Evaluation of AnnAGNPS on Mississippi Delta MSEA Watersheds

Y. Yuan, R. L. Bingner, R. A. Rebich

Abstract. *Sediment and its associated pollutants entering a water body can be very destructive to the health of that system. Best Management Practices (BMPs) can be used to reduce these pollutants, but understanding the most effective practices is very difficult. Watershed models are the most cost–effective tools to aid in the decision–making process of selecting the BMP that is most effective in reducing the pollutant loadings. The Annualized Agricultural Non–Point Source Pollutant Loading model (AnnAGNPS) is one such tool. The objectives of this study were to assemble all necessary data from the Mississippi Delta Management System Evaluation Area (MDMSEA) Deep Hollow watershed to validate AnnAGNPS, and to use the validated AnnAGNPS to evaluate the effectiveness of BMPs for sediment reduction.*

In this study, AnnAGNPS predictions were compared with three years of field observations from the MDMSEA Deep Hollow watershed. Using no calibrated parameters, AnnAGNPS underestimated observed runoff for extreme events, but the relationship between simulated and observed runoff on an event basis was significant ($R^2 = 0.9$). In contrast, the lower R^2 of 0.5 for event comparison of predicted and observed sediment yields demonstrated that the model was not best suited for short–term individual event sediment prediction. This may be due to the use of Revised Universal Soil Loss Equation (RUSLE) within AnnAGNPS, and parameters associated with determining soil loss were derived from long–term average annual soil loss estimates. The agreement between monthly average predicted sediment yield and monthly average observed sediment yield had an R^2 of 0.7. Three–year predicted total runoff was 89% of observed total runoff, and three–year predicted total sediment yield was 104% of observed total sediment yield. Alternative scenario simulations showed that winter cover crops and impoundments are promising BMPs for sediment reduction.

Keywords. *AnnAGNPS evaluation, BMPs assessment, Watershed management, Watershed modeling.*

Soil erosion has long been recognized as a threat to the productivity of U.S. farms and the quality of surface waters. Excessive amounts of sediment cause taste and odor problems for drinking water, block water supply intakes, foul treatment systems, and fill reservoirs. A high level of sediment adversely impacts aquatic life, reduces water clarity, and affects recreation. Even in relatively flat areas, such as the Mississippi Delta, considerable soil erosion can occur. Murphree and Mutchler (1981) reported a 5–year average sediment yield as high as 17.7 tons ha^{-1} yr^{-1} from a flat watershed in the Mississippi Delta. Cooper and Knight (1990) found that suspended sediment loads generally exceeded 80 to 100 parts per million (maximum for optimal fish growth) during and immediately following storm events in two upland streams in Mississippi. Ritchie et al. (1979) found that one to three inches of fine sediments accumulated per year in natural lakes along Bear Creek, a drainage system in the Mississippi Delta where 75% of the land is in cultivation. Accumulated sediment has covered the bottom of many lakes and stream sections with fine silt (Ritchie et al., 1986). Therefore, the Natural Resources Conservation Service (NRCS) has classified off–site transport of sediment and its transported pollutants from agricultural cropland as one of the major sources of water quality impairment, and water quality would directly benefit if the amount of soil loss was reduced.

The impairment to surface water quality due to sediment and nutrient transport from agricultural cropland has been estimated to be about $9 billion per year (Ribaudo, 1992). Although more than $500 billion has been spent on water pollution control since the implementation of the Clean Water Act in 1972, the quality of the nation's water still remains largely unknown (Akobundu and Riggs, 2000).

In reducing soil erosion and solving nonpoint source water quality problems, regulatory agencies promote BMP adoption on areas most susceptible to NPS pollution to reduce sediment and pollutant losses from agricultural land areas. However, the impact of a particular BMP on water quality is a challenge to estimate before any actual imple–mentation (Parker et al., 1994; Walker, 1994). It is even more difficult to predict the integrated effects of implementation of several BMPs. Data on how BMP implementation improves water quality would help decision makers determine a cost/benefit ratio of BMP implementation. Such data also would allow them to choose which BMP combina–tion would produce the maximum benefit.

The complexity and expensive nature of laboratory and field observations necessitate the development and use of water quality models such as AnnAGNPS (Annualized

Article was submitted for review in October 2000; approved for publication by the Soil & Water Division of ASAE in June 2001. Presented at the 2000 ASAE Annual Meeting as Paper No. 00–2172.

The authors are **Yongping Yuan**, *ASAE Member Engineer*, Postdoctoral Research Associate, **Ronald L. Bingner**, *ASAE Member Engineer*, Agricultural Engineer, USDA–ARS–NSL, Oxford, Mississippi; and **Richard A. Rebich**, Hydrologist, USGS, Water Resources Division, Pearl, Mississippi. **Corresponding author:** Yongping Yuan, USDA–ARS–NSL, P.O. Box 1157, Oxford, MS 38655; phone: 662–232–2907; fax: 662–232–2915; e–mail: yyuan@ars.usda.gov.

Agricultural Non–Point Source Pollutant Loading model) (Cronshey and Theurer, 1998) and SWAT (Soil and Water Assessment Tool) (Arnold et al., 1998). Such models have been developed for evaluating the hydrologic and water quality responses of a watershed to alternative management practices. An effective simulation tool can increase awareness and understanding of BMPs by producers and watershed planners and promote adoption of alternative management practices. Ultimately, this will reduce adverse agricultural effects on water resources and ecological processes.

Physically based models have the potential to simulate the erosion processes or behavior of sediment movement accurately, with little or no calibration of the parameters used. Using such models is significantly less expensive than large–scale monitoring of these processes in the field. AnnAGNPS is one such model developed for use with little local calibration on ungauged watersheds. For in–field erosion estimation, AnnAGNPS includes the advanced soil erosion prediction technology contained with the Revised Universal Soil Loss Equation (RUSLE) (Renard et al., 1997).

AnnAGNPS, a continuous simulation model, was developed as a direct replacement for the single–event model, AGNPS 5.0. AnnAGNPS includes significantly more advanced features than AGNPS 5.0 but retains many of the important features (Cronshey and Theurer, 1998). Many studies conducted using AGNPS indicated that the simulated results for runoff and sediment yield from AGNPS compare favorably with observed data (Young et al., 1989; Bingner et al., 1989; Mitchell et al., 1993). Mostaghimi et al. (1997) used AGNPS 5.0 to assess the impact of management practices on the water quality and quantity for Owl Run Watersheds in Virginia and concluded that the model is applicable for nonpoint source impact assessment. However, there is a need to validate the continuous version, AnnAGNPS, on diverse watersheds at many locations across the United States.

The objectives of this study were to: (1) assemble all necessary data from the Mississippi Delta Management System Evaluation Area (MDMSEA) Deep Hollow watershed, (2) validate and evaluate the capability of AnnAGNPS to predict runoff and sediment yield on Deep Hollow watershed using three years of field observed data, and (3) evaluate the effectiveness of BMPs on sediment yield after AnnAGNPS is validated.

METHODS AND PROCEDURES

AnnAGNPS MODEL DESCRIPTION

AnnAGNPS is an advanced technological watershed evaluation tool that has been developed through a partnering project between the USDA Agricultural Research Service (USDA–ARS) and the Natural Resources Conservation Service (NRCS). It is designed to aid in the evaluation of watershed response to agricultural management practices (Cronshey and Theurer, 1998).

AnnAGNPS is a continuous simulation, daily time step, pollutant loading model. Daily climate information is needed to account for the temporal variation in the weather. The spatial variability of soils, land use, and topography within a watershed is accounted for by dividing the watershed into many homogeneous drainage areas. These simulated drainage areas are then integrated together by simulated rivers and streams, which route the runoff and pollutants from each individual homogeneous area downstream. From individual fields, runoff can be produced from precipitation events that include rainfall, snowmelt, and irrigation. A daily soil water balance is maintained, so runoff can be determined when a precipitation event occurs. Soil erosion from each field is predicted based on the RUSLE (Renard et al., 1997). The sediment yield leaving each field is based upon the Hydro–geomorphic Universal Soil Loss Equation (HUSLE) (Theurer and Clarke, 1991). The model can be used to study the effects of alternative cropping and tillage systems including the effects of fertilizer, pesticide, and irrigation application rates as well as point source yields and feedlot management (Bosch et al., 1998).

Required input parameters for application of the model include climate data, watershed physical information, and management. Physical information includes watershed delineation, cell (subwatershed) boundaries, land slope, slope direction, and reach information, which can be generated by the AGNPS 2001 data preparation tools TOPAGNPS (Garbrecht and Martz, 1995) and AGFLOW (Bingner et al., 1997; www.sedlab.olemiss.edu/AGNPS.html). Management information can be developed using the AnnAGNPS Input Editor, a graphical user interface developed to aid users in the selection of appropriate input parameters. Additional input information includes land characteristics, crop characteristics, field operation data, chemical operation data, feedlots, and soil information. Much of this information can be obtained from databases imported from RUSLE or from NRCS sources. Climate data not available from measured data sources can be generated using the climate data generator (GEM) program (Johnson et al., 2000) based on climate stations located in the region surrounding the watershed.

Output files can include runoff, sediment, nutrient, and pesticide yields on a daily, monthly, or yearly basis according to the user's specification. Output parameters can be specified for any desired watershed source location such as specific cells, reaches, feedlots, point sources, or gullies. More information can be found in Cronshey and Theurer (1998), Geter and Theurer (1998), and Theurer and Cronshey (1998).

WATERSHED DESCRIPTION

The Deep Hollow Lake watershed is located in Leflore County, Mississippi (fig. 1). Deep Hollow is one of three watersheds studied in the Mississippi Delta Management Systems Evaluation Area project (MDMSEA), which seeks to develop and assess alternative innovative farming systems for improved water quality and ecology in the Mississippi Delta.

The entire Deep Hollow watershed is about 82 ha with very flat slopes and drains into Deep Hollow Lake. Deep Hollow Lake is an oxbow lake cutoff from the Yazoo River (fig. 1). Many inlets from the Deep Hollow watershed contribute to Deep Hollow Lake. In October of 1996, detailed watershed elevation data were obtained. The maximum elevation difference was only 4 meters, making the delineation of the watershed boundaries difficult. Deep Hollow Lake is adjacent to the Yazoo River. When the Yazoo River floods, the water level in Deep Hollow Lake can rise high enough to

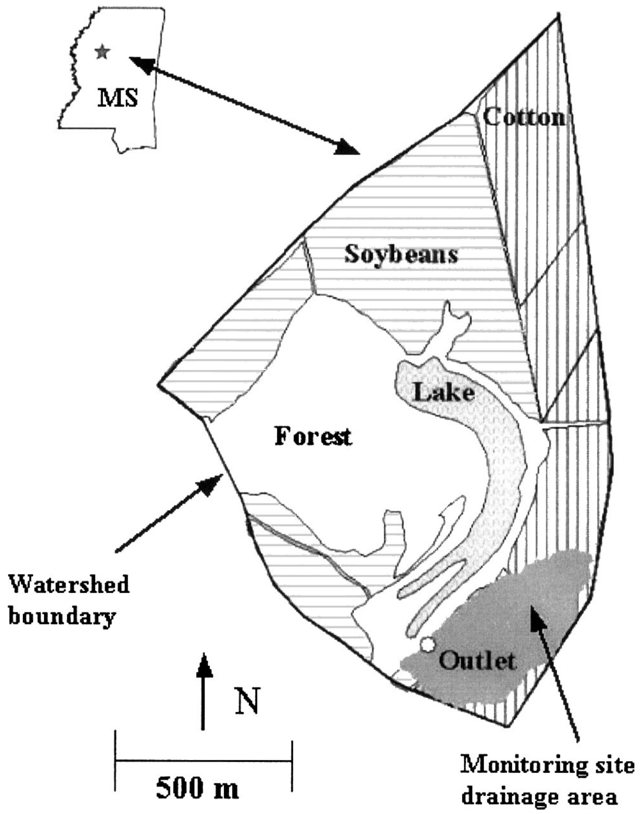


Figure 1. Deep Hollow watershed and Deep Hollow Lake. Deep Hollow Lake is located in the center of the watershed and is contributed to by many inlets from the 82–ha watershed. The monitored site, an 11–ha subwatershed of Deep Hollow Lake, included areas of both cotton and soybean.

pond water on the field, which causes difficulty in measuring runoff during such periods.

The main crops grown in the Deep Hollow watershed are cotton and soybeans. There are fifteen soil series in the watershed, with textures varying from loamy sand to silty clay, but only three series cover 80% of the total area. Detailed records of agricultural operations including tillage, planting, harvesting, fertilization, cover crop planting, and pesticide usage have been maintained since 1996. The operation management of cotton and soybeans related to this study is listed in table 1.

BMPs implemented in the watershed were based on Mississippi USDA–NRCS practice standards (www.ms.nrcs.usda.gov/fotg.htm) and included: reduced–tillage (NRCS Code 329B) cotton, no–tillage (NRCS Code 329A) soybean, and winter wheat (*Triticum aestivum* L.) cover crops (NRCS Code 340) for both cotton and soybean. These practices are widely used today in the Mississippi Delta, but their relative contributions to water quality improvement are uncertain.

In 1995–1996, the U.S. Geological Survey (USGS) installed a gauging station to monitor runoff, sediment yield, and nutrient and pesticides loadings at one of the inlets to the Deep Hollow Lake (fig. 1). Data collected at the outlet of the monitoring site were used for model validation. The drainage area for the monitored site was 11 ha. Runoff was monitored using a critical flow flume. Both discrete and composite samples were taken during rainfall events for sediment and nutrient analyses. Rainfall was monitored at the flume using a tipping bucket raingauge.

Input File Preparation

Based on the detailed elevation survey, a Digital Elevation Model (DEM) file was produced. The DEM grid size used for this study was 3 m × 3 m. From this DEM, the watershed and associated subwatershed boundaries were delineated (fig. 2). Geographical Information System (GIS) soil and land use maps were used in conjunction with the subwatershed map to determine the predominant soil and land use to assign to each subwatershed (fig. 2). The topographic, soil, and land use information were imported through the AnnAGNPS Input Editor to produce the necessary AnnAGNPS input file.

The SCS curve number (CN) is a key factor in obtaining accurate prediction of runoff and sediment yields. Curve numbers (table 2) were selected based on the *National Engineering Handbook*, Section 4 (SCS, 1985). The CN for row crop was used for cotton and soybeans when the crops were growing; the CN for fallow with residue was used when the crop was harvested but winter wheat had not yet been planted; and the CN for small grain was used during the winter wheat growth period. Curve numbers were adjusted based on daily soil moisture condition, varying between CN_1 corresponding to the wilting point (the minimum value of soil moisture storage) and CN_3 corresponding to soil moisture being equal to field capacity. CN is taken to correspond to a soil moisture value halfway between the wilting point and saturation.

To determine sediment yield accurately, crop manage–ment operation information is important because this reflects the effect that human activities will have on the watershed. Therefore, the operation management information was developed with as much detail as possible, especially concerning operations that caused soil disturbance or land cover changes. Operation information for the watershed was set up for each field based on RUSLE guidelines and databases.

The Greenwood climate station is about 20 miles away from the Deep Hollow watershed and is the nearest climate station to the Deep Hollow watershed. Using climate information from the Greenwood climate station and the relative location of the Deep Hollow watershed to the Greenwood climate station, GEM generated AnnAGNPS–required climate information: daily precipitation, maximum and minimum temperature, dew point temperature, sky cover, and wind speed. Since precipitation was measured at the site, the monitored precipitation at the raingauge was used as input to AnnAGNPS during runoff and sediment monitoring periods in order to compare predicted with observed runoff and sediment yield.

Model Validation

AnnAGNPS was used to predict the runoff and sediment loadings to the monitoring flume. Predicted runoff and sediment yield were compared with observed runoff and sediment yield. The predicted and observed monthly runoff and sediment yields listed in table 3 do not include all runoff and sediment yields that occurred in the watershed. Although an attempt was made to collect samples for every storm event, some storm events were not sampled due to unforeseen circumstances such as equipment malfunctions. Therefore, comparisons between model predictions and observations were made only when monitoring data were available. Predicted and observed runoff by events and monthly averages

Table 1. Crop management operation sequence for cotton and soybean fields at Deep Hollow watershed.

Field	Date	Action	Materials	Amount
Cotton	1 Nov 96	Spread behind tractor	Wheat	112 kg/ha
	3 Mar 97	Winter wheat, burndown (plane)	Roundup Ultra	9.4 L/ha
	17 May 97	Do–all, plant, and chemical application	Stoneville 474 Gramaxone	12.3 L/ha
	17 Sept 97	Defoliation	—	—
	25 Oct 97	Harvest	—	—
	7 Nov 97	Spread behind tractor	Wheat	112 kg/ha
	10 Mar 98	Winter wheat, burndown (plane)	Roundup Ultra	9.4 L/ha
	5 May 98	Do–all, plant, and chemical application	Stoneville 474 Gramaxone	12.3 L/ha
	13 Sept 98	Defoliation	—	—
	30 Sept 98	Harvest	—	—
	14 Oct 98	Spread behind tractor	Wheat	112 kg/ha
	1 Apr 99	Winter wheat, burndown (plane)	Roundup Ultra	12.3 L/ha
	9 May 99	Do–all, plant, and chemical application (1/4% surfactant), 20 in. band	BXN 47 Stoneville Gramaxone	12.3 L/ha
	20 Sept 99	Defoliation	—	—
	15 Oct 99	Harvest	—	—
	29 Oct 99	Wheat	—	112 kg/ha
Soybean	1 Nov 96	Spread behind tractor	Wheat	112 kg/ha
	11 Mar 97	Winter wheat, burndown (plane)	Roundup Ultra	9.4 L/ha
	2 May 97	Do–all, plant, and chemical application	Asgro RR Command	56 kg/ha
	6 Oct 97	Harvest	—	—
	6 Nov 97	Spread behind tractor	Wheat	112 kg/ha
	10 Mar 98	Winter wheat, burndown (plane)	Roundup Ultra	9.4 L/ha
	22 Apr 98	Do–all, plant, and chemical application	Asgro RR Command	56 kg/ha
	5 Oct 98	Harvest	—	—
	14 Oct 98	Spread behind tractor	Wheat	112 kg/ha
	1 Apr 99	Winter wheat, burndown (plane)	Roundup Ultra	9.4 L/ha
	28 May 99	Do–all, plant, and chemical application	Asgro RR Command	56 kg/ha
	28 Sept 99	Harvest	—	—
	11 Oct 99	Wheat	—	112 kg/ha

are plotted in figures 3 and 4, and predicted and observed sediment by events and monthly average are plotted in figures 5 and 6. Total monthly rainfall and rainfall associated with monitored data are reported in table 3.

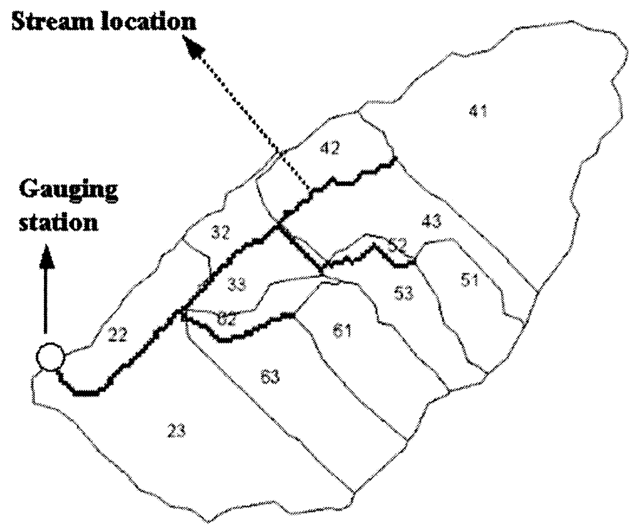
Input parameters for the simulation were not calibrated after initial estimation. This analysis reflects the capability of AnnAGNPS to estimate runoff and sediment loads that would be typical for ungauged watersheds. AnnAGNPS has been developed to include processes that utilize input parameters from databases developed by NRCS for any location in the U.S., such as climate, soil information, and crop management operations. This reduces the user effort that would otherwise be necessary to acquire the needed information to apply AnnAGNPS for ungauged watersheds and the need for calibration.

Evaluation of BMPs

To evaluate the effectiveness of BMPs on water quality, the following alternative scenarios were simulated using AnnAGNPS at the monitoring site:

1. A 0.37 m deep impoundment, with a slope of 0.008 upgrade of the main channel was added at the outlet of the monitoring site, with all other parameters remaining the same as the validation simulation. The impoundment was designed to pond water in critical flow areas so as to allow sediment transported in runoff sufficient time to settle before traveling further downstream, which in this case was into the lake.
2. The winter wheat cover crop was not planted and the field was fallow, with residue remaining from soybeans and cotton on the surface.
3. A cotton crop was assumed to be planted on the entire watershed of the monitoring site. During this simulation, the input file used in the validation study was modified to select all the subwatersheds as cotton.
4. A soybean crop was assumed to be planted on the entire watershed of the monitoring site. During this simulation, the input file used in the validation study was modified to select all the subwatersheds as soybean.

The simulation was done for the period from 1996 to 1999 to evaluate the four alternative scenarios on sediment yield. Sediment yield from the four alternative scenarios and the validation study are plotted in figure 7. Predicted results from the alternative sceneries were compared with each other. Annual sediment yield plotted in figure 7 reflect total sediment yield produced in the watershed for each scenario.



Cell Id	Area (ha.)	Soil Type	Hydrologic Soil Group	Land Use
22	0.62	284B tensas silty clay loam	D	Soybeans
23	2.2	284B tensas silty clay loam	D	Cotton
32	0.32	284B tensas silty clay loam	D	Soybeans
33	0.39	284B tensas silty clay loam	D	Soybeans
41	2.85	178A Dundee loam	C	Cotton
42	0.53	284B tensas silty clay loam	D	Soybeans
43	0.94	284B tensas silty clay loam	D	Cotton
51	0.53	164B Dubbs very fine sandy loam	B	Cotton
52	0.12	12A Alligator clay	D	Cotton
53	0.59	178A Dundee loam	C	Cotton
61	0.81	178A Dundee loam	C	Cotton
62	0.24	12A Alligator clay	C	Soybeans
63	1.15	284B tensas silty clay loam	D	Cotton

Figure 2. Subwatersheds, land use, soil information, and stream network for the monitoring site.

Table 2. Selected SCS curve numbers for the Deep Hollow watershed used in the model simulations.

	Curve number			
	Hydrologic soil group			
Land cover class	A	B	C	D
Cotton straight row (Poor)	72	81	88	91
Soybean straight row (Poor)	72	81	88	91
Small grain straight row + Crop residue (Poor)	64	75	83	86
Fallow + Crop residue (Poor)	76	85	90	93

Results and Discussion

Model Validation

Predicted versus Observed Runoff

A comparison between the predicted and observed runoff from individual events produced results that were reasonably close with a slope of 0.8 and an R^2 of 0.9 (fig. 3). Statistical tests showed that the predicted storm event runoff is not significantly different from observed storm event runoff at the 95% level of confidence. Generally, the runoff events were slightly underpredicted by AnnAGNPS, although a few rainfall events were overpredicted. Several investigators (Smith, 1978; Hawkins, 1978, 1979; Hjelmfelt et al., 1981) have expressed concern that the SCS–CN procedure may not reproduce measured flow from individual storm rainfall because of unique storm characteristics, tillage, and plant growth interaction with previous moisture. AnnAGNPS tended to underpredict runoff for larger rainfall event (over 80 mm). The observed runoff for each of the four largest rainfall events (fig. 3) was greater than the predicted runoff in this study.

In a study conducted by Rosenthal et al (1995), observed stream flow was also underestimated for extreme events using the Soil and Water Assessment Tool (SWAT) without calibration. Both SWAT and AnnAGNPS used the modified SCS–CN procedure to predict runoff volume. For this study, the underprediction of runoff for large rainfall events may be attributed to the fact that the water was impounded at the watershed outlet for large rainfall events due to the small culvert opening at the monitoring station. Theoretically, the impoundment behind a culvert would change the shape of the hydrograph for rainfall events but not the volume of total discharge. However, the impoundment of water at the monitoring flume could have increased the apparent depth of flow, which affects the stage–discharge relationship. This could produce an overestimate of the observed runoff for large runoff events.

Over a three–year period (1997–1999), AnnAGNPS–predicted runoff was 89% of the observed total runoff (table 3). Figure 4 shows that AnnAGNPS underpredicted runoff for every month but May, August, September, October, and November. Except for April, May, October, and November, fields were covered either by cotton (soybeans) or winter wheat, which reduced runoff. This showed that the model is sensitive to the cover crop conditions. No runoff was observed in August and September because of low rainfall and high evapotranspiration.

Predicted versus Observed Sediment Yield

The predicted and observed sediment yield results by event are shown in figure 5. Regression slope is close to 1, but outliers result in an R^2 of only 0.5. However, the predicted sediment yield is not significantly different from observed sediment yield at the 95% level of confidence. The AnnAGNPS–predicted sediment yield over a three–year period (1997–1999) was 104% of the observed total sediment yield (table 3). The agreement between monthly predicted sediment yield and monthly observed sediment yield has a R^2 of 0.7 (table 3). The use of RUSLE is intended to determine long–term annual average. For this reason, comparison of individual events may not agree as well as long–term average monthly and annual values.

The predicted and observed monthly average sediment yields plotted in figure 6 shows the variation of sediment loss throughout the years of study. Sediment yield is greater in December and January because of more rainfall in the winter months. In addition, some disturbance of soil by subsoiling occurs in the fall after cotton harvest prior to the December through January rainfall events. High sediment yield was both predicted and observed in May, even though there was not as much runoff as during December and January (fig. 4). During May, there was some minimal disturbance of soil during planting of the cotton fields, thus causing higher sediment yield. In addition, the soil is fallow before cotton or soybeans are planted in May, which can cause higher sediment yield.

Table 3. Monthly observed rainfall and predicted and observed runoff and sediment yield.

Year	Month	Rainfall (mm)	Runoff (mm)		Sediment yield (tons/ha)	
			Observed	Predicted	Observed	Predicted
1996	October	63.8	4.8	25.6	0.02	0.15
	November	122.4	27.4	49.5	0.07	0.09
	December	127.5	70.6	71.2	0.13	0.18
1997	January	182.1	129.5	101.4	0.70	0.23
	February[a]110	81.8	70.4	45.8	0.23	0.07
	March[a]170.7	0.0	0.0	0.0	0.0	0.0
	April	86.5	30.9	26.3	0.15	0.04
	May	152.4	82.7	70.8	1.10	0.57
	June	130.3	37.6	31.4	1.24	0.33
	July	41.1	4.1	3.1	0.12	0.02
	August[a]58	49.1	0.0	5.7	0.00	0.00
	September[a]76	0.0	0.0	0.0	0.00	0.00
	October	85.6	5.5	21.2	0.05	0.19
	November	56.4	13.1	16.6	0.06	0.29
	December	133.3	56.8	73.9	0.72	0.37
1998	January[a]142	106.6	59.3	69.6	0.58	0.51
	February[a]98	90.0	36.5	35.3	0.47	0.22
	March[a]95	88.7	37.7	18.9	0.18	0.08
	April	130.8	72.6	48.9	0.46	0.43
	May	111.5	84.6	64.3	0.81	2.08
	June	31.0	12.3	7.8	0.29	0.09
	July	166.1	53.6	48.8	0.23	0.42
	August[a]29	0.0	0.0	0.0	0.00	0.00
	September[a]74	0.0	0.0	0.0	0.00	0.00
	October	27.2	0.0	0.0	0.00	0.00
	November	141.2	39.9	50.8	0.11	0.70
	December	205.2	155.0	134.4	0.51	1.51
1999	January	224.3	214.8	147.3	1.68	1.89
	February	50.0	7.2	8.1	0.04	0.04
	March	120.4	58.1	45.9	0.24	0.22
	April	110.0	65.4	47.5	0.19	0.30
	May	73.7	6.5	7.0	0.10	0.12
	June	29.8	0.0	2.2	0.00	0.00
	July	7.1	0.0	0.1	0.05	0.01
	August	0	0.0	0	0.0	0.0
	September	40.5	0.0	3.6	0.0	0.0
Three–year total		3227.5	1437	1283	10.9	11.3
Regression			Y = 0.8X, R^2 = 0.9		Y = 0.9X, R^2 = 0.5	

[a] Indicates months when less than all storms were successfully monitored for runoff and sediment. The number after [a] shows total rainfall during that month. Rainfall reported in the "Rainfall" column reflects only the amount of rainfall associated with monitored data.

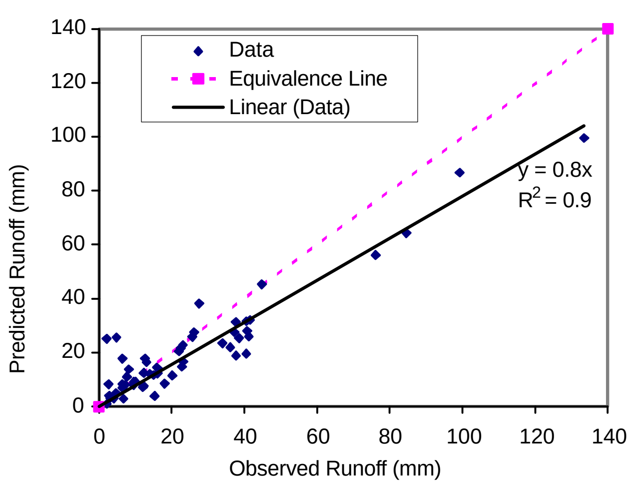


Figure 3. Comparison of observed and simulated runoff by event.

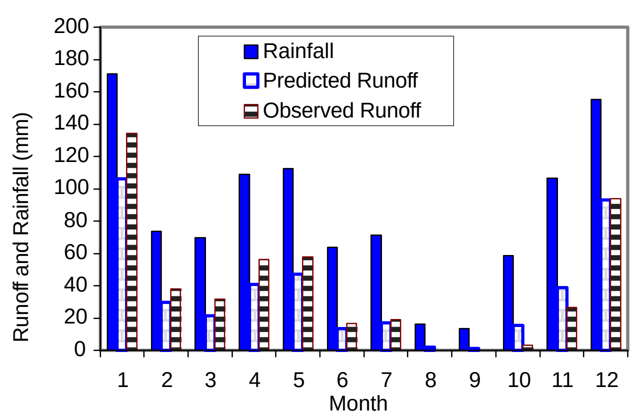


Figure 4. Comparison of monthly average predicted and observed runoff with associated rainfall.

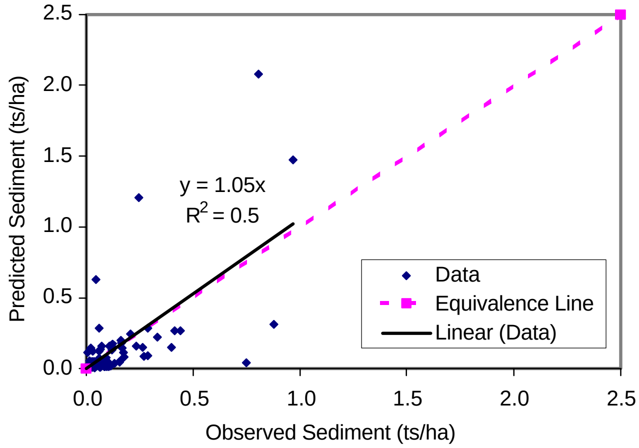


Figure 5. Comparison of observed and predicted sediment yield by event.

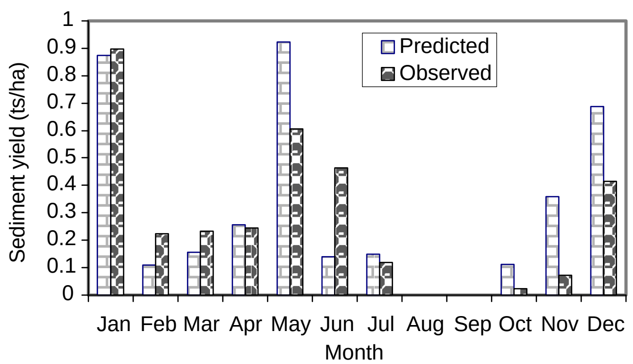


Figure 6. Comparison of monthly average predicted and observed sediment yield.

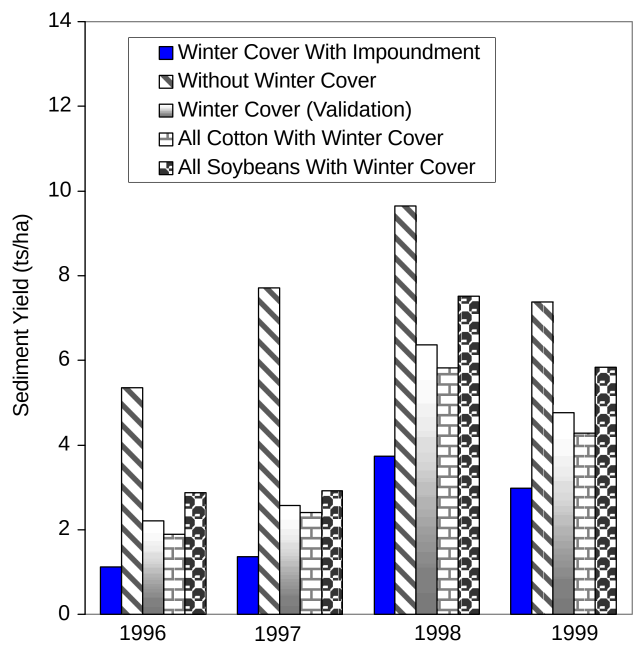


Figure 7. Predicted annual sediment yield from four alternative scenarios and the validation case. Changes for the four alternative scenarios were made based on the validation case. They are: (1) impoundment added, (2) all crops grown without a winter cover, (3) all land use defined as cotton crop, and (4) all land use defined as soybean crop.

Although the model tended to underpredict runoff, the model slightly overpredicted sediment yield. Water impounded upslope of the gauge flume during large rainfall events may have allowed sediment to deposit in front of the flume, and thus, this sediment was not included in the measured sediment yield results.

In AnnAGNPS, erosion only occurs when runoff occurs, but the runoff amounts do not directly influence the level of erosion in the field. Rainfall is used by AnnAGNPS to determine an erosion index value for each storm for use with RUSLE. RUSLE estimates gross total erosion within a field. AnnAGNPS contains processes to determine the amount of sediment deposition that occurs in the field before entering a stream system, thus providing the sediment yield leaving a field.

Sediment Yield Response to the Alternative Scenarios

Figure 7 shows that adding an impoundment in the main channel reduced sediment yield by 50%. If winter cover crops were not used and the soil remained free of vegetation following fall tillage, then sediment yield would double. Changing all crops to cotton would reduce sediment yield, and changing all crops to soybeans would increase the sediment yield, because of the influence of the RUSLE cropping factor C. However, any final decision on the selection of BMPs should consider both the cost of a BMP as well as its impact on water quality.

Conclusion

The study demonstrates that AnnAGNPS adequately predicts long–term monthly and annual runoff and sediment yield. The comparison of sediment yield for individual events was not as good as long–term average annual values because the use of RUSLE and the parameters associated with determining soil loss are meant to be used as long–term estimates. In evaluating the effects of BMPs within a watershed, long–term results are needed to determine the influence of local climatic variation. From BMP simulation, both impoundments and cover crops seem promising in sediment reduction.

The accuracy of model predictions depends on how well a user can describe the watershed characteristics. Runoff prediction is very sensitive to curve number selection, and sediment prediction is sensitive to crop cover and soil disturbance. Therefore, accurate decomposition of operation information, such as tillage, that affects residue and crop cover is very important for realistic sediment simulation.

For this study, all inputs into the model were developed using the available database information with no modification. Without calibration, model results were reasonable for evaluation of long–term monthly and annual runoff and sediment yield. Therefore, AnnAGNPS can be recommended for ungauged watershed simulation of runoff and sediment yield.

Acknowledgements

The authors would like to acknowledge the contribution of the MDMSEA project committee in funding and data collection support. The authors also wish to thank Vance

Justice for his help in model simulation, and Dr. Seth Dabney for his technical guidance on RUSLE parameter selection.

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