CHENEY LAKE CEAP PROJECT: CONSERVATION PRACTICE EFFECTS ASSESMENT

Lisa French, Project Coordinator, Cheney Lake Watershed Inc., Kansas, Lisa.French@ks.nacdnet.net; Lyle D. Frees, KS State Agronomist, USDA-NRCS; Fred D. Theurer, Agricultural Engineer, USDA-NRCS; Ronald L. Bingner, Agricultural Engineer, USDA-ARS

Abstract AnnAGNPS was used to analyze Cheney Lake Watershed, a Special Emphasis Watershed, during the Conservation Evaluation Assessment Project (CEAP). Seven (7) best management conservation practice (BMP) scenarios, which would impact sediment and nutrient loading to Cheney Lake, were identified and evaluated regarding the effect of their implementation. One of the major findings was the significance of ephemeral gully erosion. This paper describes the scenarios that were tested, the results of the evaluation, and insights into possible improvements in the evaluation process.

INTRODUCTION

The Cheney Lake Reservoir is a major source of water for the city of Wichita, Kansas and is located in the south part of the state near the town of Hutchinson. Cheney Lake watershed was chosen by the United States Department of Agriculture as a Special Emphasis Watershed in their Conservation Effects Assessment Project (CEAP) to evaluate the importance of specific agricultural conservation-related practices and the impacts of these practices on water quality that would be overlooked by the larger-scale, national assessment. A final report was submitted to USDA (Frees et al, 2009).

The total drainage area for the watershed is more than 1,000 sq. mi. The watershed is dominated by agricultural land use which consists of cropland and rangeland. The average annual rainfall varies from close to arid at the west end of the watershed to nearly humid at the east end. The average annual rainfall is 29 inches for the entire watershed. Only a small fraction of the rainfall reappears as streamflow in the river before it enters the reservoir.

The Annualized Agricultural Non-point Pollutant Source (AnnAGNPS) is a watershed-scale, water-quality, computer model (Bingner & Theurer, 2001a). It was used to predict water & pollutant loads (Bingner & Theurer, 2001a)—suspended sediment and nutrient loads—from their originating locations in the field downstream to the reservoir. This was done for several best management practice (BMP) scenarios. After the direct runoff & suspended sediment had been calibrated, the BMP scenarios were ready to be executed and interpreted.

With successful validation/calibration of the model regarding water and sediments within Cheney watershed, seven (7) best management conservation practices (BMPs) scenarios, which would impact sediment load to Cheney Lake, were identified to evaluate their effects. These seven BMP scenarios include: 1) increased adoption of mulch till, 2) removal of all existing conservation treatment from the benchmark watershed condition, 3) removal of all Conservation Reserve Program (CRP) acres, 4) treatment of all tillage induced ephemeral gullies, 5) increased

adoption of no till, 6) pristine-all native grass, and 7) adoption of improved irrigation water management on center pivot irrigation systems.
Because AnnAGNPS predicts the direct runoff (water), suspended sediment, and chemicals (nutrients & pesticides) from their respective sources in the field throughout the watershed to the outlet, it is possible to locate the most critical source area for any of the pollutants modeled within AnnAGNPS. The suspended sediment load, in units of mass per unit-area, is ranked from highest to lowest order which, in turn, ranks the erosive source areas from highest to lowest. This ranking shows that 20% of Cheney Watershed drainage area contributes 74% of the average annual suspended sediment load that originated from the fields to Cheney Reservoir. An AnnAGNPS/Geographic Information System (GIS) tool also enables the creation of maps which can be used by a local watershed planner to focus information, education, technical and financial assistance to critical source areas within the watershed.

PROCEDURES

There is a strong history for implementation of conservation practices in the Cheney Watershed. In 1994 a unique partnership between the City of Wichita and the Cheney Lake Watershed Inc was formed to improve water quality entering Cheney Reservoir. More details concerning the history of the Cheney Lake Watershed Inc can be found at www.cheneylakewatershed.org/. Since 1994 a detailed history of conservation practice implementation has been maintained by the Cheney Lake Watershed Inc. While it would be possible to model the impacts of each practice's implementation within AnnAGNPS this option was not selected due to limited personnel resources.

The Kansas Department of Health and Environment (KDHE) has established two (2) Total Maximum Daily Loads (TMDLs) for the Cheney Reservoir. One is for siltation, and the other is for eutrophication. A 10% load reduction from non point sources has been assigned for siltation. A 45% load reduction from non point sources has been assigned for eutrophication. This report will concentrate on the siltation TMDL. The eutrophication TMDL will be addressed in a future addendum to this report. The TMDL reports can be accessed at: www.kdheks.gov/tmdl/latmdl.htm#Table2

KDHE works closely with the Cheney Lake Watershed Inc. concerning non point source load reductions. Because of the aggressive conservation treatment implementation and extensive water quality monitoring system, improvements in load reduction would expect to be readily recognized.

To better assist Cheney Lake Watershed Inc. with focusing education and information activities as well as conservation treatment implementation, eight scenarios have been developed to capture the most likely potential impact to runoff and sediments as the result of most common conservation practice implementation.

Table 1 lists the various scenarios that were evaluated. Note that each scenario was for the same 35-year simulation period and watershed outlet which was to the inlet for Cheney Lake.

Table 1 Drainage areas & simulation periods used for scenarios.

Scenario ID	Drainage Area	Simulation Period
00–benchmark	642,583	1995-1999
01–mulch till	642,583	1965-1999
02–no-conservation	642,583	1965-1999
03–no CRP	642,583	1965-1999
04–no feedlots	642,583	1965-1999
05–no gullies	642,583	1965-1999
06–no till	642,583	1965-1999
07 pristine, all native grass	642,583	1965-1999
08–irrigation	642,583	1965-1999

BEST MANAGEMENT PRACTICE SCENARIOS

Scenario 00–Benchmark (1997) Cheney Watershed Conditions Scenario 00–benchmark represents present conditions in the Cheney Lake Watershed. This scenario is used as the reference condition for each of the remaining seven (7) scenarios. Scenario 00 can also be used as the TMDL benchmark to determine potential progress for the 10% siltation load reduction.

Scenario 01–Mulch Tillage Scenario 01–mulch till is designed to assess the impacts of conservation tillage mulch till with a minimum of 30% ground cover after planting. All cropland was modified to represent conservation tillage mulch till. This would include all no till cropland modified to represent conservation tillage mulch till. While the 1997 no till acres represent only 5% of the watershed, no till results in improvement in runoff and suspended sediments. While conservation tillage mulch till is an important conservation treatment, at the watershed scale this practice by itself will not attain the needed siltation load reduction. See results in Table 2 and Table 3.

Scenario 02–No Conservation Treatment Scenario 02–no conservation treatment is designed to assess the impacts of all conservation treatment implemented within Cheney Lake Watershed. This scenario removed all grassed waterways replacing them with ephemeral gullies; all terrace systems, and all conservation tillage systems. It is intended to represent pre-conservation programs as compared to conservation program implementation up to 1997. Only cropland activities were adjusted, all non-cropland conditions remained the same as 1997 conditions. Significant reductions to surface runoff (202%) and suspended sediment (173%) from the benchmark have resulted from conservation program implementation to cropland prior to 1997. See results in Table 2 and Table 3.

Scenario 03–No Conservation Reserve Program (CRP) Scenario 03–no CRP is designed to assess the impact of all 1997 CRP acres within the Cheney Lake Watershed. Removal of all

CRP acres would be expected to have a negative impact on surface runoff and suspended sediment load. The model indicates an 11% increase in surface runoff and a 27% increase in suspended sediment from the benchmark. See results in Table 2 and Table 3.

Scenario 04–All Feed Lots with Conservation Treatment (not run) Scenario 04–no feedlots is intended to assess the impact of conservation treatment of animal feeding operation. This scenario assesses the EQIP-funded animal waste systems installed within the watershed and nutrient impacts to Cheney Reservoir. All pollutants from the animal production area are assumed to be contained and land applied as a part of a nutrient management plan. This scenario has been developed, but not reported on at this time. This conservation treatment does not impact runoff or suspended sediment, but upon completion of the base flow component and nutrient analysis within AnnAGNPS an addendum will be submitted.

Scenario 05 - ALL Ephemeral Gullies with Treatment Scenario 05–no gullies is intended to assess the impact of conservation treatment of tillage-induced ephemeral gully erosion. This scenario models all ephemeral gullies with conservation treatment to eliminate erosion and all other cropland practices the same as the benchmark. A 34% reduction was observed with suspended sediments and no change to runoff. This conservation treatment has the potential to assist in meeting the load reduction for siltation. See results in Table 2 and Table 3.

Scenario 06–No Tillage Scenario 06–no till is intended to assess the impact of no till (direct seeding systems) on all cropland acres within the Cheney Lake Watershed. All cropland was modified to represent no till with non-cropland represented by the benchmark. All ephemeral gullies were left as represented in the benchmark. In-field observations indicate that no till may not reduce the erosion from concentrated flow. An 8% reduction from the benchmark was observed for surface runoff. A 5% reduction from the benchmark was observed for suspended sediments. While conversion from conventional tillage to no till is an important conservation treatment in erosion reduction at the field scale, no till by itself will not attain the siltation load reduction at the watershed scale. See results in Table 2 and Table 3.

Scenario 07–Pristine, All Native Grass Scenario 07–pristine, all native grass is intended to assess potentially pristine conditions so that unattainable water quality goals are not established for an agricultural system. See results in Table 2 and Table 3.

Scenario 08–Irrigation Scenario 08–Irrigation is intended to assess the impact of reducing the soil moisture from 70 percent of field capacity to 50 per cent of field capacity before center pivot irrigation is triggered. The model indicates a 4% reduction in surface runoff and a 2% decrease in suspended sediment from the benchmark.

RESULTS

Table 2 summarizes the water & suspended sediment load average annual unit-area statistics at the watershed outlet for each scenario.

Table 2 Average annual water and suspended sediment statistics for each scenario.

UNIT-AREA AVERAGE ANNUAL STATISTICS AT THE WATERSHED OUTLET						
CONSTITUENT	Water Load			Suspended Sediment Load		
SOURCE	Runoff	Base-flow	Streamflow	Land-scape	Bed & Bank	Total
SCENARIO ID	[in/yr]	[in/yr]	[in/yr]	[tn/ac/yr	[tn/ac/yr	[tn/ac/yr
00–benchmark	0.90230	1.23731	2.139614	0.04682	0.01061	0.05743
01–mulch till	0.90581	1.23715	2.142974	0.04831	0.01062	0.05894
02–no conservation	2.72919	1.16788	3.897082	0.13590	0.01932	0.15523
03–no CRP	1.00252	1.23286	2.235395	0.06161	0.01108	0.07269
04–no feedlots	0.90230	1.23731	2.139614	0.04682	0.01061	0.05743
05–no gullies	0.90230	1.23731	2.139614	0.02760	0.01061	0.03822
06–no till	0.83320	1.23828	2.071494	0.04422	0.01027	0.05449
07–pristine, all native	0.36809	1.21919	1.587291	0.00046	0.00787	0.00833
08–irrigation	0.86234	1.22486	2.087205	0.04599	0.01035	0.05634

Table 3 summarizes the water & suspended sediment load average annual percent differences with respect to the benchmark scenario at the watershed outlet for each scenario.

Table 3 BMP scenarios' water and suspended sediment differences with respect to Scenario 00, benchmark.

DIFFERENCES IN THE AVERAGE ANNUAL LOAD AT THE WATERSHED						
CONSTITUENT	Water Load			Suspended Sediment Load		
SOURCE	Runoff	Base-flow	Stream-flow	Land-scape	Bed & Bank	Total
	[%]	[%]	[%]	[%]	[%]	[%]
00–benchmark	—	—	—	—	—	—
01–mulch till	0.39	-0.01	0.16	3.19	0.16	2.63
02–no-conservation	202.47	-5.61	82.14	190.24	82.14	170.2
03–no CRP	11.11	-0.36	4.48	31.58	4.48	26.57
04–no feedlots	0.00	0.00	0.00	0.00	0.00	0.00
05–no gullies	0.00	0.00	0.00	-41.04	0.00	-33.46
06–no till	-7.66	0.08	-3.18	-5.56	-3.18	-5.12
07–pristine, all native grass	-59.20	-1.46	-25.81	-99.01	-25.81	-85.48
08–irrigation	-4.43	-1.01	-2.45	-1.78	-2.45	-1.90

RESULTING IMPACTS OF CONSERVATION PRACTICES

Having the model for Cheney Lake Watershed calibrated to the measured water quality data and validated with satisfactory or greater NSE allows for greater confidence in the scenario results. Conservation treatment modeled with AnnAGNPS for practice implementation prior to the benchmark (1997 Cheney Watershed conditions) indicates major reductions in runoff and suspended sediment have resulted from conservation treatment. The CRP program makes significant contributions regarding runoff but an even greater impact on sediment reaching Cheney Reservoir. As CRP contract acres are released and watershed producers make land use decision concerning CRP acres, attention should given to retaining in permanent grass cover those acres which contribute significantly to the sediment load. The authors would like to suggest a process, using modeled data, to identify those areas of the watershed which contribute the largest sediment load to Cheney Reservoir. Using the benchmark scenario and the no ephemeral gully scenario, a ratio of sediment load by each 200 acre AnnAGNPS cell with and without ephemeral gullies can be established. The graph in Figure 1 illustrates this relationship showing that approximately 20 percent of the 200 acre cells in the watershed contribute roughly 74 percent of the sediment load to the watershed outlet. Figure 1 further illustrates the difference between the sediment loads when ephemeral gullies are excluded from the equation.

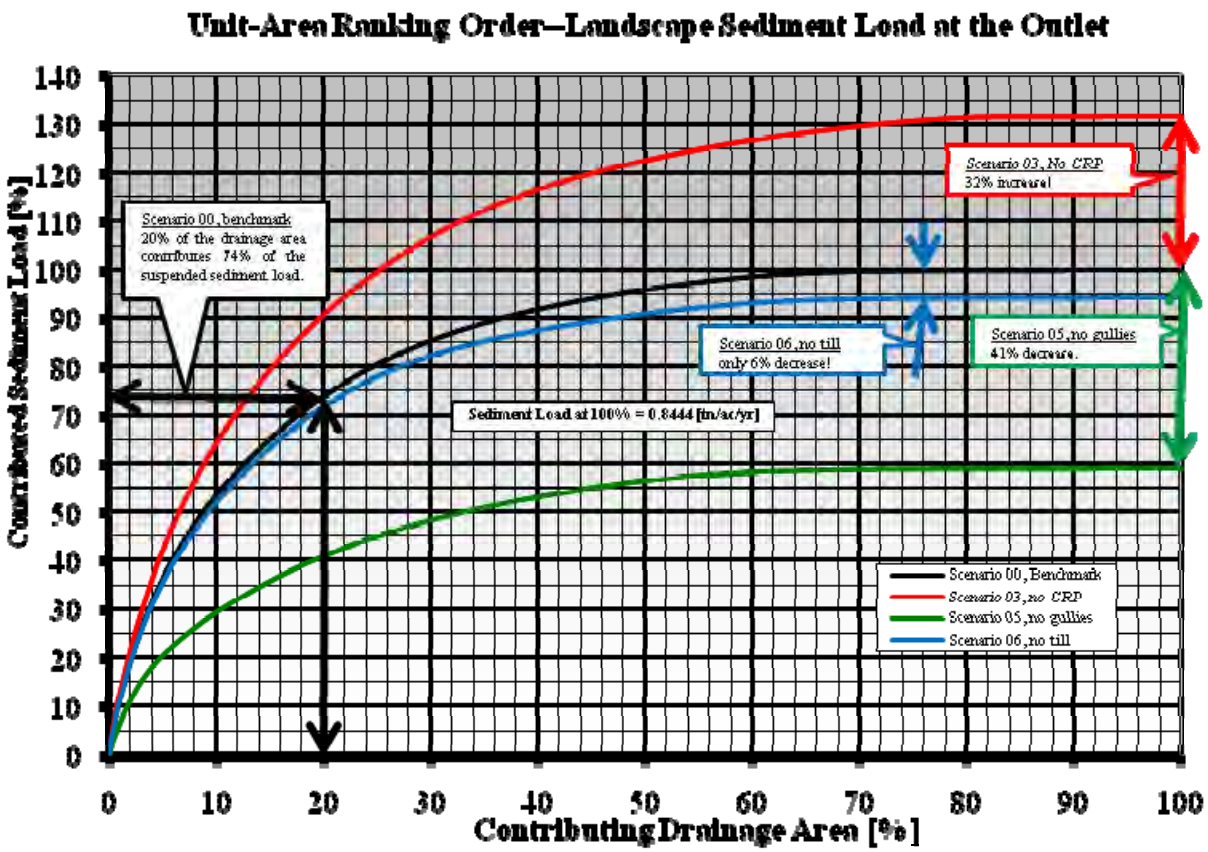

Figure 1 Cheney watershed sediment load by unit area ranking ratio.

Approximately 41 percent of the sediment load in the Cheney watershed could be eliminated by treating ephemeral gullies as seen in Scenario 05, no gullies. An increase of 31% of sediments delivered to the watershed outlet could result from the removal of CRP acres with 90% of the sediment coming from 20% of the watershed as seen in Scenario 03, no CRP. A reduction of 6% of sediments delivered to the watershed outlet could result from strategic implementation of no till.

Another valuable set of statistics is the ranking order of the more egregious sources of a pollutant leaving the outlet of the watershed. These statistics are a function of: (a) the portion of the pollutant at the outlet contributed by the source; (b) divided by the drainage area of the pollutant source; and then (c) divided by the number of simulation years. Although not included within this paper, the resulting statistics can be ranked to determine the order of the more serious sources of pollutants. These relationships between sediment load at the watershed outlet and the contributing cells can also be illustrated spatially in a watershed map. This same type of analysis can be done for each of the scenarios to determine the best possible location for the various conservation treatments.

FURTHER DISCUSSION POINTS

Better spatial and temporal information regarding precipitation is needed to make the model more accurate. Although every effort was made to locate and utilize local weather and climate information, the development of new technologies and additional recording stations will provide more accurate information on a temporal and spatial scale.

A baseflow feature that addresses the percolation into the vadose zone, groundwater movement, and interception of the top of the water table by the channel is needed within AnnAGNPS if a complete analysis of dissolved chemicals is important or when calibrating or validating. It is important to note that 38% of the total nitrogen load and 30% of the total phosphorous load is derived from base flow. While it is still important to improve AnnAGNPS baseflow routines on a monthly basis the average annual baseflow estimates are most likely correct. The 1.0ppm total nitrogen load is very close to being considered “background” concentration. It will require a different suite of conservation practices to address reductions of nutrient loads originating as baseflow from runoff derived nutrient loads.

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