershed/HRU Comparison

<table>
<thead>
<tr>
<th>Subbasins</th>
<th>Total HRUs</th>
<th>Cropland HRUs</th>
<th>Total Area (km²)</th>
<th>Cropland Area (km²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>2212</td>
<td>2122</td>
<td>2338</td>
<td>2161</td>
</tr>
<tr>
<td>405</td>
<td>6147</td>
<td>5224</td>
<td>2338</td>
<td>2162</td>
</tr>
</tbody>
</table>
Initial Wetland Results

• 405 subwatershed approach needs to be reconstructed
  - distortions apparently occurring due to some very small subwatersheds

• Baseline based on “Simulation 1”
  - ~50% long-term nitrate reduction predicted using 30 subwatershed wetland approach
Conclusions

• Need to improve baseline nitrate simulation
• Test model with sediment and P data
• Reconstruct alternative wetland delineation
  - need some measured data
• Ultimately, refinements to SWAT wetland module
  will be needed
Estimated Manure Application Zones (112 kg/ha N rate)

Data generated by C. Wolter, Geological Survey, Iowa Dept. of Natural Resources, Iowa City, Iowa; Software developed by D. James, USDA National Soil Tilth Lab., Ames, Iowa