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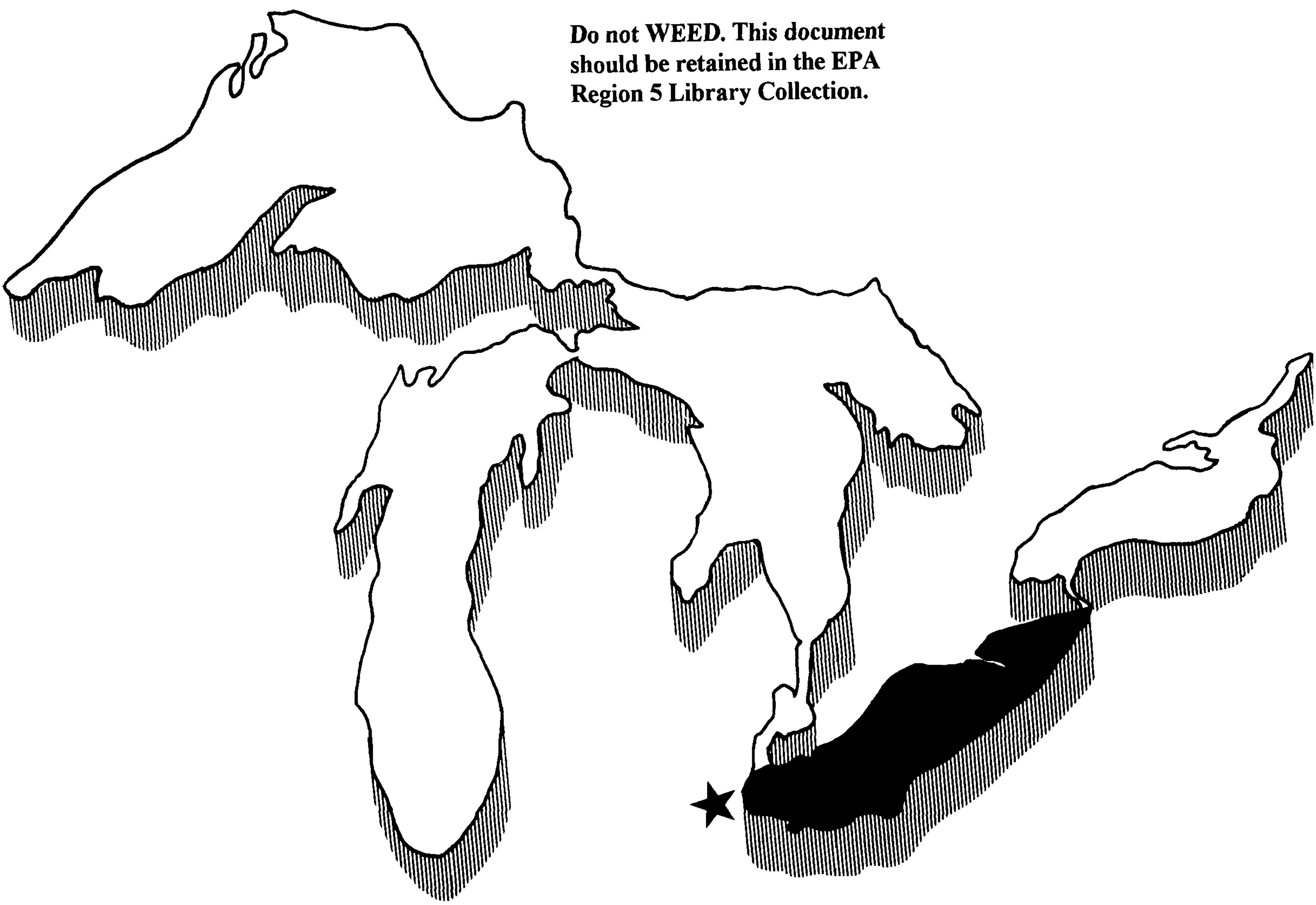
June 1987

# Tri-State Tillage Project

## Modeling Component Applying the Answers Model to Assess the Impacts of Conservation Tillage on Sediment and Phosphorus Yields to Lake Erie





## FOREWORD

The U.S. Environmental Protection Agency (USEPA) was created because of increasing public and governmental concern about the dangers of pollution to the health and welfare of the American people. Noxious air, foul water, and spoiled land are tragic testimony to the deterioration of our natural environment.

The Great Lakes National Program Office (GLNPO) of the USEPA was established in Region V, Chicago, Illinois to provide specific focus on the water quality concerns of the Great Lakes. The Section 108(a) Demonstration Grant Program of the Clean Water Act (PL 92-500) is specific to the Great Lakes drainage basin and thus is administered by the Great Lakes National Program Office.

Several sediment erosion-control projects within the Great Lakes drainage basin have been funded as a result of Section 108(a). This report describes one such project supported by this Office to carry out our responsibility to improve water quality in the Great Lakes.

We hope the information and data contained herein will help planners and managers of pollution control agencies to make better decisions in carrying forward their pollution control responsibilities.

Valdas V. Adamkus
Administrator, Region V
National Program Manager for the Great Lakes

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# TRI-STATE TILLAGE PROJECT

"Modeling Component Applying The Answers Model to Assess The Impacts of Conservation Tillage on Sediment and Yields to Lake Erie"

Final Report

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Modeling Component -- Tri-State Tillage Project

"Applying the ANSWERS Model to Assess the Impacts of Conservation Tillage on Sediment and Phosphorus Yields to Lake Erie"

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## INTRODUCTION

In late 1981, a modeling study was proposed as a part of the Tri-State Tillage project. This study had two major objectives. The primary goal of the program was to provide basin scale projections of sediment and phosphorus yield reductions in the Western Basin of Lake Erie attainable from various degrees (i.e., spatial extent) and types of tillage management. Secondarily, a study of the size of the sample area needed to make accurate projections was to be undertaken.

Two stratified 0.5% samples (based on soil association groupings) were simulated for a number of tillage management scenarios. Basin-wide projections of sediment and phosphorus yield were compared to observed river mouth data for the study area. Finally, the projections were refined based on actual conservation tillage implementation rates to provide data for tracking purposes. Data for 1982 and 1983 land use patterns in the project area (on each major Soil Group) were obtained from the Conservation Tillage Information

Center (CTIC) and used to better describe the actual patterns and percentages of cover and management in the simulations. The "potential" scenarios were also modified to correspond to the CTIC information.

The yields predicted from each Group, as well as from the Basin as a whole, are consistent with long-term river mouth and tributary monitoring of sediment yields in the project area. Predicted unit area loads of phosphorus indicate that major reductions in diffuse phosphorus loading will be rather difficult to obtain. This is due to the fact that the amount of phosphorus reduction required by Annex III of the International Joint Agreement is of a similar magnitude to the unit area agricultural loading.

Descriptions of the project area, study objectives, and developed methodology are included. The results of the final simulations are described in detail and emphasized in the Summary and Conclusions section.

## PROJECT AREA

The Tri-State Tillage Project encompasses approximately 24,200 square kilometers in Northwest Ohio, Northeast Indiana and Southeast Michigan (Figure 1). The Maumee, Portage, and Sandusky River basins make up the majority of the study area. Some "near lake" drainage area is also included. Thirty-one counties in the three states are participating in the project. The locations of all of the watersheds simulated in the study are shown in Figure 1.

The methodology developed in this project is based on the premise that "representative" samples of the basin could be identified and modeled using a "stratified" sampling technique. The stratification would be based on simi-

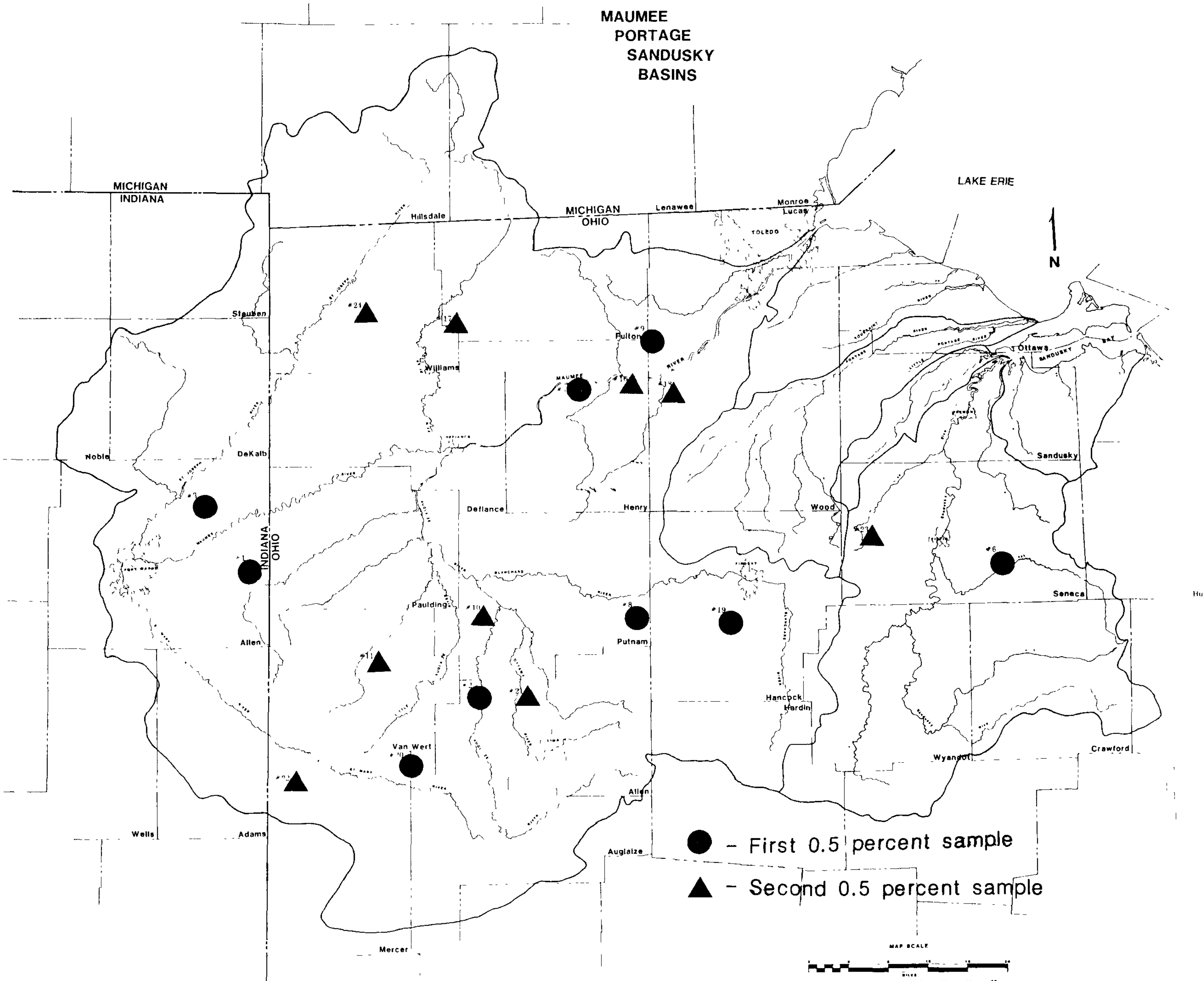


Figure 1. Study Area Drainage and Site Location Map

larities in the drainage characteristics of the numerous soil associations within the basin. The distribution of the major soil associations (Soil Groups) in the study area is depicted in Figure 2 and a description of the characteristics of each Group appears in Table 1. Soils in the study area vary from sands to loams to clays to organic mucks.

Table 1. Major Soil Group Descriptions and Spatial Extent

| Group | Drainage Class[1] | Surface Soil Texture | USDA-SCS Hydrologic Group[2] | Parent Material | Percent of Basin Area[3] |
|---|---|---|---|---|---|
| 1 | SPD-VPD | SiCL-C | D | Lacustrine-Till | 28.6 |
| 2 | WD-SPD | L-SiCL | C-D | Till | 50.5 |
| 3 | VPD | Muck | A-D | Organic | 0.2 |
| 4 | MWD-VPD | L-SiL | B-D | Outwash | 4.6 |
| 5 | SPD-VPD | SiL-SiCL | B-D | Lacustrine | 9.3 |
| 6 | WD-MWD | L-SiL | B-C | Outwash-Alluvial | 0.5 |
| 7 | WD-VPD | FS-SiL | A-B | Outwash-Alluvial | 4.5 |
| 8 | WD-VPD | SL-SiL | B-D | Till | 1.8 |

1 Drainage class abbreviations are: VPD--very poorly drained, SPD--somewhat poorly drained, MWD--moderately well drained, WD--well drained.

2 Some groups (particularly 3 and 4) contained soils which were listed as drained/undrained, thus the large range.

3 Groups 4 and 6 were later combined.

Cropping patterns are also variable. However, the predominant agricultural crops are corn, soybeans and small grains. Much of the area is composed of soils with less than adequate internal drainage and very little slope. Thus, both surface and subsurface drainage systems are numerous.

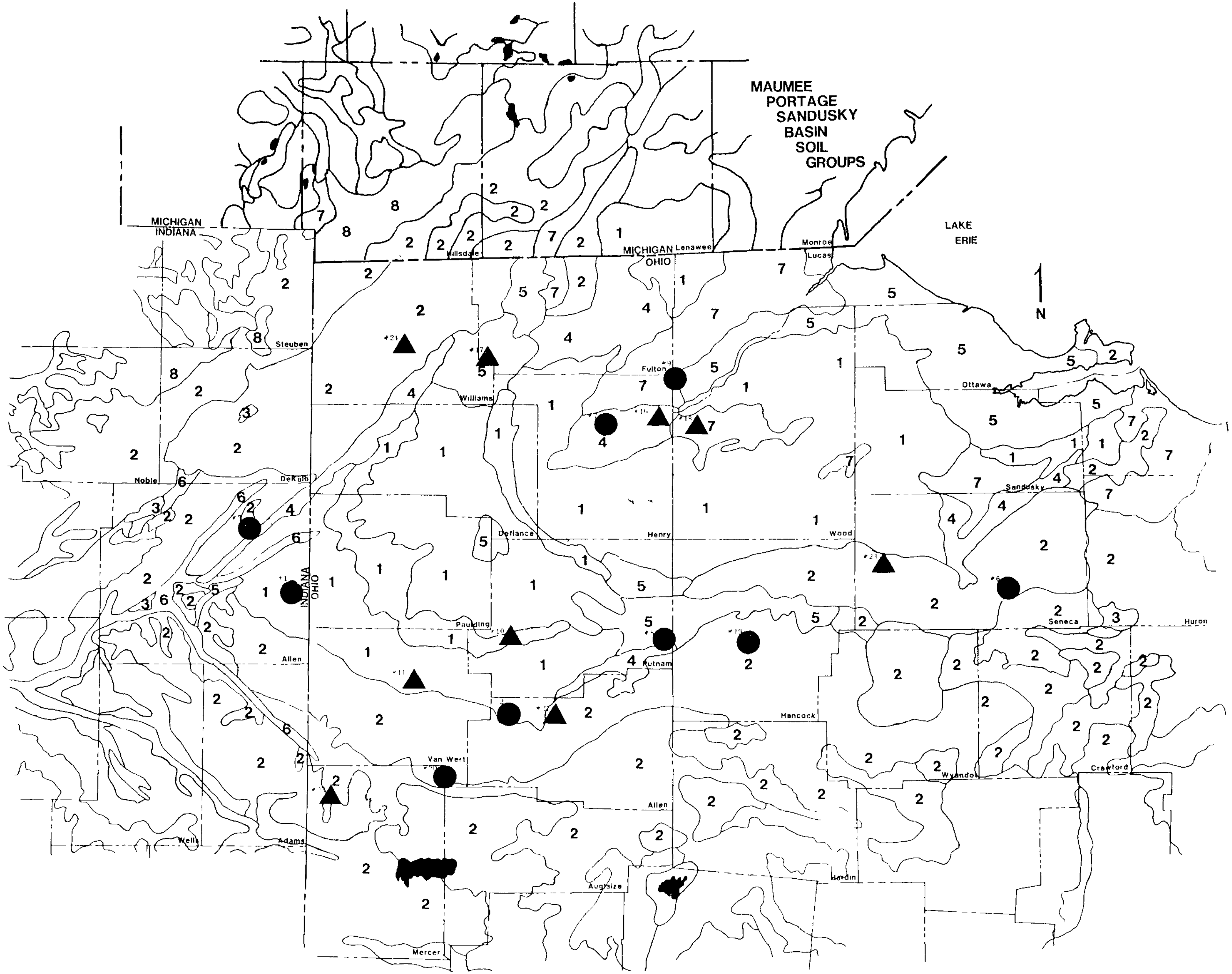


Figure 2. Study Area Soil Group Map

## STUDY METHODOLOGY

The ANSWERS (Areal Nonpoint Source Watershed Environment Response Simulation) model, developed at Purdue University (Beasley, 1977; Beasley and Huggins, 1982), was chosen as the predictive tool for the study. Since ANSWERS is an event-oriented, distributed parameter model, simulation of the entire study area was deemed both unreasonable and unnecessary. Instead, a stratified sample of the area was described, simulated and the results extended to the much larger study area.

The methodology required that a number of "representative" subwatersheds be selected and simulated. Ideally, these subwatersheds would have an area of 1,000 to 1,800 hectares so that sediment and nutrient yields at their outlets could be eventually expected to reach the larger receiving body of water (stream, river or lake). This size of watershed normally would be expected to support a second- or even third-order stream system. It would, therefore, drain to a well defined, continuously flowing channel system that should provide for ultimate delivery to the receiving body. Originally, a 0.5 percent sample of the area was chosen. This corresponded to 9 watersheds of the size mentioned above. Later work in the project included selecting and describing an additional 0.5 percent sample and comparing simulation results with those from the first sample. In doing so, a determination was made of the adequacy of the different size samples (0.5 and 1.0 percent) to describe the entire basin response of the different Soil Groups as indicated by monitored information.

The watersheds, mentioned above, were chosen based on a stratified sampling criteria. The stratification involved grouping soils (actually associations) with similar water movement characteristics (internal drainage, surface texture, hydrologic group, and parent material) in order to simplify and "normalize" data collection and expand applicability of simulation results. The application of this classification and stratification scheme resulted in 8 major Soil Groups. The Soil Groups (shown in Figure 2) were planimetered to determine the areas in each grouping. The Soil Group descriptions and their areal extent are shown in Table 1. These major Soil Groups included more than 75 soil types. Since neither Group 3 nor 8 accounted for more than 4 percent of the area (both less than 2 percent), they were eliminated from further consideration. Since Groups 4 and 6 were similar, they were combined to form an area large enough to require one watershed.

Watersheds were then selected from areas mapped as belonging to a particular Soil Group. The maps used in this original site selection were the state soil association maps for Ohio, Indiana, and Michigan. Care was taken to select drainage areas in counties that were participating in the project and that had modern soil surveys. The topography and detailed soils information from the selected areas were then collected and assembled, using USGS topographic and SCS Soil Survey maps, into detailed watershed data files as described in the ANSWERS Users Manual (Beasley and Huggins, 1982). Based on the watersheds selected to represent the various groups, 9 were required for both of the 0.5 percent samples.

The cropping data, including management, was selected using a statistical process which "populated" the watershed in a manner consistent with cropping patterns on the group being represented. Once the percentages of the various land uses were known, a random number generator was used to "populate" the watersheds with land uses so that the divisions of land uses in the watersheds and the entire county were the same. The cropping and management assumptions are detailed in Table 2. Information derived from the Conservation Tillage Information Center (CTIC) data base was used to describe the land use and management patterns on the various Soil Groups throughout the study area for the final simulations. Those percentages, upon which the conclusions of this study are based, are shown in Table 3. The scenarios chosen for simulation are presented in Table 4. There were two actual years (1982 and 1983) included along with the 6 potential or hypothetical scenarios (which were based on modifications to the 1982 percentages). The 1982 data is considered the baseline, since that year has been so designated by USEPA. The 1983 data is the first complete year of CTIC data.

For the simulations, an element size of 1 hectare (100 meters on a side) was chosen. This led to 1,000 to 1,800 overland flow elements plus somewhere between 125 and 300 channel flow elements for a chosen watershed. The time step chosen for the simulation was one minute. The rainfall event simulated corresponded to an 8-year return period, 1.5-hour duration storm with the antecedent soil moisture at field capacity. This storm typically produced sediment and total P yields that corresponded well with observed average annual yields on a number of watersheds within the basin (Black Creek area of Allen Co., IN). The definitive work on this "design storm" concept was performed by Conrad Heatwole (1980) and was utilized in both the Indiana Model Implementation Project (MIP) and Allen County Special ACP Projects.

Table 2. Land Use and Management Descriptions

| Land Use[1] | Tillage Management[2] | Area in Vegetation | Max. Roughness Height | Residue Cover[3] | USLE "C"[4] |
|---|---|---|---|---|---|
| | | - % - | - cm - | | |
| Row Crop | Conventional | 25 | 5.1 | < 30% | 0.50 |
| | Chisel Plow | 30 | 6.4 | 30% to 60% | 0.10 |
| | Mini Till | 60 | 6.4 | 40% to 70% | 0.05 |
| | No-till | 80 | 7.6 | > 70% | 0.02 |
| Other Crop | Conventional | 60 | 4.6 | < 30% | 0.10 |
| | Chisel Plow | 60 | 5.1 | 30% to 60% | 0.08 |
| | No-till | 85 | 6.4 | > 60% | 0.02 |
| Hay-Pasture | --- | 90 | 3.8 | --- | 0.04 |
| Woods | --- | 85 | 7.6 | --- | 0.01 |
| Built-up | --- | 60 | 3.8 | --- | 0.20 |

1 Row crop values depict corn, other crop values describe a combination between small grains and truck crops.

2 Conventional consists of fall turn plow and spring disk, chisel plow is fall tillage with spring harrow or similar, mini-till is either ridge plant after field cultivation or standard till-plant technique. For other crop categories, these definitions really only designate differences in residue cover.

3 Residue covers are based on high predictivity. Thus, lesser yields would probably produce more erosion and sediment yield.

4 The values are reported for crop stage 1 - the period after planting until the plants reach 1 month in age.

The 75-plus soil types were sorted for similarities based on hydrologic group, textural class, parent material, internal drainage, soil erodibility - "K", and permeability. The result was 13 different soils response classes. When conservation tillage was applied on a specific soil, the infiltration capacity of that soil was assumed to increase. The more conservative the tillage systems and the more residue that remained on the surface, the higher the infiltration rates (Beasley and Huggins, 1982).

Table 3. Cropping Distribution for the Major Soil Groups (from CTIC).

| | Crop or Cover* | | | | |
|---|---|---|---|---|---|
| Group | Row Crops | Other Crops | Pasture | Forest | Built-up |
| | -%- | -%- | -%- | -%- | -%- |
| 1 | 63 | 19 | 5 | 8 | 5 |
| 2 | 58 | 18 | 10 | 9 | 5 |
| 4+6 | 63 | 16 | 8 | 8 | 5 |
| 5 | 50 | 15 | 15 | 15 | 5 |
| 7 | 55 | 16 | 10 | 14 | 5 |

* Row crops include: corn, soybeans, sorghum, etc. Other crops include: small grains, beets, berries, etc. Pasture includes hay crops. Forest includes: brushland and swamp. Built-up includes: homesteads, farmsteads, and other semi-pervious, smooth areas.

Table 4. Scenarios Used in the Simulation Study

| Scenario | Description |
|---|---|
| 1 | Baseline. 1982 basin averages for conventional, chisel plow, reduced till, and no-till on row and other cropland. |
| 2 | 1983 basin averages for conventional, chisel plow, reduced till, and no-till on row and other cropland. |
| 3 | 1/4 of the conventional tillage on both row and other crops replaced with fall chisel plowing. |
| 4 | 1/4 of the conventional tillage on row crops only replaced by till-plant minimum tillage techniques. |
| 5 | 1/4 of the conventional tillage on both row and other crops replaced with no-till techniques. |
| 6 | 1/2 of the conventional tillage on both row and other crops replaced with fall chisel plowing. |
| 7 | 1/2 of the conventional tillage on both row and other crops replaced with no-till techniques. |
| 8 | All conventionally tilled areas switched to no-till techniques (most conservative scenario). |

The phosphorus projections used in this study are the result of an equation which relates particulate phosphorus yield (85% - 90% of Total P) to sediment yield. This equation was the result of an extensive data analysis of the water quality information gathered in the Black Creek Project (Lake and Morrison, 1977) by Dr. Darrell W. Nelson, formerly of the Agronomy Department at Purdue. The equation used was:

$$P = .00058*SED**1.12$$

where: $P$ = particulate phosphorus yield in kg/ha,

$SED$ = predicted sediment yield in kg/ha.

The predicted particulate P yield was then divided by 0.85 to produce an estimate of Total P yield.

When the representative watersheds had been described and crop and soils information supplied to the model, a number of scenarios were simulated. These scenarios described the "as is" or baseline conditions in the watersheds as well as potential conditions involving the changing of management to forms of tillage with greater conservation potential. Thus, a planner could study the impact of various levels of conservation tillage application (all the way to 100 percent no-till) and compare them to existing levels.

PROJECT RESULTS

The primary reason for conducting this study was to provide accurate estimates of the efficacy of a large-scale application of conservation tillage on sediment and phosphorus yields in the Western Basin of Lake Erie. However, other questions also needed to be answered. The question of how large an area to simulate to arrive at consistent results is quite important. >From a planner's standpoint, the question of how much time must be allotted to apply the methodology described herein is also very important.

The work conducted in the first two years of the study involved the selection and simulation of two 0.5 percent samples of the total basin. Numerically, this involved 9 watersheds in each year. While project personnel spent large amounts of time defining the basin, detailing how Soil Groups would be described, selecting appropriate watersheds for simulation, and entering data, we believe that a routine application of this methodology could be done much more efficiently. Selection of watersheds, data preparation, and simulation should be possible on a 3.5 to 5.0 days per 1,000 elements basis. Thus, it should be possible to complete work on a 1,500 element watershed in less than two weeks. Although cost information and data on individual computer requirements is generally not applicable to other systems, the simulations presented herein typically cost $8 to $14 on Purdue's CDC-6600 and required 200 to 350 CPU seconds. Simulations were also run on a Digital Equipment Corporation VAX 11/780 and typically required 500 to 800 CPU seconds.

The Group 1 and Group 2 soils were represented by multiple watersheds. Two catchments were used for Group 1 and four for Group 2. The output from the individual watersheds were combined to give a Group average. Each of the watersheds that made up the two 0.5 percent samples are described in Tables 5 and 6.

In an effort to more closely detail the cropping and management systems presently in use, the CTIC Data Base was utilized. Table 3 displays the land use percentages for the baseline (1982) scenario for each of the major soil groups.

The simulation results for the 8 scenarios for both of the 0.5 percent samples are shown in Tables 7 and 8. Watersheds composed primarily of Group 2 soils stand out as sources of sediment and phosphorus in both samples. Since the soils in this Group are typically more erodible, the topography more variable, and the infiltration rates fairly low, it is quite logical that these soils would have the highest erosion and phosphorus yields. Each of the other Groups had at least one factor which lessened its impact when compared to Group 2. All other Groups had lower average values of slope, and several had much higher infiltration capacities. Also, other Groups contained soils which were more resistant to erosion than soils classified in Group 2.

When the information in Table 1 is combined with that in Tables 7 and 8, the problem with the Group 2 soils becomes even more evident. Since these soils make up over 50 percent of the basin, any large-scale reduction in the phosphorus yields to the Western Basin of Lake Erie will have to be achieved by reducing Group 2 phosphorus yields. Table 9 highlights this information by

Table 5. General Watershed Information (First 0.5 Percent Sample)

| No. | Name | Location | Description |
|---|---|---|---|
| 1 | Edgerton-Carson and Miller Ditches | Allen Co., IN | Group 1 soils, 1,164 hectares, 0.21 percent average slope. |
| 2 | Unnamed Tributary to Auglaize River | Allen Co., OH | Group 1 soils, 1,118 hectares, 0.44 percent average slope. |
| 3 | Bottern, Kurtz, and Roth Ditches | Allen Co., IN | Group 2 soils, 1,366 hectares, 1.16 percent average slope. |
| 6 | East Branch | Seneca Co., OH | Group 2 soils, 1,192 hectares, 1.74 percent average slope. |
| 19 | Aurand Run | Hancock Co., OH | Group 2 soils, 1,573 hectares, 0.66 percent average slope. |
| 20 | Kyle Prairie Creek | Mercer Co., OH | Group 2 soils, 1,372 hectares, 0.68 percent average slope. |
| 7 | Unnamed Tributary to Maumee River | Henry Co., OH | Groups 4 and 6 soils, 1,827 hectares, 0.53 percent average slope. |
| 8 | Cartwright Run | Putnam Co., OH | Group 5 soils, 1,234 hectares, 0.62 percent average slope. |
| 9 | Harris Ditch | Lucas, Henry, and Fulton Co., OH | Group 7 soils, 1,606 hectares, 0.66 percent average slope. |

Table 6. General Watershed Information (Second 0.5 Percent Sample)

| No. | Name | Location | Description |
|---|---|---|---|
| 10 | Unnamed Tributary to Auglaize River | Putnam Co., OH | Group 1 soils, 1,628 hectares, 0.23 percent average slope. |
| 11 | Town Creek | Van Wert Co., OH | Group 1 soils, 1,263 hectares, 0.31 percent average slope. |
| 21 | Beaver Run | Allen Co., OH | Group 2 soils, 1,535 hectares, 0.69 percent average slope. |
| 22 | Unnamed Tributary to Black Creek | Mercer Co., OH | Group 2 soils, 1,057 hectares, 0.76 percent average slope. |
| 23 | Harrison Creek | Seneca Co., OH | Group 2 soils, 1,560 hectares, 0.72 percent average slope. |
| 24 | Lick Creek | Williams Co., OH | Group 2 soils, 1,284 hectares, 1.59 percent average slope. |
| 16 | Coon and Lick Creeks | Henry Co., OH | Groups 4 and 6 soils, 930 hectares, 0.56 percent average slope. |
| 17 | Owl Creek | Williams Co., OH | Group 5 soils, 1,661 hectares, 0.38 percent average slope. |
| 18 | Unnamed Tributary to Beaver Creek | Wood Co., OH | Group 7 soils, 1,311 hectares, 0.37 percent average slope. |

* Land use was broken into five categories: row crops, other crops, hay or pasture, woodlands, and built-up areas. For this table, cropland includes the first two categories.

Table 7. Predicted Sediment and Phosphorus Yields for Each Scenario on Each Watershed - First 0.5% Sample.

| Watershed | Soil Group | Parameter | Scenario 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | ----- kg/ha ----- | | | | | | | |
| #1 - Edgerton-Carson and Miller Ditches | 1 | Sed | 210 | 210 | 210 | 170 | 160 | 170 | 120 | 50 |
| | | P | 0.27 | 0.27 | 0.24 | 0.22 | 0.21 | 0.21 | 0.15 | 0.06 |
| #2 - Unnamed Tributary to Auglaize River | 1 | Sed | 600 | 600 | 520 | 500 | 480 | 440 | 350 | 110 |
| | | P | 0.88 | 0.87 | 0.75 | 0.72 | 0.68 | 0.63 | 0.48 | 0.13 |
| #3 - Bottern, Kurtz, and Roth Ditches | 2 | Sed | 1,330 | 1,250 | 1,140 | 1,100 | 1,060 | 940 | 770 | 220 |
| | | P | 2.14 | 2.01 | 1.81 | 1.74 | 1.66 | 1.45 | 1.16 | 0.29 |
| #6 - East Branch | 2 | Sed | 2,210 | 2,060 | 1,880 | 1,820 | 1,760 | 1,540 | 1,280 | 350 |
| | | P | 3.80 | 3.51 | 3.17 | 3.06 | 2.94 | 2.54 | 2.06 | 0.48 |
| #19 - Aurand Run | 2 | Sed | 680 | 640 | 600 | 570 | 540 | 510 | 400 | 150 |
| | | P | 1.02 | 0.95 | 0.88 | 0.84 | 0.78 | 0.74 | 0.56 | 0.19 |
| #20 - Kyle Prairie Creek | 2 | Sed | 840 | 790 | 730 | 700 | 670 | 620 | 490 | 160 |
| | | P | 1.28 | 1.20 | 1.10 | 1.05 | 0.99 | 0.91 | 0.70 | 0.21 |
| #7 - Unnamed Tributary to Maumee River | 4+6 | Sed | 400 | 370 | 350 | 340 | 320 | 290 | 250 | 90 |
| | | P | 0.55 | 0.52 | 0.48 | 0.46 | 0.44 | 0.40 | 0.33 | 0.11 |
| #8 - Cartwright Run | 5 | Sed | 530 | 530 | 450 | 420 | 410 | 380 | 300 | 90 |
| | | P | 0.77 | 0.76 | 0.65 | 0.60 | 0.58 | 0.53 | 0.41 | 0.11 |
| #9 - Harris Ditch | 7 | Sed | 130 | 130 | 120 | 120 | 110 | 100 | 80 | 30 |
| | | P | 0.17 | 0.15 | 0.15 | 0.14 | 0.14 | 0.12 | 0.10 | 0.04 |

Table 8. Predicted Sediment and Phosphorus Yields for Each Scenario on Each Watershed - Second 0.5% Sample.

| Watershed | Soil Group | Parameter | Scenario 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | ----- kg/ha ----- | | | | | | | |
| #10 - Unnamed Tributary to Auglaize River | 1 | Sed | 210 | 200 | 190 | 180 | 170 | 180 | 130 | 60 |
| | | P | 0.27 | 0.26 | 0.24 | 0.23 | 0.21 | 0.23 | 0.17 | 0.06 |
| #11 - Town Creek | 1 | Sed | 170 | 170 | 150 | 140 | 140 | 130 | 100 | 40 |
| | | P | 0.21 | 0.21 | 0.19 | 0.18 | 0.17 | 0.17 | 0.12 | 0.04 |
| #21 - Beaver Run | 2 | Sed | 690 | 660 | 620 | 590 | 550 | 520 | 410 | 140 |
| | | P | 1.04 | 0.97 | 0.91 | 0.86 | 0.81 | 0.75 | 0.58 | 0.18 |
| #22 - Unnamed Tributary to Black Creek | 2 | Sed | 860 | 810 | 740 | 710 | 680 | 640 | 520 | 160 |
| | | P | 1.31 | 1.23 | 1.11 | 1.06 | 1.02 | 0.94 | 0.75 | 0.21 |
| #23 - Harrison Creek | 2 | Sed | 940 | 880 | 810 | 780 | 750 | 710 | 580 | 200 |
| | | P | 1.45 | 1.36 | 1.24 | 1.19 | 1.12 | 1.07 | 0.85 | 0.26 |
| #24 - Lick Creek | 2 | Sed | 1,750 | 1,620 | 1,470 | 1,420 | 1,360 | 1,240 | 1,030 | 280 |
| | | P | 2.92 | 2.68 | 2.41 | 2.32 | 2.21 | 1.99 | 1.61 | 0.38 |
| #16 - Coon and Lick Creeks | 4+6 | Sed | 550 | 510 | 470 | 450 | 430 | 400 | 320 | 130 |
| | | P | 0.80 | 0.74 | 0.67 | 0.64 | 0.61 | 0.56 | 0.44 | 0.16 |
| #17 - Owl Creek | 5 | Sed | 380 | 380 | 340 | 320 | 310 | 290 | 230 | 90 |
| | | P | 0.54 | 0.53 | 0.47 | 0.43 | 0.42 | 0.39 | 0.30 | 0.10 |
| #18 - Unnamed Tributary to Beaver Creek | 7 | Sed | 140 | 130 | 130 | 130 | 120 | 110 | 90 | 50 |
| | | P | 0.17 | 0.16 | 0.16 | 0.15 | 0.15 | 0.14 | 0.11 | 0.06 |

Table 9. Predicted Sediment and Phosphorus Yields for Eight Scenarios on Each Soil Group -- Western Basin Totals.

| Group[1] | Sample[2] | Parameter | Scenario 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | ----- tonnes ----- | | | | | | | |
| 1 | A | Sed | 280,300 | 280,300 | 252,600 | 231,900 | 221,500 | 211,100 | 162,600 | 55,400 |
| | | P | 400 | 395 | 345 | 325 | 310 | 290 | 220 | 65 |
| | B | Sed | 131,500 | 128,000 | 117,700 | 110,700 | 107,300 | 107,300 | 79,600 | 34,600 |
| | | P | 165 | 165 | 150 | 140 | 130 | 140 | 100 | 35 |
| 2 | A | Sed | 1,546,000 | 1,448,200 | 1,329,000 | 1,280,100 | 1,231,300 | 1,102,900 | 898,200 | 268,800 |
| | | P | 2,520 | 2,345 | 2,125 | 2,045 | 1,945 | 1,725 | 1,370 | 355 |
| | B | Sed | 1,295,400 | 1,212,900 | 1,112,100 | 1,069,300 | 1,020,500 | 950,200 | 776,000 | 238,300 |
| | | P | 2,055 | 1,905 | 1,730 | 1,660 | 1,575 | 1,450 | 1,160 | 315 |
| 4+6 | A | Sed | 49,400 | 45,700 | 43,200 | 42,000 | 39,500 | 35,800 | 30,900 | 11,100 |
| | | P | 65 | 65 | 60 | 55 | 55 | 50 | 40 | 15 |
| | B | Sed | 67,900 | 62,900 | 58,000 | 55,500 | 53,100 | 49,400 | 39,500 | 16,000 |
| | | P | 100 | 90 | 85 | 80 | 75 | 70 | 55 | 20 |
| 5 | A | Sed | 119,300 | 119,300 | 101,300 | 94,500 | 92,300 | 85,500 | 67,500 | 20,300 |
| | | P | 175 | 170 | 145 | 135 | 130 | 120 | 90 | 25 |
| | B | Sed | 85,500 | 85,500 | 76,500 | 72,000 | 69,800 | 65,300 | 51,800 | 20,300 |
| | | P | 120 | 120 | 105 | 95 | 95 | 90 | 70 | 25 |
| 7 | A | Sed | 14,200 | 14,200 | 13,000 | 13,000 | 12,000 | 10,900 | 8,700 | 3,300 |
| | | P | 20 | 15 | 15 | 15 | 15 | 15 | 10 | 5 |
| | B | Sed | 15,200 | 14,200 | 14,200 | 14,200 | 13,100 | 12,000 | 9,800 | 5,400 |
| | | P | 20 | 15 | 15 | 15 | 15 | 15 | 10 | 5 |

1 Groups 1 and 2 utilized multiple watershed simulations. Figures reported are averages.

2 A and B samples correspond to the first and second 0.5 percent samples.

showing Basin-wide tonnages for each major Soil Group. Several of the scenarios indicate reasonable reduction levels can be achieved without extreme changes in management. Obviously, levels of reduction approaching 50 percent or more (unless all cropland goes to no-till) will only be achieved with a mixture of tillage and structural (terraces, sediment basins, waterways, etc.) BMPs.

A notable result is that the baseline (1982 scenario) yield for the 0.5 and 1.0 percent samples were within 85 kg/ha (10 percent) of each other. This indicates that the information gained from the 0.5 percent sample would have been essentially the same as that gained from the full 1.0 percent sample.

An uncertainty analysis was conducted on the 1.0 percent sample (since each Soil Group had at least 2 observations) using the 90% Confidence Interval as the test criteria. The analysis looked at the uncertainties (based on sample standard deviation and Student's t) both within Soil Groups and for the entire, basin-wide estimation. Both sediment and phosphorus yields were subjected to the analysis. The results indicated that for the 1.0 percent sample (18 watersheds) the uncertainty associated with sampling ranged from 26% (Scenario 8) to 28% (Scenario 1) for sediment estimations and from 25% (Scenario 8) to 32% (Scenario 1) for phosphorus estimations. This translated to 745 $\pm$ 207 kg/ha (Scenario 1) and 139 $\pm$ 36 kg/ha (Scenario 8) for Basin-wide sediment yields. The sampling uncertainty (at the 90% C.I.) for phosphorus yields ranged from 1.16 $\pm$ 0.37 kg/ha (Scenario 1) to 0.16 $\pm$ 0.04 kg/ha (Scenario 8).

Sediment yields in the basin are low. The predicted baseline average (1.0 percent sample) of 745 kg/ha compares very well with the area weighted averages of the Maumee (average of water years 1975-1978), Portage (average of water years 1975-1978), and Sandusky (average of water years 1975-1979) basins of 680 kg/ha/yr (USACE, 1982).

The data from both 0.5 percent samples were used to produce the information shown in Table 10. Long-term monitoring information (USACE, 1979) indicates that the mean annual unit-area P loads (both agriculture and non-agriculture) for the basin average approximately 1.07 to 1.21 kg/ha. The modeling program indicates that the predominantly agricultural study area ranges from 1.16 to 1.31 kg/ha (with individual Soil Groups ranging from 0.17 to 2.06 kg/ha). Hence, the observed basin average and the simulated average are essentially the same. While the Group 2 soils have unit area loads of P approaching 2 kg/ha, the entire basin is closer to 1 kg/ha. Even though these yields are relatively high when compared to some other agricultural situations, they are certainly not out of line with highly fertile and highly agricultural areas in other parts of this country. Tables 7 and 8 indicate that substantial reductions in sediment and phosphorus yields will only occur with large changeovers to more conservative tillage types (or addition of structural measures).

## SUMMARY AND CONCLUSIONS

A modeling study was undertaken to help in assessing the effectiveness of increasing amounts of conservation tillage for reducing phosphorus and sediment yields to Lake Erie. The study area included the Maumee, Portage, and

Table 10. Unit Area Loading Information

| | kg-P/ha |
|---|---|
| Mean Annual Monitoring Data (from LEWMS reports) | |
| 1975 Basin Average | 1.21 |
| 1976 Basin Average | 1.10 |
| 1977 Basin Average | 1.07 |
| ANSWERS Predictions | |
| 0.5 percent sample | 1.31 |
| 1.0 percent sample | 1.17 |

Sandusky River basins and near-lake areas. The ANSWERS model was combined with a stratified sampling procedure to produce estimates, based on representative watersheds, for major Soil Groups. These estimates were then area weighted to yield basin-wide predictions.

Predictions for two 0.5 percent samples of the study area were produced. The second sampling was used to make an overall 1.0 percent sample.

Statistical cropping and management data from county Soil Surveys were originally used in the watershed data files. However, CTIC data was used to update the tillage management scenarios and produce more representative descriptions for the final simulations presented herein.

There are a number of important results and conclusions that can be drawn from this project:

1. Since both the 0.5 and 1.0 percent sample results compared closely with monitored information, a 0.5 percent sample appears to be adequate for the region under consideration.

2. The Group 2 soils predominate in both areal extent and sediment and phosphorus yields. These soils must be the primary target in any major reduction program.

3. The "representative watershed" concept produced results that were consistent with both USGS and LEWMS information. Thus, the projected impacts of tillage management changes should be quite reasonable.

4. The cost of producing these simulations is only a very small fraction of what a continuous monitoring program would cost. Watershed description is the major cost and is a "one-time" expense. In addition, results are available much more quickly than monitoring data and can be obtained for hypothetical as well as actual conditions.

5. The amount of reduction achievable from conservation tillage only is probably not adequate for the Annex III goals. The 1,000 + metric tonnes required of the study area could only be achieved if almost 50% of the basin changes over to no-till. If only the Group 2 soils were treated, approximately 60% of all Group 2 soils in the row crop or other crop categories would have to be switched over to no-till to achieve the sought after reduction.

6. A realistic, short-term expectation might be a 50 percent switchover to chisel plowing (scenario 6). This would indicate a reduction of 837 tonne over 1982 yields (against an approximate 1,100 tonne goal), assuming all cropland in the basin was treated equally.

7. The model used for phosphorus prediction produces an estimate of total phosphorus. Monitoring data suggests that as much as half of the biologically available P is soluble. While the estimation technique gives credit to some soluble P, it may not be accurate for small, low sediment yield events. Hence, the weight given to soluble P may not be great enough.

8. ANSWERS produces estimates of **total** sediment yield. Most monitoring programs are reporting results based on suspended sediment monitoring. While bedload is not a significant problem in some parts of this country, it should certainly be considered in the upper Midwest! Many of the particles moving through saltation are aggregates that are almost entirely made up of clay and silt particles. These particles carry P in almost exactly the same concentrations as the primary particles. Their large weight, when compared to dispersed, suspended particles, indicates the importance of adequately accounting for their presence in the sediment and P loading sampling programs.

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16. ABSTRACT

This modeling study was undertaken to help in the assessing the effectiveness of increasing amounts of conservation tillage for reducing phosphorus and sediment yields to Lake Erie. The study area included the Maumee, Portage, and Sandusky River basins and the near-lake areas. The ANSWERS model was combined with a stratified sampling procedure to produce estimates, based on representative watersheds, for major Soil Groups. These estimates were then area weighted to yield basin-wide predictions. Predictions for two 0.5 percent samples of the study area were produced. The second sampling was used to make an overall 1.0 percent sample. Simulations of the data collected are reported in the report. Eight different scenarios were done with varying residue cover and tillage methods with the different soil types.

17. KEY WORDS AND DOCUMENT ANALYSIS

| a. DESCRIPTORS | | b. IDENTIFIERS/OPEN ENDED TERMS | c. COSATI Field/Group |
|---|---|---|---|
| Modeling | Runoff | | |
| Sediment | Yields | | |
| Phosphorus | Unit area loads | | |
| Tillage | | | |
| No-till | | | |
| Conservation tillage | | | |
| Conventional tillage | | | |
| Water quality | | | |

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