North Walnut Creek, Iowa
(An ARS Benchmark Research Watershed, one of 24 CEAP watershed projects.)

Characteristics
Walnut Creek in Boone and Story counties Iowa drains 5,130 ha in the Central Iowa and Minnesota Till Prairies (MLRA) and Des Moines Lobe physiographic regions (Fig. B2). The landscape is underlain by glacial till deposited 10-15,000 years ago. The maximum relief on the poorly dissected terrain is generally less than 5 m with internally drained prairie potholes common in the upper parts of the watershed. Aquic soils occupy 60% of the watershed area. The Clarion-Nicollet-Webster soil association dominates the landscape, with Okoboji and Harps soils occupying potholes. Subsurface tile drains and ditches installed over the past 120 years accelerate drainage and transport of several dissolved contaminants. Normal annual precipitation is 818 mm with 52% falling during May through August in relatively short, but intense events. Annual base flow, which includes tile flow, constitutes 75% of the total stream discharge. Much of the remaining runoff is derived from inlets into the subsurface drain system. About 80% of the watershed is under corn and soybean rotation; 3% in forage crops, 3% in pasture; 4% in woodland; and the remainder in small grains, transportation, and farmsteads. The only animal production operations in the watershed are a seasonal beef pasture area and a small horse farm.

Environmental Impacts

Stream Flow  Discharge from Walnut Creek has been extremely variable during the past 12 yrs. Annual discharge varied from a low of 7 mm in 2000 to a high of 865 mm in 1993. This represents a range of 1 to 67% of the annual precipitation. Discharge from the watershed is dominated by base flow in all years and all months. Average monthly discharge is greatest during the March-July period and runoff is the largest percentage of total discharge in March due to snowmelt and rainfall on frozen ground.

Surface Water Quality  During the past 12 years, atrazine and metolachlor have been detected at concentrations > 0.2 µg L⁻¹ in about half of all surface water samples, while alachlor and metribuzin have been seldom detected. Atrazine and metolachlor concentrations have rarely exceeded health advisory limits and mean yearly concentrations have been below 2 µg L⁻¹ for all locations within the watershed. In contrast, nitrate concentrations have often exceeded 10 mg N L⁻¹ during April - July. Total nitrate losses from the watershed have ranged from 1 to 66 kg N ha⁻¹ yr⁻¹ which are equivalent to 1.5 to 115% of the fertilizer N applied in any year. Thus, nitrate is the primary pollutant of concern related to agricultural activities within the watershed.

Research Objectives

General  To evaluate alternative methods for reducing nitrate concentrations in the surface water of an intensively tile-drained agricultural watershed.
Specific
1. Quantify the impact of intensive row crop agriculture on the water quality of a small watershed.
2. Quantify the impact of adopting the late spring nitrogen test (LSNT) best management practice for nitrogen fertilizer application to corn on NO₃-concentration and load in subsurface drainage at the watershed scale.
3. Improve the management of N in soil by: determining the temporal dynamics of N mineralization/immobilization in soil as affected by soil microbial biomass/activity,
shoot and root residue inputs, labile organic matter pools, N fertility status, and tillage; and improving synchronization between N availability in soil and N requirement by crop.  
4. Modify and evaluate the SWAT watershed model for simulating hydrology and water quality in an intensively tile-drained watershed and apply the model to evaluate the water quality and economic impact of adopting various N control strategies.  
5. Assess the impact of current tillage and cropping practices on soil quality using the NRCS Soil Conditioning Index (SCI) and the Soil Management Assessment Framework (SMAF) being developed by the ARS and NRCS Soil Quality Institute.

**Approaches**

Long-term monitoring of a watershed with intensive row crop production and little animal agriculture will provide a baseline of crop production impacts on surface water quality. The LSNT N management system will be applied to a subbasin within Walnut Creek and compared to two companion subbasins by a paired watershed approach. This study will spur further research into accounting for N mineralization when making N fertilizer recommendations and in developing sidedress technology to help increase the adoption of this N management approach. A limitation in adjusting N fertilization rates for soil mineralization (and in the LSNT) is a lack of understanding of how N and C cycle through soil and the effect of various plant residues on the rate of cycling. Objective 3 will investigate in detail the dynamics of plant residue decomposition with the long-term intention of designing systems that synchronize the release of organic bound N with crop uptake. This work will also concentrate on ways to improve soil tests for estimating N mineralization, including the use of near infrared reflectance spectroscopy to replace or improve the performance of the LSNT. Finally, we recognize that even the best efforts of managing N may result in unacceptably high NO3- concentrations and loads in drainage waters leaving corn fields. Thus, new technologies are needed for treating these drainage waters to remove NO3-.

The first phase of calibration and testing of the SWAT model will use Walnut Creek stream and county drain data from 1992-1996. Evaluation of model performance will include comparison at daily and monthly time scales of water discharge and nitrate concentration and loads. Multiple comparison criteria including maximum error, root mean square error, coefficient of determination, modeling efficiency and coefficient of residual mass will be used to evaluate SWAT model performance. After initial calibration and testing of the model, the model will be used to predict watershed response for the years 1997-2004 to test the robustness of the model - calibrated parameter set to accurately predict watershed response for a range of weather patterns. If satisfactory, the model will be used to test the impact of various N management practices on water quality within Walnut Creek. Initially, the model will be used to investigate the effect of switching from a fall to spring N-fertilizer application with LSNT scenario and predictions compared to the results of the watershed project currently underway within Walnut Creek using this strategy.

Soil quality assessments will be made using two different approaches. First, recognizing that soil organic matter is a primary indicator of soil quality and an important factor in carbon sequestration and global change, the NRCS Soil Conditioning Index (SCI) will be used to assess the consequences of the tillage and cropping systems being used within the watershed. The SCI will provide estimates on whether the applied conservation
practices are maintaining or increasing soil organic matter. The predictions will be verified with the available data being collected by either the farmer-cooperators (i.e. through their soil test records) or other researchers contributing to the overall CEAP database. A more comprehensive assessment of soil quality will be made using the Soil Management Assessment Framework (SMAF) that is currently being developed by the ARS and the NRCS Soil Quality Institute. SMAF is designed to evaluate the dynamic impact of soil management practices on soil function and consists of three steps: indicator selection, indicator interpretation, and integration into an index. Designed as a framework, SMAF allows researchers to continually update and refine the interpretations for many soils, climates, and land use practices. Therefore, in addition to providing soil quality assessments for CEAP, the project will provide data for further improvements of the SMAF. This will occur by applying decision rules based on management goals and other site-specific factors in the selection step for each watershed. The interpretation step will provide site-specific indicator scores. Individually and collectively (through the index), the indicator scores will be correlated to critical endpoints including crop yield, water quality (i.e. nitrate, phosphorus, and sediment loads), and air quality indicators.

**Cooperating agencies and groups**

USGS, EPA, and Iowa State University have been active in this watershed in the past. Currently, the watershed is included on the Iowa list of impacted waters. Current cooperators include Jeff Arnold (ARS) and Ali Saleh (TIAER) looking at applying SWAT. Susan Andrews with the NRCS Soil Quality Institute will work with the SMAF, contributing refinements in and developing new scoring curves for critical indicators within the various watersheds.