Environmental Impact Of Land Use On Water Quality
(Progress Report)

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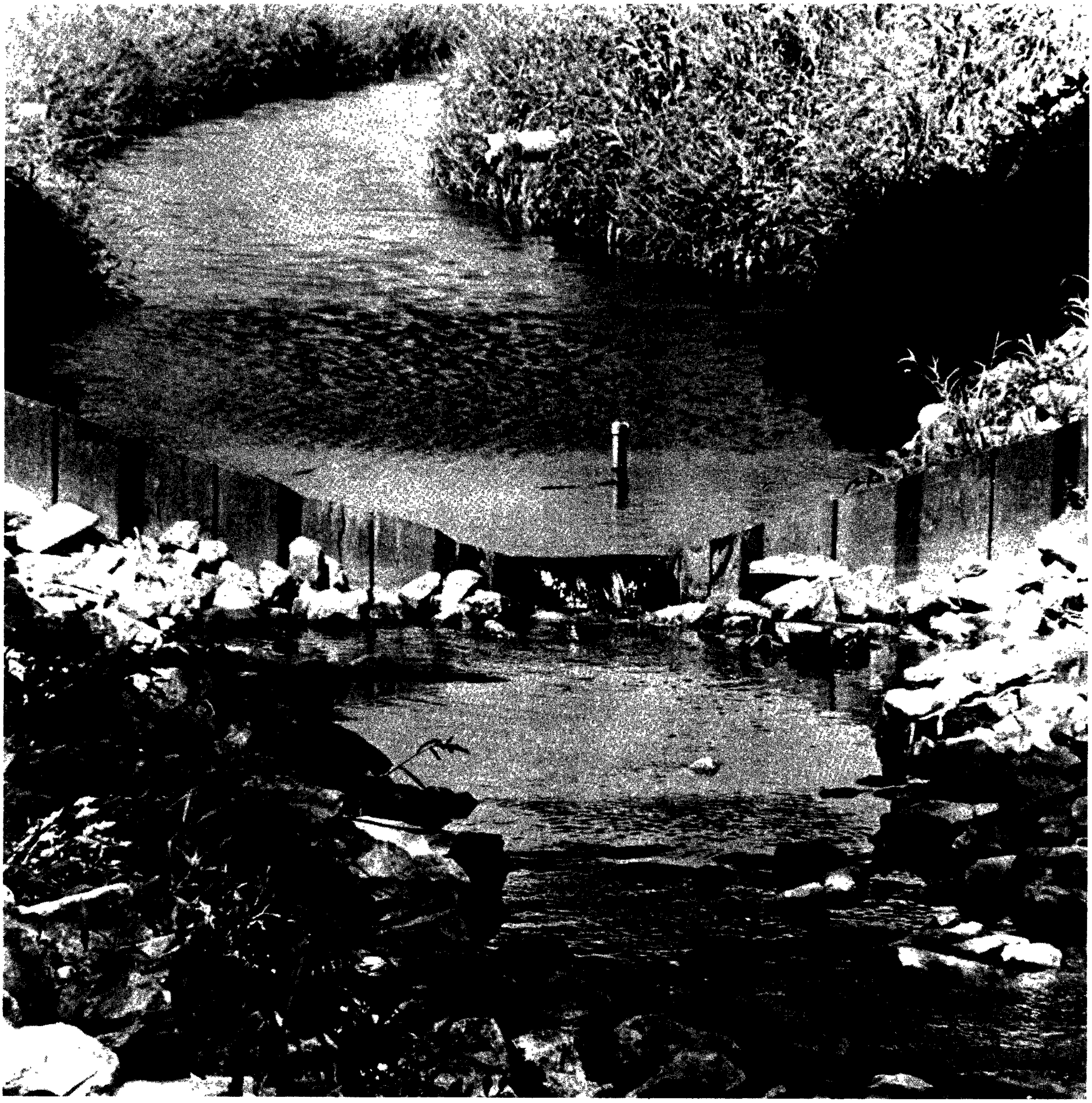

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ENVIRONMENTAL IMPACT OF LAND USE ON WATER QUALITY

(Progress Report)

BLACK CREEK PROJECT

Allen County, Indiana

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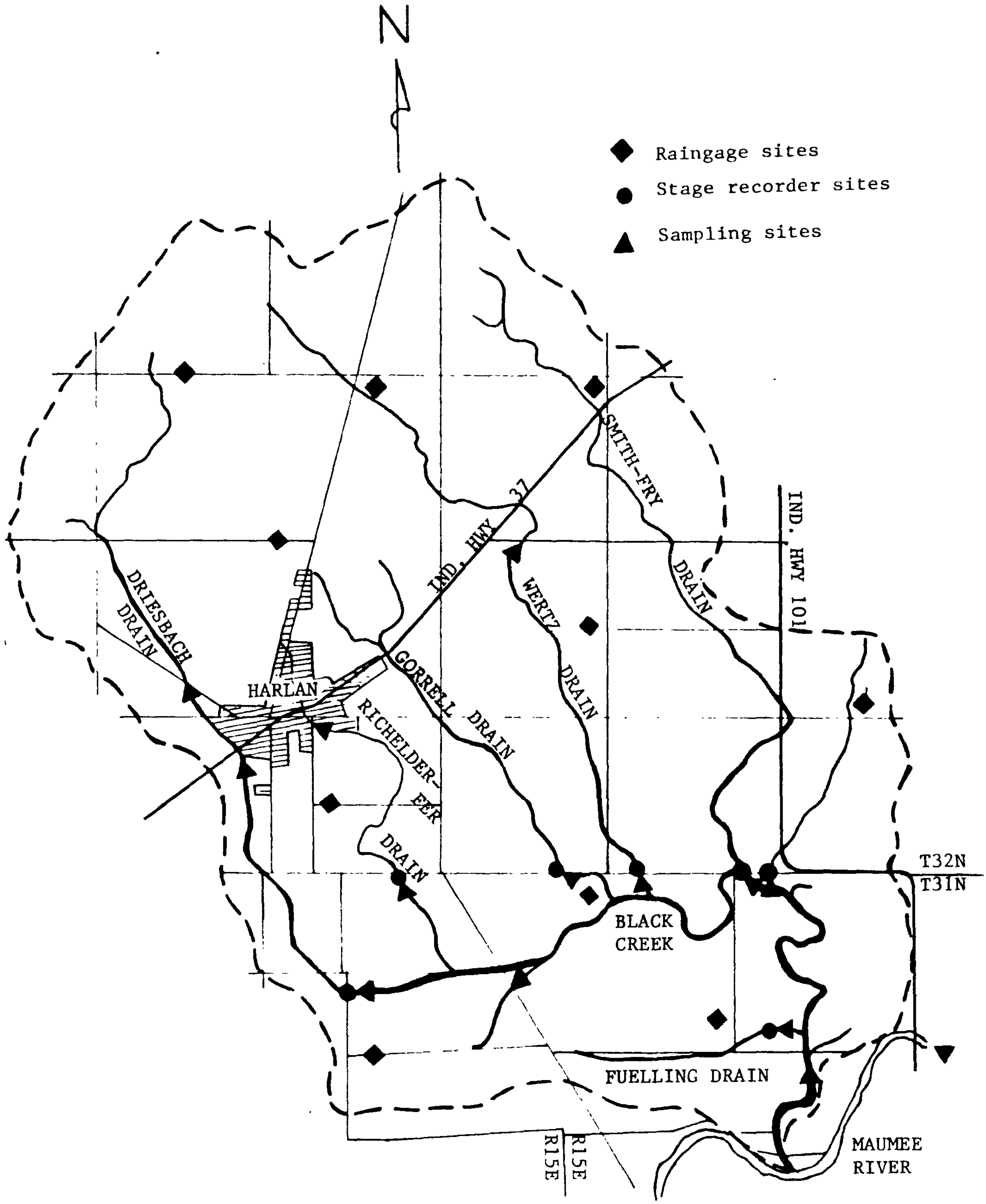

BLACK CREEK WATERSHED

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INTRODUCTION
BLACK CREEK PROJECT

This document is a progress report on the Black Creek Project, Allen County, Indiana, being undertaken by the Allen County Soil and Water Conservation District under U.S. EPA Grant No. G005103. It concentrates on work done during the 1975-1976 project year and is the last scheduled major publication describing work on the project prior to the final report which is due in the autumn of 1977.

This progress report supplements the following major publications previously issued as the result of the Black Creek Project:

(a) Environmental Impact of Land Use on Water Quality (EPA G005103) published in May of 1973 and outlining the plan of work for the study.
(b) Operations Manual Black Creek Study, Allen County Indiana (EPA-905-74-002) which set forth in detail standards by which the work was to be carried out.
(c) Annual Report No. 1 which described work undertaken during the first year of the project.
(d) Environmental Impact of Land Use on Water Quality --Progress Report (EPA-905/9-75-006) which reported on work undertaken through November of 1975.

Data presented in this report are not as extensive as those reported in the preceding progress reports. This is because investigators were instructed not to report data unless they provided additional insight or conflicted with previously reported findings. A comprehensive report on all investigations and all data collected during the project will be made in the final report.

The Black Creek Project was funded by the Environmental Protection Agency in October of 1972 in an attempt to determine the impact of agricultural activities in the Maumee Basin on the water quality of the Maumee River and on Lake Erie. It is an outgrowth of a conference on the Maumee River sponsored by Rep. J. Edward Roush in January of 1972 at Fort Wayne, Indiana.

There is, perhaps, some significance to the fact that the Black Creek Project was designed and that a proposal for the project was forwarded to the U.S. Environmental Protection Agency under the provisions for Special Great Lakes Programs prior to the adoption of PL 92-500 which provided a direct Congressional mandate for a program, under Sec. 208, to deal with non-point sources of pollution. The Black Creek Project deals with non-point pollution, specifically as it is impacted by normal agricultural operations in the Maumee Basin.

The design of the Black Creek Project, accomplished by a consortium of the Environmental Protection Agency, the Soil Conservation Service of the United States Department of Agriculture, Purdue University, and the Allen County Soil and Water Conservation District, is that of a demonstration supported by intensive research. The basic idea was to select an area, typical of the Maumee Basin. Through intensive planning efforts and conservation salesmanship, needed conservation practices would be applied on the land, working toward 100 per cent treatment by the end of the five-year study. Land treatment was to be designed in accordance with the specification of the Technical Guide of the Soil Conservation Service.

Concurrently, researchers would attempt to evaluate the efforts at conservation. Specifically, an attempt would be made to correlate improvements in water quality that could be attributed to improved conservation practices with the cost of the practices and the social and economic aspects of their adoption.

During the course of the project, there have been significant changes in emphasis in both the technical and the demonstration portions of the work. However, considering the scope of the demonstration effort, the success of the work to date has been better than could have been reasonably anticipated.

The most substantial change to date has involved a refocussing of the planning and application of conservation practices to reflect the growing awareness of the concept of best management practices.

In the research portion of the project, the scope of the modeling effort has been reduced somewhat, and the attention paid to the biota of the Black Creek area has increased over that envisioned when the work plan was developed. On balance, it can be fairly said that it is not remarkable that there have been changes in the work, but it is remarkable that there have been so few of them.

SECTION 1
LAND TREATMENT IN BLACK CREEK WATERSHED
1976 PROGRESS

As of Sept. 30, 1976, the success of the Allen County Soil and Water Conservation District in meeting the land treatment goals set forth in the work plan for the watershed has been mixed. Per cent of goals accomplished ranges from a low of 0 per cent on several practices to a figure nearly double that originally contemplated in the case of terraces.

Land treatment goals for the project were established by a team of Soil Conservation Service technical personnel. The original goals are outlined in Table A-10 of the work plan, Environmental Impact of Land Use on Water Quality --A Work Plan.

The disparity in the degree of success which has been obtained can be attributed to several factors, not the least of which is that project personnel were entering new areas without a firm idea of how the maximum impact of land treatment on water quality could be obtained.

As a result, every practice from the Soil Conservation Service Technical Guide that seemed likely to be usable was included in the basic planning. In all, 32 practices were recommended, not all of which can be expected to have their maximum impact on water quality.

With the increasing emphasis on the concept of Best Management Practices, the emphasis of the Allen County Soil and Water Conservation District has shifted over the first three-and-one-half years of the project toward those practices which it is now believed will have the greatest impact on water quality.

This does not imply a criticism of any of the practices which were outlined in the original work plan. In fact, in another area and with different conditions of soil types, drainage patterns, and land use patterns, practices not given so much attention in the Black Creek area could easily have become more prominent.

The original goals for land treatment on the Black Creek Watershed, an indication of the amount of those goals which have been accomplished, and the per cent of success this represents are summarized in Table 1.

Table 1 is instructive for several reasons. A ready glance will identify practices, such as contouring and strip cropping that could not reasonably be expected to be major practices in the flat lands of the Maumee Basin. Low goals were set for these practices, and low accomplishments were made, in each case zero. In another type of area, either or

TABLE 1 ACCOMPLISHMENTS OF BLACK CREEK LAND TREATMENT

ITEM (Unit)	GOAL	ACCOMP-LISHMENTS	PERCENT
District Cooperators (No.)	148	145	95
Conservation Plans (No.)	170	133	78
Contour Farming (Ac.)	769	0	0
Land Adequately Treated (Ac.)	10,573	5,986	57
Conservation Cropping System (Ac.)	7,418	5,621	76
Critical Area Planting (Ac.)	10	15	150
Crop Residue Management (Ac.)	7,491	1,149	15
Diversions (Ft.)	39,200	1,750	4
Farmstead and Feedlot Windbreak (Ac.)	75	4	5
Field Border (Ft.)	288,320	102,809	39
Field Windbreak (Ft.)	12,000	0	0
Grade Stabilization Structure (No.)	368	138	38
Grassed Waterway or Outlet (Ac.)	68	62	91
Holding Ponds and Tanks (No.)	11	7	64
Land Smoothing (Ac.)	300	0	0
Livestock Exclusion (Ac.)	215	22	8
Livestock Watering Facility (No.)	28	2	7
Minimum Tillage (Ac.)	7,656	291	4
Pasture & Hayland Management (Ac.)	402	97	24
Pasture & Hayland Planting (Ac.)	501	30	6
Pond (No.)	39	9	23
Recreation Area Improvement (Ac.)	12	9	75
Sediment Control Basin (No.)	6	3	50
Stream Channel Stabilization (Ft.)	6,000	9,900	166
Streambank Protection (Ft.)	122,000	74,100	61
Stripcropping (Ac.)	300	0	0
Surface Drains (Ft.)	90,000	200	1
Terraces (Ft.)	22,000	41,612	189
Tile Drains (Ft.)	200,300	63,599	32
Tree Planting (Ac.)	10	0	0
Wildlife Habitat Management (Ac.)	222	148	67
Woodland Improved Harvesting (Ac.)	610	0	0
Woodland Pruning (Ac.)	50	0	0

both of these practices could easily be important from the standpoint of best management practices.

An illustration of the adaptation of a practice which at first does not seem particularly important in this type of area is also provided in Table 1. In the case of parallel tile outlet terraces, no accomplishment was reported in the Black Creek area until the beginning of this project year. The general consensus among project personnel was that terraces, like contouring and stripcropping, were best suited to more rolling, rougher land.

The factor that made project personnel change their minds was the enthusiasm of a soil conservationist, Gregg Woods, who came to the project after experience with terraces in Iowa. Mr. Woods not only demonstrated that landowners in the Black Creek Watershed could be convinced that terracing was a useful practice, he convinced project personnel that sets of parallel tile outlet terraces could be a useful best management practice which it is believed will be very important in reducing sediment and related pollutants. A set of terraces can be used with success in most areas where a grassed waterway might be considered and can be more acceptable in some areas than a waterway due to the ease with which large farm machinery can be used with terraces.

Several reviewers of the Black Creek project have offered the opinion that the goals for tile drainage were set too high on this project and that too much money was spent to encourage a practice that would have been carried out without incentives. It is therefore important that the conditions under which drainage became eligible for cost share payment be spelled out.

It is true that a large majority of the land in the Black Creek area cannot be cultivated successfully without some form of tile drainage. In that sense, drainage is a production related rather than a water quality improvement practice. On the other hand, practices which require the establishment of vegetative cover, such as grassed waterways, also may require tile drainage for their establishment. As a result, it has been the policy of The Allen County Soil and Water Conservation District to cost-share on tile drainage only for that portion which was necessary to carry out another practice. In this situation, drainage would be considered a Best Management Practice for the area.

In reflecting on the land treatment program, two important points stand out. (1) The cost of land treatment with a water quality goal is not trivial. (2) It will not be possible to spend the full amount budgeted for this purpose on the project. This latter point calls into question the dogma that given enough technical assistance and cost-share money, 100 per cent treatment can be achieved in any area.

A majority of the non-Amish farmers of the Black Creek Watershed can be considered progressive farmers. As can be seen in Table 1, a majority of these progressive individuals agreed to cooperate with the district on a voluntary land treatment program. As can be inferred from the other information contained in the table, a commitment to cooperate did not necessarily imply a commitment to spend all of the private funds necessary to bring these farms into a condition which we would describe as "adequately treated." Some farmers would not cooperate. Unfortunately, these farmers tended to be those which we would consider most likely to need assistance. It is becoming clear that even with the best of intentions, a voluntary program will not achieve either 100 per cent treatment or 100 per cent cooperation. The question of how landowners who refuse to cooperate with a voluntary program should be approached is a policy consideration which is beyond the scope of this report.

Even though the originally budgeted $750,000 for land treatment cost sharing will not be spent, the total cost of land treatment, including the cost of technical assistance provided under a contract between the Allen County Soil and Water Conservation District and the Soil Conservation Service, is not trivial.

A summary of cost data is presented in Table 2.

The total of incentive payments made for acres under contract as of the date of this report was $444,702.89 which represented cost sharing at an average of 70.3 per cent for the district share. Technical assistance costs for these acres totaled $183,432.87. If this is compared to the total acres under contract on the project, 10,795, the cost to the district is $55.01 per acre for technical assistance and incentive payments.

It is possible to look at these cost figures, not from the standpoint of acres under contract, but from the standpoint of acres adequately treated. It is believed that of the 10,795 acres under contract, 5,986 are adequately treated. Based on the cost share and technical assistance totals given above, this works out to an average cost to the district of $99.20 per acre for every acre which is considered to be adequately treated.

If it were possible to project this per acre cost to a large area, such as the Maumee Basin, it would be possible to state that the cost of adequately treating the Maumee Basin could total more than a half billion dollars. There are several reasons why this cost figure should not be used for this purpose.

Based on the information that is now available to us, we believe that it would be possible to spend less money in some cases for practices that do not relate directly to water quality. In other cases, we could achieve better treatment at lower cost by focusing on better management practices rather than some more cosmetic but less effective practices. Also some land treatment funds spent are known

TABLE 2 COST OF LAND TREATMENT IN BLACK CREEK WATERSHED

ITEM	DISTRICT COST SHARE	UNIT COST	PERCENT TOTAL COST
Conservation Cropping System	4,035.60	.56	70
Critical Area Planting	2,752.57	183.50	65
Crop Residue Management	2,159.60	1.87	70
Diversions	1,222.31	.70	75
Farmstead & Feedlot Windbreak	289.70	72.42	70
Field Border	24,678.76	.24	70
Grade Stabilization Structure	71,900.36	521.02	75
Grassed Waterway or Outlet	33,004.95	532.33	80
Holding Ponds and Tanks	1>,711.08	1,387.30	50
Livestock Exclusion	7,772.68	353.30	80
Livestock Watering Facility	864.50	432.25	70
Minimum Tillage	1,550.80	5.32	80
Pasture & Hayland Management	474.40	3.85	65
Pasture & Hayland Planting	4,462.72	148.76	70
Pond	10,827.66	1,203.07	60
Recreation Area Improvement	549.29	61.30	50
Sediment Control Basin	4,448.90	1,482.97	70
Stream Channel Stabilization	95,673.53	9.57	80
Streambank Protection	51,424.74	.69	70
Surface Drains	408.54	2.04	65
Terraces	26,714.85	.64	90
Tile Drains	81,703.98	1.28	70
Wildlife Habitat Management	1,171.37	7.91	60

to have had little positive effect on water quality. Some practice money that has been spent would not be spent if we were starting from the beginning. It is clear, however, that the cost of undertaking adequate land treatment on large areas of farm land will not be a small one. It will be one of the goals of the final report to make some sort of assessment of what these costs might be expected to be, how they might be paid, and who can be expected to pay them.

SECTION II
PLANNING AND APPLICATION
-- CHANGES IN PHILOSOPHY

Changes in the philosophy of planning and applying land treatment practices in the Black Creek Watershed reflect changes in approach rather than changes in the objectives of the project. Initial planning undertook a diverse, broad spectrum approach which is sound conservation but not necessarily the most cost effective method of focusing efforts on obtaining improved water quality.

Because the Black Creek Project involved voluntary cooperation on the part of local landowners, it was necessary to find practices which could meet the needs of the farmers while at the same time meeting the needs of the project. Many times, the farmers assessment of needs and the assessment of needs by project personnel were very different. Farmers were interested in drainage improvement and other similar practices which also represent sound conservation in areas such as Black Creek, but which do not always improve water quality.

Conservation planning has traditionally focused on maintaining the productive capability of agricultural land. If soil losses can be kept within predetermined limits, land has been considered to be adequately treated. Such an approach makes feasible a rather rigid technical guide.

For many years, technical guides have shown conservation practices, each with their own set of detailed specifications. Frequently, planners have been unable to complete farm plan because a potential cooperator was unable to modify his operation. The ability to modify specification and planning requirements in the Black Creek project has greatly increased flexibility.

A problem in developing total plans for improved water quality was pointed up during the spring of 1976 in the Black Creek area. Several farmers who had invested in the equipment for minimum tillage did not use this approach, but instead worked their fields intensively. This was brought about be a warm, dry spring with many days suitable for field work. Farmers felt compelled to work and rework their fields, saying that they were afraid that the weeds would "get ahead of them" or that their neighbors "might wonder why I'm not busy." It was obvious that these farmers considered intensive field work a better management practice than the application of minimum tillage.

Selling management and treatment practices, without the existence of any ultimate mandatory program, is not simple. The mechanics of planning and management of treatment practices is, however, rather basic. There are just three alternatives:

(a) Land use change

(b) Crop rotation change

(c) Practice intallation.

In evaluating a farm, each field is analyzed for basic soil loss using the universal soil loss equaltion, a complete discussion of which is carried in the interim report, Environmental Impact of Land Use on Water Quality -- a Progress Report. The universal soil loss equation involves six variables, only three on which can be significantly changed through management or construction. The three on which an impact can be obtained are:

(a) Slope length

(b) Cropping management

(c) Control practices.

Pollution arising from soil erosion is generally defined as non-point pollution. Within the context of non-point, there are specific areas which can be defined as point and non-point areas. Within this framework, a point area is an area where a single source of erosion can be treated with a single management practice providing a long-term solution. Point areas are generally not farmed actively and do not provide significant farm income. Practices that ofen can be applied to point areas include streambank protection, critical area planting, grade stabilization structures and grassed waterways.

Non-point areas require a combination of management practices working together to provide a long-term solution. These areas are often actively farmed. Practices which can deal with this type of pollution includ conservation tillage, parallel tile outlet terraces, pasture-hayland planting, and conservation cropping systems.

To consider this in operation, assume a farm field in which a gulley has formed and heading has occured. Under the previous definition, the gulley and heading would fit into a point category. Even if land use is not altered, the gully and heading can be attacked through the installtion of a grassed waterway and grade stabilization structure. These will eliminate or greagly reduce the point-source erosion and sediment contribution.

Unless land-use is within proper limits, however; the installation of these practices may not have much impact on water quality as the grassed waterway and grade stabilization structure become a means of sediment transport for erosion dependent on crop rotation, the tillage practices, and the degree of slope.

This hypothetical situation makes clear the need to incorporate a series of practices which are usable and which provide benefits of both erosion reduction and improved water quality. If the practices are to be maintained without intensive supervision and a more effective set of legal tools, the practices applied should be relatively maintenance free and should be capable of exacting a long-term committment from the landowners.

In the Black Creek, a practice which seems to have a good chance of meeting these requirements is a parallel tile outlet terrace system. The PTO Terrace System, planned to satisfy the needs of tillage methods, cropping system,tile drains, etc. gets to the root of the problem of upland erosion by leaving the landowner with a comfortable rotation, better drainage, and better field topography. It also helps meet the fundamental water quality objective.

John Hanway, Professor of Agronomy at Iowa State University and John M Laflen, Agricutlural Engineer, North Central Region, ARS, studied several PTO terrace systems over a three year period. They found that the terraces reduced surface water yields at least 30 per cent. Sediment output loads average about 4.5 per cent of estimated erosion between terraces. Average total phosphorus concentrations were highly correlated with the sediment in the runofff.

SECTION III
SIMULATED RAINFALL PROGRAM
STATUS REPORT

The field phase of the simulated rainfall program was completed during the summer of 1976. However, some of the samples are yet to be analyzed, and much of the data remains to be organized and analyzed. Therefore, conclusions presented as a portion of this annual report should be considered as preliminary and subject to change after analyses of data has been completed.

The objectives outlined in the work plan, Environmental Impact of Land Use on Water Quality -- A Work Plan, published in April of 1973 were as follows:

(a) To determine the base values for the sediment contributions of the major soil capability units in the study area.

(b) To determine runoff and sediment composition (physical and chemical) from the major soil capability units.

(c) To determine the relative importance of raindrop impact and surface runoff in detatching soil material from nearly level lake plain soil.

(d) To compare the runoff and soil erosion effects of presently used cultural practices to those conservation cultural practices recommended by the Soil Conservation Service. (Several forms of Conservation tillage compared to fall plowing, effects of crop rotations, effects of various methods of residue management, effects of winter cover, effects of over grazing, effects of fertilizer and manure applications on cropland and pastures).

Work was carried out in all of these areas during the 1973-1976 project period. Preliminary results are presented in the following discussion:

The simulated rainfall program was started in the summer of 1973, and approximately six weeks of field testing has been committed to this study each year during the last four years. The individual studies and the status of each at the close of the 1975-1976 project year are outlined below.

1. Base Erosion Losses

Values for the major soils in the watershed were obtained during the summer of 1973. Thirteen cm (5 in) of simulated rainfall were applied to fall plots under uniform test conditions on four different soils. Runoff, infiltration, sediment concentration,and total soil loss were obtained in each study, or have been organized and reported in the first annual report.

2. Particle Size in Sediment.

Sediments in runoff from all four soils in the 1973 tests were analyzed for particle size distribution (five sand fractions, silt, total clay, colloidal clay, and organic matter content. These values have been compared to the values that occur in the soil in place. All data have been obtained, but analyses are incomplete.

3. Soil Loss as Aggregates

Sediment occuring in runoff from four soils (each soil with fall plow, fall chisel, fall disk, and no tillage treatments) has been analyzed for soil loss in aggregated form as constrated to that occuring as primary particles. Field and laboratory work was completed during the 1975- 1976 project year and data have been fully analyzed and reported in an M.S. thesis by Steve Schroeder, Soil Aggregates Transported in Runoff from Cropland and Their Relationship to Total Soil Loss, Purdue University, May 1976.

4. Fertilizer Loss in Runoff

The effects of surface applied nitrogen and phosphorus fertilizer on nutrient content of runoff were obtained under fallow plot conditions in 1973 and under four tillage systems (fall plow, fall chisel. fall disk, no tillage) in 1974 and 1975. In some instances, the tests were conducted on soybean land and in other instances, the tests were conducted on corn land. In all instances, runoff from fertilized plots was compared to runoff from not-fertilized plots. The analyses of all samples has been completed and most of the data has been organized and reported in the M.S. thesis of D.B. Kaminsky, Jr., Nitrogen

<u>and Phosphorus in Surface Runoff from Agricultural Soils</u>, Purdue University, May 1975.

5. Raindrop Energy vs. Surface Runoff

The relative importance of raindrop energer and runoff in the soil erosion process on both nearly level and sloping soils was measured in 1973. The tests were conducted on fallow plots on four major soils in the watershed. The results were reported in the first annual report.

5. Tillage and Crop Residue Effects on Sediment Loss

Soil erosion was determined from four basic fall land treatments (fall plow, fall chisel, fall disk, no tillage) following both corn and soybeans during 1974, 1975, and 1976. Runoff, infiltration, and sediment concentration of the runoff were also obtained. Per cent surface covered by crop residues were determined for all treatments. A portion of the data have been analyzed and reported in the 1975 and 1976 progress reeports. Some of the runoff samples from 1976 remain to be analyzed. When this is completed a report will be made.

7. Effect of Application of Animal Waste

The effects of animal waste application to land both on run-off and soil loss as well as on water quality were tested during the spring of 1976. Individual tests were of the following:

(a) Spring application of liquid and solid swine waste (surface applied and incorporated) on corn stalk land.

(b) Spring application of solid swine waste on corn stalk land that had four different fall treatments (plow, chisel, disk, no tillage).

(c) Spring application of soild cattle waste to closely grazed pastures.

8. Sod Buffer Strips and Water Quality

   The effects of sod buffer strips in reducing the sediment load of runoff water was a preliminary investigation and results obtained are at best an indication of the efficiency of the system. Results were reported in the first annual report.

Much of the analyses are yet to be completed so valid conclusions are still premature at this time. However, to assist other workers on the project, a brief interpretive summary is offered where sufficient data exists.

1. Base Erosion Losses

   Soil erosion losses from nearly level lake plain soils are low when compared to the more sloping soils in the watershed. Under fallow conditions, soil losses from 13 cm (5 in) of simulated rainfall ranged from 4.5 MT/ha(2 - 4.5 t/a) for soils with slopes less than one per cent to over 34 MT/ha (15t/a) for a soil on a 5 per cent slope.

2. Particle Size Distribution of Sediment in Runoff

   Results show the erosion process to be highly selective with the sediment showing distinct clay enrichment and a decreasing sand content compared to the soil in place. In many comparisons, the sediment also showed an enrichment of the silt fraction. The relationships occurred on both the nearly level soils as well as the sloping fields.

Soil Loss as Aggregates

   Soil transported in runoff as aggregates larger than 210 microns was less than 30 per cent of the total soil loss on all soils and treatments tested. The values ranged from a low of 1.75 per cent to a high of 29 per cent with differences (in some cases) attributed to treatment (especially those where appreciable surface crop residues were present). It was concluded that on nearly level soils, effective measures for reducing erosion should be based on prevention of detachment and dispersion of naturally occurring aggregates by raindrops since the low-velocity runoff is not capable of transporting much soil as aggregates.

4. Fertilizer runoff from Surface Applications

   This information is discussed in Section V of this report.

5. Raindrop Energy vs. Surface Runoff

   On all four soils tested, raindrop induced runoff contained approximately 10 times the sediment concentration of that obtained when equal amounts of runoff were introduced by inflow. These results suggest the importance of protecting the soil surface from raindrop impact if sediment concentrations in runoff are to be minimized.

6. Effects of Conservation Tillage vs Fall Plowing

   Although analyses of these data are incomplete, some significant conclusions can be made from the present data. Soil losses are greatly reduced by those tillage systems that leave appreciable residues on the surface. Spring measurements of surface residue cover on the four locations ranged from 50 to 80 percent on the no-tillage disk treatments to a low of less than five per cent on the fall plow treatments where corn was the prior crop. Residue cover from the chisel system ranged from 30 to 60 per cent.

   Where soybeans was the prior crop, Spring residue cover ranged from eight to 26 per cent on the no tillage and disk treatments to less than five per cent on the fall plow treatments. Chisel values ranged from nine to 12 percent.

   Soil losses from the treatments on corn land from 13 cm (5 in) of simulated rainfall ranged from 0.9 - 5.4 MT/ha (.04 -2.4 t/a) on the no tillage and disk treatment to 4.5 -26 MT/ha (1.9 - 11.6 t/a) on the fall plow treatment. Losses from fall chisel ranged from 1.6 - 13.9 MT/ha (.07 - 6.1 t/a).

   Soil losses from these treatments on soybean land ranged from 6.9 to 17.5 MT/ha (3.1 - 7.8 t/a) on the no tillage and disk treatments to 5.4 - 17.7 MT/ha (2.4 -7.9 t/a) on the fall plow treatment. Losses from fall chisel ranged from 6.3 - 15.9 MT/ha (2.8 - 7.1 t/a).

Comparison of results from two nearly level locations can be made between the erosion effects of corn vs. soybeans. Soil losses following corn were about 12 percent (no tillage and disk), 24 per cent (chisel), and 68 per cent (fall plow) of those from the respective treatment following soybeans.

Although these tests were made at only one stage of the erosion season, they do illustrate the major influence various crop species can have on the erosion process and most of this difference can be attributed to the amount of soil surface protected by crop residues.

7. Effects of Animal Waste Application

The analyses of samples have not been completed, but observation during the tests indicated that animal waste containing appreciable amount of bedding (straw, etc.) is very effective in reducing soil erosion when surface applied to the land.

8. Effects of Sod Buffer Strips

Sediment concentration of runoff decreased from 1,01 per cent to 0.46 per cent (a 54 percent reduction) when passed through a 15 m (50 ft) strip of bluegrass sod. Although this was a significant reduction, a change in appearance of the runoff water was not obvious.

SECTION IV
CONSERVATION
TILLAGE TRIALS

Simulated rainfall studies (Section III) have shown that conservation tillage techniques are quite effective in reducing water runoff, soil loss, and pollutants associated with soil loss. Previous research in Indiana and other Cornbelt states indicates that the various conservation tillage systems are not uniformly adapted in all soil - climate situations.

Factors shown to have a major influence on the success of conservation tillage systems are as follows:

(a) Soil drainage

(b) Previous crop

(c) Length of growing season

(d) Soil physical properties

Soils in the Black Creek Watershed are quite diverse in drainage and other physical characteristics. Cropping sequences also vary greatly. The watershed is in the northern fringe of the Cornbelt areas where conservation tillage is more popular.

Two primary objectives were identified for the conservation tillage trials portion of the Black Creek project. These are:

(a) To determine which conservation tillage systems are adapted on the primary soil types in the watershed.

(b) To have conservation tillage techniques in use by a high percentage of farmers in the watershed.

Adapted in this case simply means that the system can be used by farmers of average managerial ability without risk of significant yield reduction.

Original efforts to obtain information and promote conservation tillage consisted of farmer comparisons of several tillage systems on several different soil types. Due to unusual weather, non-replication of the plots, and farmer inexperience with the new techniques, little information was gained during the first three years of the project. However, fall chisel plowing, with limited secondary tillage in the spring, appeared to be successful with a wide range of soil types and weather conditions.

It was decided to expand the tillage trial phase of the project in 1976. Researchers now control and implement the trials producing greater uniformity which shoud provide more accurate information on which to base tillage recommendations to farmers in the watershed.

Five sites, representing major soil types in the watershed, were leased to conduct replicated tillage trials. Tillage systems now being compared include moldbord plowing, chisel plowing, disking, and no-tillage. Comparisons will be made with continuous corn, corn after soybeans, and soybeans after corn. Conservation tillage practices are being demonstrated in other areas by special agreement with cooperating farmers. This information is summarized in Tables 3 and 4.

TABLE 3 1976 REPLICATED TRIALS

Farm	Soils	1975 Residue	Number replications
Shanebrook	Hoytville c.l.	Soybeans	4
Woebbeking	Napannee si.c.l.	Corn	4
Stieglitz	Whitaker si.l.	Soybeans	4
Shaffer	Haskins l.	Soybeabs	4
	Morley c.l.	Soybeans	2
Bennett	Morley c.l.	Soybeans	2

The following material has been purchased by the Allen County Soil and Water Conservation District to implement the tillage work:

(a) J.D. 4020 tractor with spray tanks

TABLE 4 1976 DEMONSTRATIONS

Farm	Soils	1976 Crop	1975 Residue	1976 Tillage
Schlatter	Rensselaer l.	Corn	Soybeans	a.No-till b.Disk
Delagrange	Morley si.l.	Corn	Soybeans	a.No-till
	Pewamo si.c.l.	Corn	Soybeans	b.Disk
Schaefer	Haskins l.	Corn	Sod	No-till

(b) A.C. four-row, no-till planter with broadcast spray attachments.

(c) Four-bottom plow

(d) 13-foot disk

(e) 10-foot chisel plow

(f) 10-foot field cultivator

(g) Four-row Lilliston cultivator

Other equipment needed , such as a stalk chopper, has been borrowed from cooperating farmers. Seed, fertilizer, and chemicals are purchased by the District for leased acreage, but are provided by cooperating farmers for demonstration plots.

Not all tillage treatments could be accomplished as planned for the first year in the replicated trials. Plowing and chiseling, intended for fall practices, were done in the spring since the land and equipment were not available in the fall. The 1975 crop residue was the same for all tillage at a particular site. Thus, residue effect on tillage cannot be measured. In two of the trials (Shanebrook and Stieglitz), row direction must be opposite from the 1975 rows in order to have plots go across existing tile lines. This would be too non-uniform for no-till planting, so these plots were disked once this year.

Corn and soybean plantings were begun on April 23 and May 21 respectively on the well-drained Whitaker soil. The only major problem at planting was in getting coulter penetration and seed cover in no-till planting on the poorly structured Nappanee silt loam soil. Corn germination was variable in these plots.

Weeds not controlled with no-plow systems were primarily species resistent to herbicides used. These included field bindweed, morning glory, and Canada thistle. The pre-emergence herbicides used were an Atrex-Bladex-Lasso-Paraquat combination on corn and a Lorox-Lasso-Paraquat combination on soybeans.

Phytophthora root rot disease of soybeans developed in the Nappanee silt loam trial. It became much more severe in no till and disk plots. This disease will have an effect on yield.

All three of the conservation tillage demonstrations appear to be successful. The sod-planted corn showed no drouth stress during an early season dry period, while other corn in the same fields was showing drouth symptoms. Moisture conserved with no-till sod planting is a prime advantage for this system on well-drained soils. Grain yields will be checked for both corn and soybeans in replicated and demonstration trials. While tillage practices in the first year of the revised study do not always represent intended tillage systems, information gained on chisel and disk tillage should be of great interest to farmers in the watershed.

Farmers in the watershed have been made aware of the tillage trials underway through field tours and mass media coverage. A field tour of the trials on July 13 drew 60 area farmers. Fort Wayne television farm director Wayne Rothgeb filmed segments at planting and at several times during the growing season. Newspaper coverage has also been very good. Conservation advantages of the no-plow tillage systems and soils where they are likely to be adapted were emphasized in all contacts with farmers.

SECTION V
NUTRIENT TRANSPORT IN BLACK CREEK WATERSHED DURING 1975

One of the key questions posed in the work plan, Environmental Impact of Land Use on Water Quality was the effect of land use on the nutrient loadings to the Maumee River and Lake Erie. This was studied during 1975 and 1976. Analyses of data for 1975 have been completed.

Nutrient transport in the Black Creek Watershed during 1975 was studied by continuously measuring the flow of water past monitoring sites 2 and 6 and by analysis of water samples collected by hand (representing base flow) or by automatic pump samples (operated during storm events).

Data flow measurements and chemical analyses were integrated by computer techniques to provide information on total transport of sediment and various nutrient forms by a given storm event and by flow past the sampling sites for the entire year. Table 5 provides information on the subwatersheds contributing water, sediments, and nutrients to the ditches flowing past sites 2 and 6. Values for the subsurface drainage component were estimated from hydrologic data for similar agricultural watershed and values for amounts of nitrogen and phosphorus (N and P) applied in fertilizers and manures was estimated based on interviews with farmers in the watershed.

TABLE 5 CHARACTERISTICS OF THE STUDY AREA

CHARACTERISTIC	SITE 2	SITE 6
Area (ha)	942	714
Tiled area (ha)	421	431
Rainfall (cm)	107	107
Combined runoff & subsurface drainage	53.7	48.5
Tile drainage (cm)	15.4	12.7
Subsurface drainage (untiled areas) (cm)	22.9	22.9
Houses in watershed	28	143
Nitrogen applied (kg)	40,246	33,080
Phosphorus applied (kg)	31,934	24,205
Water samples taken	705	441

The total amounts of nutrients and sediments transported past sites 2 and 6 during 1975 are reported in Table 6. The amounts of sediment were fairly consistent at the two sites; however, higher amounts of soluble nutrients were present in water flowing past Site 6 as compared to Site 2. Conversely, the amounts of sediment bound nutrients at Site 2 were higher than those at Site 6. Sediment and nutrient losses were generally similar to those of other agricultural watershed previously studied with the exception that nitrate N losses in the Black Creek Watershed were quite large.

TABLE 6 NUTRIENT AND SEDIMENT TRANSPORT DURING 1975

COMPONENT	SITE 2	SITE 6
Water (cm)	53.8	48.5
Sediment (kg/ha)	5,644	5,402
Soluble inorganic P (kg/ha)	.331	.581
Soluble organic P (kg/ha)	.175	.231
Sediment P (kg/ha)	11.526	7.357
Ammonium N (kg/ha)	2.75	3.39
Nitrate N (hg/ha)	33.65	25.14
Soluble Organic N (kg/ha)	71.84	34.73

From, 90 to 96 per cent of the total P transported in the watershed was sediment P whereas soluble inorganic P (SIP) accounted for 3 - 7 per cent of the total P transported. The relatively high percentate of total P transported as SIP at Site 6 was the result of the large amount of SIP discharged into ditches from septic tanks in this subwatershed. Sediment N and nitrate N accounted for 52 - 64 and 30 - 37 per cent respectively of the total N transported in the watershed. The finding that nitrate N accounts for a substantial amount of total N transport in the watershed suggests that nitrogen movement in an agricultural watershed cannot be modelled by relation to sediment transport.

Computer techniques were used to partition the total transport of sediment and nutrients in the watershed into classes based on types of flow. Base flow was arbitrarily defined as any flow in which the stage was less than 18 cm , and large events were defined as storms producing 2.5 cm or greater of total subsurface drainage and surface runoff. Small events comprise all flow other than base flow or large events.

Table 7 presents data on the partitioning of sediment and nutrient transport at Site 3 into base flow, small events, and large events. Data for Site 6 are very similar to that for Site 2. Base flow accounts for relatively small proportions of the total amounts of water, sediment, and nutrients transported in the watershed. The two large events which occured in 1975 accounted for about 14 per cent of the total water flowing past Site 2. However, the proportion of sediment, sediment P, and ammonium N and Sediment N transported in the two storms was higher than that for water. This finding suggests that proportionally large storms move more sediment and sediment associated nutrients than do base flow or small events.

The large percentage of water, sediment and nutrients were transported in small events which occured frequently throughout much of 1975.

TABLE 7 PER CENT OF TOTAL TRANSPORT BY TYPE FLOW (SITE 2)

COMPONENT	BASE FLOW	SMALL EVENTS	LARGE EVENTS
	Per Cent of Total Transport		
Water	8.3	78.0	13.7
Sediment	2.3	72.3	25.5
Soluble Inorganic P	5.5	72.3	25.5
Soluble Organic P	8.0	77.3	14.7
Sediment P	1.8	71.7	26.5
Ammonium N	8.9	68.3	22.8
Nitrate N	5.9	83.8	10.3
Soluble Organic N	4.7	81.4	13.9
Sediment N	4.0	67.5	28.6

The finding that almost all sediment and nutrients transported in an agricultural watershed are associated with storm events points out the necessity for carefully measuring water flow and sampling continuously during the event. Grab sampling of streams (Most samples would be taken during base flow) does not provide an adequate base from which to access nutrient transport.

The sources of nutrients present in ditches of the Black Creek watershed were determined from estimates of flows originating from each source and knowledge of concentration in non-til subsurface drainage water. Nutrients in surface runoff for each subwatershed were computed from knowledge of total nutrient transport and estimated amounts of nutrient originating from tiles, subsurface drainage, and septic tanks.

Table 8 gives data on the percentages of nutrients passing Site 2 which originated from tile drainage, subsurface drainage, septic tank effluent, and surface runoff. Water was derived alost equally from surface runoff and subsurface P plus tile drainage water. Almost all sediment, on the other hand, originated from surface runoff. About 80 per cent of SIP originated from surface runoff and 11 per cent of the SIP was calculated as coming from septic tanks.

TABLE 8 PER CENT OF TRANSPORT BY SOURCE (SITE 2)

COMPONENT	TILE FLOW	SUBSURFACE RUNOFF	SEPTIC FLOW	SURFACE RUNOFF
	Per Cent of Total Transport			
Water	10.6	36.6	0.2	52.7
Sediment	0.6		0.1	99.3
Soluble Inorganic P	2.2	7.7	10.6	79.4
Soluble Organic P	7.1	24.8	2.7	65.3
Sediment P	0.2		0.6	99.2
Ammonium N	6.1	13.7	2.4	70.0
Nitrate N	17.7	62.4	.06	19.6
Soluble Organic N	5.8	20.4		73.8
Sediment N	0.1		0.2	99.7

At site 6, over 40 per cent of the SIP originated from septic tanks due to the large number of homes in this subwatershed. A substantial proportion of soluble organic P (SOP) was dervived from subsurface and tile drainage water although 65 per cent of the total SOP at Site 2 originated in surface runoff. Surface runoff was responsible for an excess of 99 per cent of the total sediment N and sediment P passing Site 2, whereas 80 per cent of the nitrite N at this site originated from subsurface and tile drainage water. Surface runoff was the source of greater than 70 per cent of the ammonium N and soluble organic N passing Site 2. A substantial proportion of total ammonimum N transported at Site 6 originated from septic tanks.

Determination of the amounts of nutrients in percipitation revealed that from 146 to 180 per cent of the total ammonium N transported in the watershed is accounted for in rain and snow. Similar values for nitrate N and SIP are 19 - 25 per cent and 24 - 45 per cent respectively. These represent a contribution of about 5 kg/ha of ammonium N, 6 kg/ha of nitrate N, and 0.15 kg/ha of inorganic P per year. This finding demonstrates that a natural source may account for significant proportions of the total amounts of soluble nutrients transported in the watershed.

SECTION VI
SEDIMENT BASINS
AND CHANNEL STABILITY STUDIES

Discussions of techniques useful for the control of pollution from non-point sources has often included a reference to construction of basins at the base of watersheds to allow sediment and related pollutants to settle out of the drainage way. These sediment removal basins function by removing velocity from the drainage stream. At lower velocities, the flowing water is capable of carrying less sediment. Two of these basins were constructed in the Black Creek watershed. To distinguish between them, they have been designated as The Sediment Pond and The Desilting Basin.

The Sediment Pond was constructed on the Virgil Hirsch farm in the early fall of 1973. It was filled to overflowing in November of that year. The pond serves a drainage area of 460 acres (185 ha) in which Hoytville and Nappanee soil types predominate. Slopes are generally less than one per cent. When the water level is at the crest of the mechanical spillway, the water surface area of the pond is slightly more than six acres. Flood storage is 11 acre feet (14,000 cubic meters) with a detention time at flood design of 4 1/2 hours and an estimated flow-through time of one hour.

On May 18, 1976, cross sectional profiles of the pond were run with the assistance of the Soil Conservation Service and the SCS State Geologist. Depth of accumulated sediment was determined across each base line or station with a recording fathometer and by probing. Sediment deposits were examined for determination of particle size. Sediment samples were collected for analysis at a later date.

Sediment deposits were found to be of uniform depth throughout the pond. Average accumulation was 6.1 cm. Particle size also appeared to be uniform. Particles were primarily in the clay and silt fractions with a small amount of fine sand. Laboratory analysis of the sediment samples has not been completed.

Between the construction of the pond and the late spring of 1976, the sediment pond has accumulated approximately 2,400 cubic yards (1880 cubic meters) of sediment. If an average dry weight of 55 pounds per cubic foot (857 kg/cu m) is assumed, this amounts to an average of nearly 1.2 tons (2.8 MT/ha) of sediment per year per acre for each of the three years between construction and survey.

Projection of this figure beyond the three-year average should be approached with caution. It is probable that the accumulation is well above the long-term average because of the following factors:

(a) The area immediately north of the pond was in transition and was subject to erosion until the conservation practices on it were completed in 1975. Thus, this area may have contributed an above average amount of sediment in this period. There has also been some construction activity on the west end of the pond site.

(b) In May 1975, a storm of nearly 100-year frequency was received. This storm produced the highest runoff volume and sediment concentrations yet measured at many of the monitoring stations. It produced between 1/3 and 1/2 of the annual sediment transport for 1975 at some monitoring stations.

(c) No easy way of determining what portion of the sediment collected has resulted from uniform erosion over the watershed and what portion has resulted from stream bank erosion exists.

The Desilting Basin is located on the main stem of Black Creek. It was constructed in September 1974 and was first surveyed on July 30, 1975. A second survey was conducted July 7, 1976. Sediment samples have been collected from the basin for particle size determination.

The first survey covered a period of approximately 9 months. It revealed an accumulation of 80 cubic yards (770 cubic meters) of material. The second survey showed an additional accumulation of 530 yards (416 cubic meters) in approximately a one year additional period. Sediment sample analyses have not been completed, but observation of the material indicates that it is mostly sand and gravel as was found in the first nine-month accumulation.

These observations lead to a tentative conclusion that much of the material being trapped by the desilting Basin is bed load. However, to date no evidence has been seen of additional scour of the channel immediately below the desilting basin.

The first 150 feet (50 m) of the basin is nearly full of sediment and there is considerable accumulation throughout the entire basin. If material is trapped at the current rate, the basin will require cleaning within two years if it is to remain effective.

The original work plan included a study of bank stabiltiy. This work has been completed. It was reported in earlier documents including the interim report. Studies consisted of slope-mulch studies plus a 100 per cent bank erosion survey by the Soil Conservation Service Staff as part of the Maumee River Study of the International Joint Commission on Great Lakes Water Quality.

The IJC study reported bank erosion to be relatively small, although conceding that at eroding locations it could be quite severe.

To determine if bank cover, particularly trees vs grass has any relationship to bank stability, the reported data of the SCS study has been reviewed. While this data shows a strong correlation between soil type and bank erosion, it is not possible to relate erosion and cover in the published data. An additional review is being undertaken, but it appears that the effect of soil type may mask any effect of type cover on bank erosion.

Considerable effort has been put into the Black Creek watershed to stabilize channel banks and slopes throughout the area. Earlier reports have indicated that the structures and the bank stabilizing practices have generally been very successful. However, continued observations throughout the study have suggested that in some reaches of the channel, the bottoms may be continuing to downgrade.

Early soil mechanics studies identified several locations where the channel bottoms were potentially unstable. This study showed that the most likely reason for instability was excess channel slope and often a less resistent soil material in the profile near the channel bottom. It is evident that if a channel bottom degrades,eventually even stable banks must become unstable.

Channel stability studies were initiated by the selection of four sites in 1975. One of these, on the Joe Graber farm, was known to have lowered one or two feet deeper following revegetation of the banks. In this area, small rock drop structures were installed in 1975 in an attempt to control the channel degradation. The 1976 results in this area shown both degradation and aggradation.

About 150 feet (50 m) above the structure, the channel has accumulated sediment and appears to be filling up, but farther up stream, there has been continued erosion since the last survey was made approximately one year ago.

It cannot be determined if the erosion occurred before the installation of the rock structure, or if it is erosion since the installation of the control structure. These surveys will be repeated in 1977 and possibly in succeeding years to determine whether or not the rock structures as installed will adequately control the erosion of the channel bottom.

Another site on the Gorrell drain along Notestine Road, stretching for about 500 feet (165 m) downstream of the monitoring site, shows the ditch bottom to be almost identical with the original conformation. This is the smallest slope of any of the four sites being studied.

The Black Creek channel at Notestine Road was surveyed for a distance of 150 feet (30 m) upstream and 200 feet (65 m) downstream of the bridge. This is an area where rock was used for channel training. It is also an area that the soil mechanics studies indicated

had a potentially unstable channel at flood flow. This channel was shown to be unstable because of the soil material in the channel bottom and also because of the slope (.25 per cent). This 350 foot (115 m) section has degraded approximately 1.4 feet (42 cm) between May of 1974 and August of 1976. The channel appears to have considerable grass and other water vegetation in the bottom. It may become stabilized at its present position. Additional surveys will be made to determine this.

Wertz drain between Notestine Road and the main channel of the Black Creek for a distance of approximately 1,000 feet (305 m) was a site of the bank slope-mulch studies. This channel reash has an average slope of .4 per cent (4 feet per 1,000 feet or 0.4 meters per 100). Earlier observations had indicated that the channel bottom was eroding in several sites. The survey conducted in August 1976 shows that with the exception of a section between 600 and 700 feet (200 and 230 m) below the Notestine Road, all of the channel has eroded. For the first 500 feet (160 m), an average lowering of approximately one foot (30 cm) occurred between March 1974 and August 1976. The 200 feet (160 m) of the Wertz Drain above the main Black Creek channel eroded approximately 1.5 feet (45 cm) during this period. There are several areas in this 1000-foot section where erosion of the channel bottom has caused the toe of the banks to slip into the channel. This survey will also be repeated during 1977 to determine if the erosion is continuing.

These survey results, plus other observations, indicate that there are a number of sections throughout the Black Creek watershed where channel bottom erosion is producing unstable bank conditions. If this channel bottom erosion continues at the present rate, it will be necessary to install some type of control structure in order to stabilize the total channel.

SECTION VII
FILTERING CAPACITY OF BLACK CREEK WATERSHED BIOTA

Several attempts are being made by various water quality planning agencies to utilize the Universal Soil Loss Equation and a set of modifying parameters to predict the sediment potential of a watershed.

Changes in nutrient and sediment dynamics of streams following the clearing of natural vegetation are well documented. These studies indicate that intensification of land use results in a decay in water quality as the buffering capacity of the terrestial vegetation is lost.

Evidence from a small study area in the Black Creek Watershed suggests that small scale changes in land use may have a profound effect on sediment and nutrient dynamics. Caution should therefore be exercised in the application of the Universal Soil Loss Equation to estimate the sediment potential of a watershed.

Small scale variation in the vegetation cover near the stream and characteristics of the stream channel (especially pool and riffle frequency and meander characteristics) are particularly significant. They affect the sediment and nutrient dynamics of the stream and the nature of the stream biota, a prime indicator of water quality.

Studies conducted in Black Creek have demonstrated the significance of a small area of forest on sediment dynamics in Wertz Drain. However, sample intensity and distribution has been limited by time and manpower availability. As a result, the sampling required to determine the effects of a more general set of channel and bank characteristics on sediments and nutrients have not been undertaken

In June of 1976, an expanded sampling effort was undertaken by Dr. James Karr, University of Illinois, and Dan Dudley to investigate the following questions:

(a) How much filtering capacity do grass channels with and without field borders have to reduce sediments?

(b) How do those potentials compare with sediment reductions in heavily forested areas?

(c) What is the impact of buffer strips on trees and shrubs?

(d) What are the dynamics of sediment transport in straight vs meandering channel areas when vegetation cover is held constant?

(e) How do these patterns relate to the nature of the stream biota, especially fish communities?

(e) What is the microbiological status of the Black Creek Watershed?

(f) How are nutrient and sediment dynamics in the Black Creek Watershed correlated with varying agricultural practices.

The Black Creek Watershed has been divided into four major regions as follows:

(a) Driesbach Drain (20 channel stations)

(b) Wertz Drain (33 stations)

(c) Smith Fry-Drain (23 stations)

(d) Black Creek (32 stations)

An additional 12 stations at PTO terraces and other sites are located to monitor areas of special interest. For the period March to October, samples will be taken at biweekly intervals with monthly samples from November to February.

These four major sample areas differ in a number of respects and are therefor idea for this study program. The Driesbach Drain has been the subject of intense efforts to improve agricultural and conservation practices. Wertz drain has several areas of forest and agricultural activity; and the Smith-Fry Drain has seen little activity as the result of the Black Creek project. The Smith-Fry Drain has also been the site of several major fish kills and more intensive monitoring may help clarify the reason for these fish kills. The main Black Creek channel is a major area for seasonal changes in fish communities and considerable effort has been made to stabilize stream banks in this area.

A large number of water quality parameters will routinely be monitored at each sample station. These include total alkalinity, specific conductance, total dissolved ionized solids, hardness, turbidity, total phosphorus, soluble orthophosphate, nitrate, nitrite, ammonia, organic nitrogen, total residue (suspended solids) and sulfate.

At each sample station, a number of parameters are being measured to characterize the biota and landform near the sample site. A major effort will be made to identify correlations between water quality and biota and landform characteristic near the sample station.

The expanded biological program also includes some small scale surveys of heavy metal, PCB, and possibly pesticide contamination in the watershed, including samples of water and of fish tissues. The low flows during the summer of 1976 made it impossible to collect samples for these studies.

Finally, 42 sample stations have been located throughout the watershed for routine studies on microorganisms. About half of the samples (20) are from tile outlets with the rest (22) from the streams in the watershed. Samples from each of these locations will be taken two or three times. Sample times will be selected to coincide with high and low flow periods. Total coliform, fecal coliform, and fecal streptococcus counts will be made on each sample. Laboratory analyses of these samples are being done by the Allen County Board of Health Laboratory.

SECTION VIII
DATA ACQUISITION, PROCESSING AND SIMULATION

In the Black Creek Watershed, rainfall data is collected from as many as seven recording rain gages. Water stage data is collected from as many as nine pressure-activated stage recorders. Water quality samples are collected either manually or mechanically.

Three pumping samplers, each capable of collecting 72 consecutive samples, are located at junctions of two primary drains into Black Creek and on the main stem of Black Creek approximately 1.5 miles from its confluence with the Maumee River. The pumping samplers are storm-activated. Grab samples are collected at all stage recorder sites, at strategic locations upstream from the stage recorder sites, and at selected till outfalls. Grab samples are collected weekly and during storm events.

Rainfall or water stage data and water quality samples have been collected since early 1973. An enormous amount of information is available for various kinds of analyses, some of which have not yet been devised. In order to put the data into useful form for future analysis, a procedure as illustrated by Figure 1 was initiated. Raw data, as represented by rainfall charts, water stage charts, grab samples, and automated pump samples are processed largely by computer and then stored to be used by researchers connected with the project and researchers outside of the project who may be interested in the regional aspects of the data.

Figure 1 is a schematic diagram of data processing for the Black Creek project. Steps in this process are as follows:

Step 1 Water stage and rain gage charts are read on a chart reader and the data punched on paper tape.

Step 2 Data on paper tape are read into the digital computer file.

Step 3 Rainfall data which are in accumulated inches of rainfall are transferred into rates in cm/hr

Step 4 Areal rainfall is calculated by taking the weighted average of the rainfall data on an area basis between adjacent

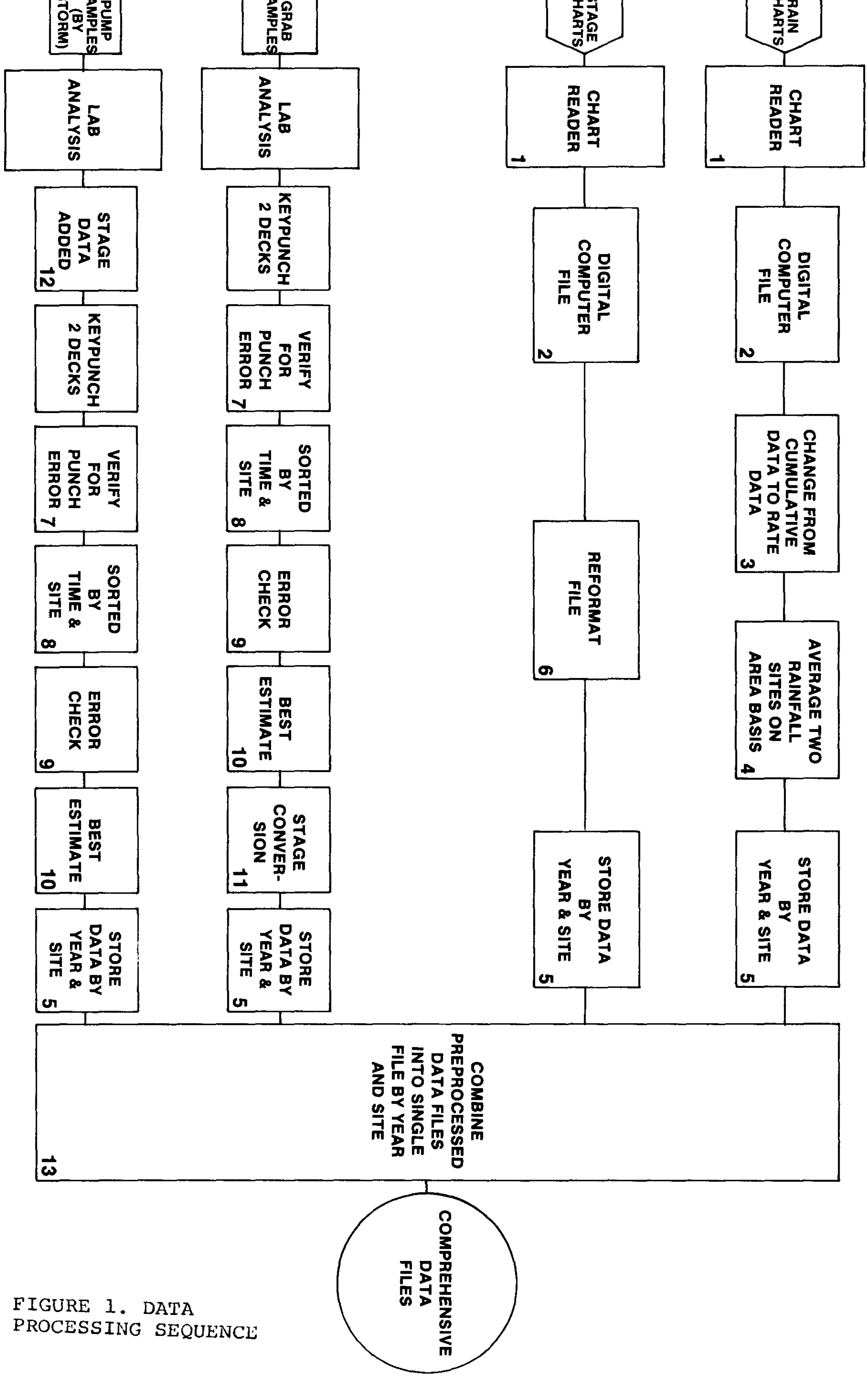

FIGURE 1. DATA PROCESSING SEQUENCE

sites.

Step 5 Rainfall data and waterstage and water quality data are stored by year and by the site number.

Step 6 Water stage data are edited for commas and characters and then stored by year and by the site number as in Step 5.

Step 7 Grab sample data are verified for punching errors and corrections made.

Step 8 Grab sample data are then sorted out by time, date, and site number

Step 9 Grab sample data and also pump sample data are checked for errors and omissions such as poor response from a site, unrealistic dates and times, unreadable characters, abnormally high values, and bad values of N or P constitutents.

Step 10 Best estimates are made for missing data or for water quality parameters which are flagged for possible error in analysis or for wrong entries in the data log. If errors are duto faulty analysis, rules for obtaining the best estimate are:

Let soluble N = $NO_3 + NH_4$ if $NO_3 + NH_4$ > soluble N
Let total N = soluble N if soluble N > total N
Let soluble P = inorganic P if inorganic P > soluble P
Let total P = soluble P if soluble P > total P

Step 11 The distance from a benchmark to the water level is converted to depth of water for the stage record with grab samples. The grab sample data are now stored as in Step 5.

Step 12 As in Step 11 for the grab samples, stage data are added to the pump sample file. Stage data are necessary to calculate for loadings. The pumping sample data then go through the same steps as for grab sample data and are also stored as in Step 5.

Step 13 The data files are now combined and sorted according to time and location and then placed on disks into a comprehensive data base.

Automatic Data Acquisition Network

Primary emphasis concerning the development and installation of an automatic, real-time data acquisition network for the Black Creek Watershed has been concentrated on three major areas:

(a) Design, construction, and installation of interfacing electronics for the various remote instrument locations

(b) Reduction of data errors in the transmission of information over the dedicated telephone line between the watershed and the computer facilities in West Lafayette

(c) Development of the fundamental operating system software to permit real-time interaction between the instrumentation in the watershed and the computer system which is located 240 km away.

The automatic data acquisition system planned for the Black Creek watershed was designed to provide data transmission from the network of instruments distributed throughout the catchment to a central site using a combination of local dedicated telephone lines and radio telemetry. Data acquisition received at the central watershed receiving station are punched on paper tape and transmitted to the computer in West Lafayette over a dedicated, long-distance telephone linkage. The entire system is designed to provide two-way communication so than an analysis of the incoming data can be used by the computer to control operation of water sampling equipment in the watershed.

During 1976, most of the field instrumentation were received and installed including sensors for water-level, rainfall, temperature, etc. The central watershed receiving location was full instrumented together with its battery-operated paper tape punch. This equipment has been operating satisfactorily since early in 1976. Both the local telephone drops for data communication within the watershed and the long-distance linkage wave been installed. Existing water sampling equipment has been modified to accommodate remote computer control.

Although data collected during the past spring and summer have been successfully recorded on paper tape at the central station, prolonged difficulties with data transmission errors on the long-distance telephone line made it impossible to attain an operation status with the interactive control system. Because of the dry conditions during 1976, this has been relatively unimportant for an operational viewpoint. A major cooperative effort between General Telephone of Indiana and project personnel seems to have overcome these problems to an acceptable degree.

The sensing instrumentation to be used with the automated data acquisition system was all commercially available; however, the equipment necessary to interconnect it to a loop of telephone lines with the watershed in order to transmit data and to receive commands from the central site was designed and built by project personnel. All of this equipment was designed to permit unattended, battery-powered operation. Intital designs experienced componet failures due to electrical transients on the local telephone lines. Subsequent design modifications appear to have eliminated these problems.

The fundamental operating software (computer program) necessary to allow remote, interactive data acquisition and control on a general purpose, multi-user, time-sharing system has now been developed and successfully installed on the host computer in West Lafayette. While substantial development remains to be done on the application programs which will collect and analyze the data, the operating system system now permits this to proceed in an orderly fashion without disruption of the other concurrent demands for computer access.

During 1977, it is anticipated that the primary equipment development will be related to the design an construction of the radio telemetry portion of the data network. A licence to operate the fm transceivers was obtained during 1976. The primary software effort will be on application programs to analyze incoming data and provide for tansfer of updated data files to a remote large computer which will be used for hydrologic simulation studies.

The inability to fill a graduate instructorship position on the project seriously delayed progress in the real-time modelling effort. A decision to forgo filling the position with a graduate student was finally necessary. Dr. J.R. Burney, an individual with several years experience with distributed hydrologic models, was subsequently hired.

The Land Use Model

Currently, there are two basic approaches to the modelling of hydrologic processes and the resulting runoff. The more widely used and publicized concept is the "lumped parameter" approach to modeling. The newer and more complex concept is the "distributed parameter" approach.

In the "lumped parameter" approach, the watershed is treated as a unit. The varying hydrologic responses of the different areas within the watershed are "lumped" into several parameters which describe the watershed's response as a whole. Such widely known models as the Stanford Watershed Model(s) and the USDAHL - 74 are examples of the "lumped parameter" approach. This type of model has several strengths. It is a much cheaper model to run and can simulate long, continuous records when calibrated and verified correctly. It is also somewhat easier to set up the descriptive data file for the simulation runs. The "lumped parameter" approach has several weaknesses, however. In order to simulate even small changes in land use within the watershed, the parameters describing the watershed characteristics must be totally recalculated. The output of the model can only be collected at a specific point (generally a gaging station, or similar location). Due to the "lumped" nature of the hydrologic parameters, very little physical significance exists in the simulation, and as a result, sediment production, deposition, and transport can only be handled on a statistical or stochastic basis. Finally, a rather extensive data base is required in order to calibrate and verify the model.

The "distributed parameter" approach involves dividing the watershed into areas small enough to be considered uniform (soil type, slope, crop, etc.). The small areas or elements are modeled separately (using flow from upstream or uphill elements as inputs along with rainfall) and the outputs routed through the watershed. There are several strengths in this approach. The actual processes occurring at a specific point in the watershed are being simulated. The output from the model can be collected at any point or many points in the watershed. Although the data file necessary for the simulation is rather complex, it is easily and quickly changed to reflect management or cropping changes. Finally, the sedimentation process can be described much more precisely. Two weaknesses are inherent in this model. First, it requires very large amounts of processor time and computer core run. It is not capable of simulating long periods of record economically. Thus it is limited to event or single storm simulations. It requires more data for its descriptive data file.

The need for a computer model of agricultural runoff for use in prediction and management practice optimization was realized at the outset of the Black Creek study. However, certain portions of the modeling philosophy have changed as the project investigators have become more familiar with the processes that govern runoff, drainage, and sedimentation. In order to accurately describe the processes involved in agricultural runoff, it is necessary to select an area that is small enough so that most of the factors influencing the processes of water and sediment movement can be considered to be uniform. For this reason, a distributed parameter modelling approach was chosen for this study.

There are several levels of descriptive parameters within the model. First, there are watershed-level descriptive parameters. These include the interception parameters, channel descriptions, antecedent moisture conditions, and control depth for infiltration. Next, there are elemental descriptive parameters. The include the element's location within the watershed, the magnitude and direction of slope, the element's soil type, the crop being grown, the current management practices, whether or not the element is a stream element, and whether or not the element is tile drained. Finally there are descriptive parameters based on combinations of the above parameters. The infiltration, soil roughness, and sedimentation parameters are based on combinations of the soil type, crop, and management practices within and element.

The element used in this model is a square-shaped area that is 330 feet on a side. This means that the element is exactly 2.5 acres or approximately 1 hectare in size. The topographic information (direction and magnitude of the steepest slope) is obtained from USGS 7.5 minute quadrangles that have been photographically enlarged to a scale of 16 inches to the mile and then have been partitioned off using a 1-inch grid pattern. Likewise, the field boundaries and soil types are taken from aerial photographs that have been similarly enlarged and divided into grid patterns. The model then divides the flow off an element into its horizontal and verticle components with respect to the map and sends this output to the receiving elements. No flow is routed to diagonally located elements.

The inputs to an element can consist of rainfall, overland flow from uphill elements, channel flow from upstream elements, and subsurface drainage or tile flow (channel elements only). The outputs from an element consist of a depth of flow (either channel or overland) a subsurface drainage rate, and a rate of sediment movement. (The lesser of total detachment or transport).

In order to accomplish the complex task of routing the overland, channel, and subsurface drainage flows and to set up the elemental data files, a separate program was written in order to set up all of the data files necessary for the simulation. This was also necessitated by the fact that the combination of an initialization and simulation program took up more computer core that the Purdue Computer Center would allocate for a single program.

The simulation program uses the data file (common blocks) set up by the initialization program and stored for this purpose. The simulation consists of adding the rainfall for a specified (GASP IV dependent) period of time and routing the resulting runoff and subsurface flow throughout the watershed in a sequential manner (upper left to lower right). The rainfall intensity and overland flow rates are used to determine the amount of detachment and transport of sediment within each element. The channel flow elements also determine the transport capacity of the stream flow. Thus, as flow builds up, the detached sediments begin to move. Subsurface drainage uses the same routing as surface drainage for simplicity. The normal output of the model describes the flow and sediment concentration with respect to time that occurs at the watershed outlet element. However, as stated earlier, the output from any element or elements can be collected.

Simulation of Tile Effluent

A model to provide a predictive tool for the determination of sediment losses from tile effluent is under development as a part of the Black Creek effort. The model will provide a flow hydrograph with associated sediment loading as a function of the input variables (rainfall and initial soil moisture profile). The model will have the capability of being easily modified to represent different tile system designs and soil properties.

The need for a better knowledge of tile drainage's influence on water quality is shown by the significant contribution it has to stream flow. Approximately 50 per cent of the Black Creek Watershed is drained by subsurface tile systems. A tile system can contribute anywhere from 10 to 100 per cent (typically 30 per cent) of the total runoff of a given area. This indicates that approximately 15 per cent of the runoff from Black Creek is from tile effluent. Values will vary greatly depending on the rainfall distribution.

An estimate of the sediment contribution of the Maumee River from Black Creek tile effluent is approximately 100 kg/ha/yr. This is based on the previous flow assumptions and the mean sediment concentration of tile effluent being approximately 100 ppm. The loading rate can be much larger as shown by G.O. Schwab (1973). He measured annual sediment losses from tiles as high as 4000 kg/ha/yr. His results indicate that in some critical areas, the tile effluent may be the dominant effect on water quality.

Glacial tilled soils of the Midwest seem to be very susceptible to erosion losses through tiles. These soils generally have high fine silt and clay contents. The fine particles are able to move within the soil profile by forces exerted on them by flowing water.

A model for the force balance of particles in cohesive soils is given by D. Zaslavsky. The value of this model is the implied interrelationship of the flow and the fine particles movement. Particularly, it shows that for a given particle size, a threshold flow level must be reached before particle movement will occur. Also the effect of the flow channel size on the critical flow is provided. Therefore, it is now possible to obtain an expression which will relate the critical flow for particle movement to a given particle size assuming a mean pore channel size is available. The particle movement model described above requires knowledge of the flow distribution within the soil profile. The flow in the unsaturated profile region is determined by Darcy's law which is the tension - conductivity method. The water flow from the tile is determined by Toksoz and Kirkham's (1961) relationship using the watertable height above the tile. The watertable position in the soil profile can now be determined by continuity i.e.

Change in water storage = Inflow - Outflow

Using the assumption that the flow pattern near the tile is radial, the magnitude of water movement near the tile can be generated as a function of R (radial distance from the tile). This flow magnitude is then used to determine the relative volume of soil which is greater or equal to the critical flow as determined by a given particle size. Therefore, knowing the flow properties and the soil particle size distribution, one can express the potential for the erosion loss as a function of time. The sediment loss, as indicated, is determined as a distribution shape, and therefore absolute magnitudes are not directly provided by this approach. Field data are needed to quantify the sediment loss distribution.

The tile model is programmed in the GASP IV Simulation Language. GASP IV was selected because of its advanced time stepping and differential equation solving techniques. The computer model breaks the soil profile above the tile into N layers. Hydraulic conductivity for each layer can be provided separately. This gets tremendous latitude in the types of soil profiles which can be analyzed. Flow between each layer is determined for each time step by use of Darcy's law.

$$q = k \{ \partial(T + z) / \partial Z\} \Delta t$$

Continuity at the watertable is determined by comparison of the flow into the layer in which the watertable is located and the flow out of the tile as determined by Toksoz and Kirkham's method

$$Tq \text{ (Tile flow)} = \frac{RH}{SF+H}$$

the relationship of an erosion potential can be determined by

$$\text{Potential} = \frac{\sum_{i=1}^{n} f_i \times \left(\frac{Tq}{Qcr_i} - 1 \right)}{\sum_{i=1}^{m} f_i \times \left(\frac{Tq_{max}}{Qcr_i} - 1 \right)}$$

The computer model solves the above relationships for an rainfall distribution provided. The output of the model is a plot and table of tile outflow and sediment loading rate as a function of time. Also, at any time during the simulation, a moisture plot can be obtained for the soil profile above the tile.

List of Variables

Variable		Description
q	=	Vertical water flux
R	=	Hydraulic conductivity
T	=	Soil mositure tension head
Z	=	Elevation head
t	=	time
H	=	height of watertable above tile
Tq	=	Flow out of tile per unit length
S	=	tile spacing
F	=	Geometry coefficient for tile system
Qcr	=	critical flow for particle movement
g	=	Zaslavsky piping function
s	=	Mean particle size

fi = Fraction of particle sizes in ith interval

The hydrological part of the tile model has been developed and tentative results obtained. However, additional work is required in the water movement part of the model to determine the effect that different simplifying assumptions have on the output. This is needed so the run times for the model can be reduced. Soil moisture profile plots have also been made and appear to behave according to the theory. Five different methods of initializing moisture contents in the soil profile have been developed to provide greater flexibility in the testing and convergence of the model. The sediment loss potential function has been developed, but has not yet been added to the computer model. The potential function will be added when the hydrological model is running satisfactorily.

The need for field data to calibrate and verify the computer model is critical. The sediment loss potential as determined by the model does not provide absolute magnitudes of the sediment loss. Therefore, to calibrate this potential distribution, at least one water quality sample is needed during a significant flow period. This in itself does not assure that the computed shape of the potential distribution is correct. Therefore, it is necessary to have water quality data for as many flow conditions as possible in order to compare the distribution shapes of both the actual and simulated sediment loss curves. To obtain this data base, as automatic pumping tile sampler was installed on a tile line draining a typical soil type (Hoytville) in the watershed.

The sampler has been operational since March 1976. Due to low rainfall amounts, only five samples have been collected since its installation. The pump sampler data will be analyzed to provide loading rates directly for the determination of the tile effluent's effect on water quality. The fertilizer nutrients will also be looked at closely to find their loss rate through the tile system.

SECTION IX
ECONOMIC AND SOCIAL ASPECTS

Several activities were accomplished during 1976. The major work involved preparing an instrument to survey the social and economic characteristics of the farmers in the Black Creek watershed. This instrument was prepared during the winter. Interviews were conducted with the farmers before they began their spring work. Amish farmers were questioned about both economic and social characteristics because they represent a smaller subset of the watershed. The larger group of Non-Amish farmers were questioned about either the economic characteristics of their farming operation or the social questions relating to attitudes.

This sampling procedure permitted reliable extension of the results to the population of the Black Creek area while at the same time minimizing the amount of time each respondent would have to spend in the interview process.

The data collected in interviews are being utilized in several ways. A summary is provided here. These data provide useful insights into the economic potential for modifying operations and on changing attitudes of farmers toward soil conservation.

While summarizing the data and comparing them to the results of the survey conducted two years earlier provides useful insights, the more fundamental research results from detail analysis of these data in various economic and sociological models. The more fundamental research provides the opportunity to reach specific conclusions and recommendations which are valuable for planning pollution control activities. The specific models include single period and multi-period farm management models of representative farms which can aid in identification of the cost to the farmer of adopting specific best management practices to control nonpoint pollution. In addition, specific models which identify the factors which influence the attitudes of different farmers toward soil and water conservation activities are being developed in the sociological area of the research on them is completed this winter.

Returning now to the summary of the survey data, two examples will be cited to illustrate the kind of information available about the Black Creek project. This will be interpreted in respect to the EPA program in water quality.

The data presented below in Table 9 clearly indicate the positive impact of the educational program conducted by the Allen County Soil and Water Conservation District in the Black Creek Watershed. Farmers were asked if pollution of streams was a major problem in Allen County. During the survey conducted in the Spring of 1974, only 19 per cent of the Amish farmers and 53 per cent of the non-Amish farmers agreed with that statement. In contrast, during the survey conducted in the spring of 1976, 59 per cent of the Amish and 71 per cent of the non Amish agreed with that statement. This reflects a major change in attitude and the identification of a major social problem by the people. The major change was a reduction of the number of people who did not know whether pollution of streams was a problem. In 1974, 44 per cent of the Amish and 19 per cent of the non Amish were undecided, but in 1976 only 14 per cent of the Amish and 8 per cent of the non-Amish were still undecided.

From a policy standpoint, it is possible to change farmers awareness of the problem. It is most useful to direct the educational material toward those who lack the information to take a position on the problem. As is illustrated in this question, when provided with appropriate information, most of the undecided will recognize that pollution of the streams is a serious social problem.

TABLE 9. RESPONSE TO THE QUESTION:
"Is Pollution of Streams a Major Problem in this Country?"

	1974 Percentage		1976 Percentage	
RESPONSE	AMISH	NON-AMISH	AMISH	NON-AMISH
Agree	19	53	59	71
Did not know	44	19	14	8
Disagree	37	221	27	21

The initial evaluation of the economic data indicated the diversity of farming operations in the watershed. These data were grouped into five classes of farms for the purpose of analysis. The 1975 crop year information on selected farm characteristics are presented in Table 10.

TABLE 10. SELECTED CHARACTERISTICS OF BLACK CREEK FARMS IN 1975

CHARACTERISTIC	CLASS				
	Full Time Large Non-Amish	Full Time Medium Non-Amish	Part Time Non-Amish	Full Time Amish	Part Time Amish
Acres in Farm	680	254	61	122	87
Typical Power Source	125,75,+60 HP Tractors	110+60 HP Tractors	60+45 HP Tractors	13 hours	15 hours
Full Time Employees (Average)	1.7	1.6	1.0	2.8	2.3
Acres in Corn	210	107	11	31	15
Yield of Corn	90 bu/a	100 bu/a	100 bu/a	60 bu/a	56 bu/a
Average Commercial Fertilizer Application (Pounds Per Acre)					
Nitrogen	110	95	129	26	39
Phosphorus	71	50	74	26	34
Potassium	109	56	92	24	34

The diversity in farm size and type of operation reinforce the need to maintain flexibility in the 208 planning guidelines related to farm managment practices. For example, it is not feasible for the Amish community to shift to certain agricultural practices, e.g. chisel plowing unless new equipment not presently available is developed for use with horses. However, their extensive use of pasture and hay may permit significant reductions in soil loss through rotations.

Different amounts of fertilizers are applied per acre by the differnt classes of farms which indicates that control of fertilizer application would have differential economic impacts. These and other aspects of diversity will be explored in more detail in the economic models presently under study.

KEY PERSONNEL
BLACK CREEK PROJECT

The following are brief biographical sketches of some of the key personnel for the Black Creek Project:

DAVID B. BEASLEY held the position of graduate research insrctor in agricultural engineering at Purdue with full-time responsibilities for wathershed modeling, data analysis, and data interfacing with companion projects. He completed requirements for Ph.D from Purdue on March 30, 1977 and presently holds the position of Assistant Professor of Agricultural Engineering in Soil and Water at the University of Arkansas.

ADELBERT B. BOTTCHER is a graduate research instructor in the Agricultural Engineering Department at Purdue University. He is a graduate of South Florida and the University of Florida in physics, mathematics and agricultural engineering respectively. His work on the Black Creek Study includes responsibility for maintenance of sampling equipment, data analysis of all water quality and climatic data from Black Creek, and development of a tile drainage simulation model.

DR. JACK BURNEY, visiting associate professor in tne Department of Agricultural Engineering, is specializing in increasing the capability and optimizing the storage and execution time requirements for the distributed parameter watershed model being developed by the project. Primary areas of emphasis include developing procedures to model channel flow, inundation area and rainfall intensity dependent infiltration, and independent element rainfall, cropping, management and soil parameter selection.

DANIEL R. DUDLEY is an aquatic biologist employed by the Allen County Soil and Water Conservation District to assist Dr. James Karr in studies of fisheries, microbiological parameters, and water quality within the Black Creek watershed. He holds a BS in biology from Kent State University and an MS in animal ecology from Iowa State University.

DONALD R. GRIFFITH is a research and extension agronomist at Purdue University who has particular interest in corn and soybean cultural practices. He has directed the conservation tillage trials and demonstrations on the Black Creek Study. At Purdue, he has coordinated agronomic research at regional Purdue agricultural centers, served as leader of an interdepartmental research project on tillage-planting systems for corn and soybeans, and as coordinator of state-wide extension program in the tillage area. He is a member of the American Society of Agronomy, Alpha Zeta, Gamma Sigma Delta, and Epsilon Sigma Phi. He holds BS and MS degrees from the University of Illinois in general agronomy and soil fertility.

DR. LARRY F. HUGGINS, Professor of Agricultural Engineering, has been involved with two aspects of the project: watershed modelling and field data acquisition automation. In the modelling area, he has been involved with supervising the development of the hydrologic components of the distributed parameter watershed model, ANSWERS. The work concerning field data acquisition has involved supervising both the design/installation of the real-time, automatic data acquisition system, ALERT, located on the watershed and the development of the associated computer programs required to control this network of instruments from a remote on-line computer.

JAMES R.KARR is associate professor of ecology at the University of Illinois in Urbana-Champaign. He holds a B.Sc. degree in fisheries and wildlife from Iowa State University and M.Sc. and Ph.D degrees from the University of Illinois in Zoology. He is a member of the American Association for the Advancement of Science, Ecological Society of America, Association for Tropical Biology, American Institute of Biological Sciences, and the Wildlife Society. His principal areas of research involve the study of structure and function in ecological systems. Special areas of interest include community ecology, effects of land use on water quality, and strategies for development of natural resource systems.

JAMES E. LAKE is executive director of the Allen County Soil and Water Conservation District and project manager for the Black Creek Study. He is responsible for day-to-day supervision of all phases of the project including coordination of the efforts of subcontractors and communication with USEPA. He holds a BS in agricultural education from Purdue University with a minor in soils.

RICHARD E. LAND is field coordinator for Purdue University on the Black Creek Study with responsibility for continuing field data acquisition, sampling of tile and stream water, collection of climatological data, and recording field cover changes. He has designed and installed special sites for measuring stream discharge and sediment accumulation. He also coordinated the application, monitoring, and research phases of the project. He holds the BS in Agricultural Engineering from Purdue and has been employed by the Soil Conservation Service and in private industry working on agricultural drainage and irrigation.

STEPHEN J. MAHLER is a visiting instructor in the Agricultural Engineering Department. He received a Bachelor of Science in 1975 from Purdue. During his undergraduate studies he designed and implemented software for a USDA researcher to control and store weather data. He was involved in the design, construction, installation, and maintainence of the Remote Data Acquisition and Control System, ALERT, for the project. In addition, he developed the software to interface the monitoring system to a computer to be used for real-time simulation of the watershed. Free time activities include upgrading the systems level software for the in-house computer and when the weather cooperates water sports.

DR. JERRY V. MANNERING is professor of agronomy and extension agronomist at Purdue University. He directed simulated rainfall research in the Black Creek Study to establish base erodibility values for major soils in the watershed and to evaluate the influence of crops and tillage practices on runoff. soil loss, and nutrient loss from major soils. Dr. Mannering has held his present position since 1967. Prior to that time, he conducted soil erosion research as a member of the Agricultural Research Service of USDA. He holds the BS degree from Oklahoma State and the MS and Ph.D from Purdue.

THOMAS DANIEL McCAIN is district conservationist assigned by SCS to assist the Allen County Soil and Water Conservation District. Since 1969, he has been responsibile for SCS filed office operations in Fort Wayne. McCain holds a BS in agronomy from Purdue.

WILLIAM L. MILLER holds the Ph.D. in agricultural economics from Michigan State University. He has specialized in resource economics at Purdue

University where he has been a member of the Department of Agricultural Economics since 1965. He is in charge of socio-economic studies on the Black Creek Project.

DR. EDWIN J. MONKE is Professor of agricultural engineering at Purdue University where he teaches and does research in soil and water resources. He received a BS in agricultural engineering in 1950, an MS in the same discipline in 1953, and a Ph.D in civil engineering in 1959, all from the University of Illinois. He has been on the Purdue staff since 1958. Dr. Monke's research has been in the mechanics of erosion, hydrologic modeling, the hydraulics of sediment-laden flow, the treatment of water from small reservoirs for domestic consumption and the movement of water and chemicals in soils. In the Black Creek Study, he has been engaged in the use of mathematical simulation of surface and subsurface discharge of sediments and related pollutants into receiving streams. He is a registered professional engineer in Indiana and is a member of the National Society of Professional Engineers, American Society of Agricultural Engineers, Soil Conservation Society of America, and American Geophysical Union.

JAMES B. MORRISON is an information specialist in the Department of Agricultural Information at Purdue University. He was a field representative for Cong. J. Edward Roush during the design of the Black Creek Study and has served as project editor for basic documentation of the project. He holds a BS in mathematics and has completed requirements for an MS in biology, both from Purdue.

ROLLAND Z. WHEATON has coordinated Purdue research efforts on the project and retained responsibility for ditch bank studies and for studies of sediment basins. He holds a Ph.D in engineering from the University of California. His major areas of specialization are irrigation and soil and water.

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15. SUPPLEMENTARY NOTES

Carl D. Wilson-EPA Project Officer
Ralph G. Christensen-Section 108(a) Program Coordinator

16. ABSTRACT

This is a progress report on the Black Creek sediment control project. This project is to determine the environmental impact of land use on water quality and has completed its third year of watershed activity. The project, which is directed by the Allen County Soil and Water Conservation District, is an attempt to determine the role that agricultural pollutants play in the degradation of water qualtiy in the Maumee River Basin and ultimately in Lake Erie.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
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