FINAL REPORT

IMPLEMENTATION OF CONSERVATION SYSTEMS

PILOT WATERSHED STUDY - SWEEP

Prepared for

AGRICULTURE CANADA
70 Fountain Street
Guelph, Ontario N1H 3N6

Prepared by

ECOLOGISTICS LIMITED
490 Dutton Drive, Suite A1
Waterloo, Ontario N2L 6H7

May 1994

540-93
0540\93\93CONSER.REJ

TABLE OF CONTENTS

Page

TABLE OF CONTENTS (cont'd)

LIST OF TABLES

LIST OF TABLES (cont'd)

LIST OF FIGURES

LIST OF APPENDICES

EXECUTIVE SUMMARY

IMPLEMENTATION OF CONSERVATION SYSTEMS
PILOT WATERSHED STUDY, SWEEP

1.0 Introduction

The mandate of the Soil and Water Environmental Enhancement Program (SWEEP) was to reduce phosphorus loadings to the Lake Erie basin and to maintain or improve agricultural productivity by reducing or correcting soil erosion and degradation. Conservation cropping and tillage systems were identified as the best means to achieve these goals over such a wide geographic region as the Lake Erie watershed. The Pilot Watershed Study (PWS) was developed as a means of evaluating the impact of conservation systems on soil erosion and degradation, water quality and crop production when implemented on a watershed basis.

The development and successful implementation of integrated phosphorus and soil management strategies in agricultural areas is a complex undertaking. Because climate and geology are not manageable parameters in most instances, management of nutrient export and soil erosion in the agricultural environment tends to focus on the structural and non-structural erosion control practices which can be implemented by individual farmers. The potential to reduce nutrient runoff, soil erosion and degradation, as well as factors including ease of implementation, farm community acceptance, agricultural productivity and agricultural cost must all be considered in developing workable control options.

2.0 Objectives

The components of the study documented in this report relate to the following objectives and strategies developed by the study contractors in keeping with the general objectives of the project.

* To achieve a high level of adoption of the most appropriate soil and water conservation practices among farm operators utilizing lands in the test watersheds.

  <u>Strategy</u>: Develop and utilize improved soil and water conservation planning tools for application at the farm and watershed levels.

  Develop and utilize contract arrangements with cooperating farm operators which specify and compensate for participation in the project without "buying" their participation.

* To determine the nature and degree of changes in relevant soil and water quality parameters and crop yields as influenced by "basin-wide" soil and water practices.

  <u>Strategy</u>: Develop and apply mechanisms to encourage adoption of soil and water conservation practices throughout the life of the project in the test watersheds and to discourage adoption in the control watersheds.

Evaluate improvements to planning tools (models) achieved during the sub-program.

Evaluate factors that affect the adoption of soil and water conservation practices and that influence farmer attitudes towards both the practices and the goals of the sub-program.

* To prepare information about the sub-program activities and results and to transmit this to participating farmers and other related SWEEP sub-programs.

Strategy: Collect and transmit, as required, to the SWEEP sub-program contractor responsible for the farm-level and basin-wide economic analysis.

Prepare information on activities and results for the communications sub-program contractor.

Prepare periodic reports to cooperating farmers on activities and results in written and meeting formats.

3.0 Methodology

To achieve the objectives of the PWS it was evident from the outset that a high degree of interaction between the project proponents and the landowners/farm managers operating within the targeted watersheds was required. Because the project proposed the adoption of conservation practices within the test watersheds a teaching or extension approach was necessary to first increase awareness and identification of the problems and then to encourage the successful adoption of suitable solutions. The strategy used to implement the study was guided by the proactive nature of the PWS and was formulated on the basis of an adoption incentive package and a recognition of the human dimensions to providing technical support in any extension program.

The provision of incentives and technical support was designed to:

- lessen the risk or perceived risk associated with new management practices:
- encourage cooperators to be as open as possible to a variety of new practices which were consistent with their own conservation objectives and farm management systems; and
- compensate for project-related learning, inconveniences, and potential out-of-pocket costs.

A conscious effort was made to ensure that incentives to participate in the study were provided to both test and control cooperators and that these incentives did not distort the basic economic motivations that govern farm operations by "buying" participation.

As a result the implementation of the PWS was achieved by providing the cooperators with access to:

- information,
- experience,

- conservation equipment, and
- financial assistance.

4.0 Conclusions

- The approach and process used during the implementation phase of the PWS was appropriate. Results indicate that study objectives were met.

Information and Education:

- The project newsletter was critical to keeping all cooperators and other interested parties informed about the project on a regular basis. Survey results indicated that all cooperators read the newsletter at least sometimes with a majority reading it always.

- The provision of printed material about conservation practices and issues from a variety of sources increased the interest of cooperators and advanced the adoption process. Provision of a one year subscription to the magazine *Successful Farming* caused many favourable remarks from the cooperators and resulted in renewed subscriptions paid by the farmers themselves.

- A responsive technical support system was important to maintaining cooperator interest in adopting conservation practices.

- Meetings, workshops and tours were very important educational tools in the PWS. When asked for input producers indicated a preference for tours to see solutions in practice and meetings with a specific management theme using recognized speakers. During and following the above an increased enthusiasm and interest in conservation practices was often observed amongst the attending cooperators.

- Social functions incorporated in the PWS were useful but not critical to building a working relationship between project staff and cooperators. Socializing between project staff and cooperators occurred during meetings, workshops and especially tours. Although the aim of the social functions that were organized early in the PWS was to foster a family and community involvement in the project the absence of these appeared not to be missed during the latter stages of the study in two of the three pairs of watersheds.

- Community interest increased as the project proceeded. Study staff and cooperators were asked to give presentations and host visitors.

Benefits Package:

- See PWS report Evaluation of Conservation Systems: Cooperator Attitude Change.

- In the PWS, as a proactive, targeted project where results were required within a relatively short adoption timeframe, an incentives component including access to information, experience, specialized equipment and financial assistance was required.

  Without the above tools to encourage immediate cooperator participation in the PWS project staff felt that several more years would have been required to achieve the objectives of the project.

- The objectives and timeframe of the project influenced the allocation of resources between and within the different incentives.

  For example achieving a change in crop rotation patterns was not feasible within the PWS and was therefore not emphasized. Significant resources were allocated to providing a complete technical support service to cooperators in order to reduce potential short term adoption risks. In a longer term project the emphasis on these and other items in the incentive component would shift.

- Having completed the implementation phase of the original study, the allocation of resources was appropriate to meet the objectives.

  Comments provided by the cooperators and project staff indicated a general satisfaction with the benefits package. (See also PWS report Evaluation of Conservation Systems: Cooperator Attitude Change.)

<u>Cooperator Agreements and Compensation Payments</u>:

- The agreement and compensation schedule used in the PWS were appropriate for the purposes they were intended to serve. The initial content and format of the agreement, amendments and compensation schedule changed very little throughout the PWS and few problems arose between the cooperators and the study.

- When compared to the cooperator commitment created through the project implementation process the agreement was much less useful in this regard. The agreement did serve to involve spouses and offset liability concerns.

<u>Conservation Farm Planning</u>:

- Using a conservation farm planning approach which considered both on-site (farm level) and off-site (watershed level) erosion and sedimentation impacts was a unique feature of the approach used in the PWS.

- GAMES, through its use of the USLE, could model sheet and rill erosion losses only. Modelling gully erosion was not possible with GAMES. Neither was it capable of modelling erosion by tillage displacement of soil, which research in Ontario has shown to be a significant factor in affecting soil productivity.

This weakness in GAMES was overcome somewhat by making crude assumptions in the effectiveness of a structure and adjusting sediment delivery pathways to reflect this assumption. For example, terraces were assumed to be 100 percent effective in settling out sediment. Catchbasins were assumed to have no settling affect and would actually improve delivery once the water entered the tile system.

. As a result of using the USLE factors it was difficult to model subtle changes landowners made in cropping/management practices. For example, converting from a fall moldboard plough system to a full modified moldboard plough (cut-offs) system was a positive measure taken by cooperators to increase soil residue cover. It was difficult, however, to model this change in residue management simply through the C-Factor.

A series of tables were prepared for determining C factors for a variety of crops and residue levels to better model the small changes in residue level remaining on the fields following planting. If residue levels were between the levels provided on the C factor sheets, an interpolated C factor was used.

. Only erosion and sedimentation components of the planning process were considered by the analysis model. The economic and other aspects were left to the planners to evaluate using other tools and/or their own experience.

. Defining the target erosion and sediment delivery rates proved difficult. Target erosion rates were better defined once the 1989 water quality data became available. The exercise of selecting applicable targets for all watersheds illustrated the inappropriateness of a single rule-of-thumb target for erosion and sediment delivery in consideration of the variety of landscapes in Ontario.

. The GAMES analysis gave planners important background data with which to initiate farm planning discussions. Because of the capacity to model on a specific polygon basis, it was possible for planners to address erosion sensitive areas as well to plan on a field-by-field basis.

. The Lotus spreadsheet derived from GAMES and the Farm Planning Module (FPM) output allowed quick comparisons of alternative conservation solutions so that cooperators could test their preferences and more easily adjust the effect of practices. For example, chisel points versus chisel sweeps could be compared by simply adjusting the residue levels which could be expected.

. The GAMES analysis allowed users to test the effect field management decisions would have on water quality at the watershed outlet. The presentation of the data, however, remained at the field scale - the management unit.

- The 1990 and 1991 Lotus spreadsheet approach provided an efficient means of recording conservation plans for the next crop year.

- The approach used computer analysis tools but left it with one-to-one contact between the cooperator and PWS field staff to make experienced decisions. This avoided cookbook solutions and encouraged innovation.

- The primary weakness at the field discussion level of planning was the sensitivity gap between knowing precisely what field situations were versus what was reported in the GAMES information. The field staff who were making recommendations to the farmer cooperator had been provided with a great deal of helpful information but lacked the familiarity and experience with the land that the cooperator possessed. It was, therefore occasionally difficult to answer questions raised by cooperators and sometimes required time consuming (but necessary) additional site visits to the area (polygon) of concern.

- Field discussions in conservation farm planning were an obvious necessity. In this project they had some additional peripheral benefits as well:

    1. They provided an opportunity for cooperators to raise, and often resolve, concerns about the use of new practices.

    2. They provided an opportunity for PWS field staff to establish a common identity with cooperators in addressing the objectives of the project.

    3. They provided an opportunity for cooperators to discuss or suggest ways to make the project more acceptable, a necessary first step if an effective plan was to follow, and an opportunity for cooperators to gain ownership in the project.

<u>Indicators of Adoption</u>:

- In the PWS the social indicators of adoption were monitored by documenting the attitudinal change experienced by the cooperators. The reader is referred to the PWS report Evaluation of Conservation Systems: Cooperator Attitude Change for more information.

- The short term economic indicators of adoption in the PWS were embodied in the planning and adoption decisions of the cooperators. It may be assumed that continued adoption of a given practice meant that in the short term the cooperator did not experience a large enough negative impact, including economic, to cause him to change his mind about proceeding.

- An inventory of physical change does not indicate how effectively the changes were implemented with resulting impacts on soil movement and water quality.

- Across all test watersheds the number of potential conservation actions identified during the planning sessions each year ranged from 51 to 72 discrete actions. Over the three years documented, on average approximately half of the identified actions were planned for at the beginning of each crop year (August/September). The high degree of uncertainty in making plans reflected mainly the impacts of weather and the effect this had on farming activities. Many producers were unwilling to make a commitment they were unsure of keeping. Without exception across all years and watersheds the percentage of completed conservation actions was greater than what was planned for.

- Future program planners may anticipate an increase in actual adoption when compared with initial indications obtained through the planning process.

- In Essex and Kettle there was a definite general shift during the project toward the use of conservation tillage systems. In the Pittock watershed the nature of the adoption trends for conservation tillage systems were less clear. There was little doubt, however, that a positive shift occurred in the adoption of conservation tillage systems.

- In most cases the PWS acted as the catalyst and/or means by which cooperators were able to implement conservation buffers, seed critical areas and build structures. The continued presence of these control practices to the end of the project and beyond (especially with regard to the structures) served as a useful indicator of adoption.

- In general those buffers and critical areas considered important to achieving PWS objectives were implemented by cooperators. The prioritization of the structures for project purposes meant that cooperators were more likely to install high priority structures first. The greatest adoption in this regard was achieved in the Kettle watershed. In Essex and Pittock, where the visual impact of the problems was less striking, the cooperators implemented less than half of the structures suggested.

5.0 Recommendations

- Future proactive and targeted programs should incorporate all of the elements of the incentive package described herein.

- Future proactive and targeted programs should ensure that staff working directly with producers are knowledgeable and experienced in the adoption of conservation farming systems.

Information and Education:

- Educational material should be provided and/or available from a variety of sources including both the project, the scientific literature and the popular press. This would expose the cooperators to a range of viewpoints and should add supporting evidence to the ideas promoted by the project.

- Information material regarding the project should be current, relevant and frequent enough to maintain the interest of the participants. A clear language writing style is important to enhance communication. A project newsletter can serve this purpose well.

- Technical support must be responsive to cooperator needs especially regarding specific information (e.g. what herbicide to use under certain circumstances) and timeliness (e.g. when a question is raised a response or recommendation is often required immediately). For best results an "on-call" technical support system is desirable.

- Input from project cooperators regarding the content of the information and education component is recommended. Producers will identify those areas of interest and methods of learning that are of most use to them. This input allows the cooperators to guide the project in addressing their changing concerns about adopting conservation practices. It also gives project staff insight into what practices cooperators may initially be most responsive to adopting.

- Whenever possible visits to farm operations practicing conservation measures should be encouraged. In contrast experienced conservation farmers should be invited to meet with cooperators on a regular basis to discuss their specific needs. If possible this should be done at least once during a walk over the farm.

- To help ensure adequate attendance at general project meetings the reason and need for the meeting should be well defined. A special interest event or guest speaker in conjunction with the meeting will also encourage attendance.

- If resources allow, social events should be incorporated into those programs where the target group of cooperators is well defined. These events however could be organized in conjunction with other project activities; for example a banquet or barbecue held in conjunction with the annual meeting.

- If a project is visible, community interest will exist. Satisfying requests and even seeking out opportunities to discuss the study can build a sense of achievement in the participants and provide a forum for positive feedback. It is recommended that these opportunities be recognized for their value in aiding the adoption process. If resources permit, a proactive community information component should be incorporated into the project plan. At the very least resources should be allocated to serving community requests when they occur.

- When asking cooperators to give presentations and host visitors on behalf of the project, care should be taken to distribute the requests across a number of cooperators. The tendency is to repeatedly call on the natural leaders in the group instead of giving the less outspoken cooperators an opportunity to participate in this experience.

<u>Benefits Package</u>:

- See PWS report Evaluation of Conservation Systems: Cooperator Attitude Change.

- The benefits provided to cooperators should be categorized into those required to meet the projects objectives and those required to meet the cooperators' objectives. Each category should be annually evaluated as to the ongoing usefulness of each. In some cases this would result in project resources being reallocated or decreased if apparent usefulness or effectiveness is low.

  For example the PWS newsletter included conservation article reprints as a way to continue introducing conservation ideas and practices to cooperators. In the final survey however cooperators did not find this service useful. Crop scouting services were provided to help cooperators meet their objective to adopt conservation practices with as little risk as possible. Apparently however few farmers used the information on a frequent basis. Crop scouting services provided on a request basis would have met the needs of those wanting the service and allowed either a reallocation of resources or a decrease in project costs.

- Project staff working directly with the cooperators should possess at least three years experience working as an extension specialist promoting the adoption of conservation farming systems. A farm background would be an asset. The credibility and practicality of the "front line" personnel are key to the success of the project.

- Backup technical assistance should be allowed for to maintain the timeliness of response to cooperator needs.

- Project staff turnover can have a negative effect on project progress from a technical support standpoint. This potential problem should be recognized and efforts made to minimize its occurrence and/or impact.

Cooperator Agreements and Compensation Payments:

- Care should be taken to keep formal agreements as simple as possible while ensuring they fulfil the purpose for which they were intended.

- Compensation payments made on an annual basis will save time and resources when compared to payments made on an instalment basis. This saving probably offsets the early financial benefit (or incentive) cooperators receive for participating in the study when the instalment plan is used.

Conservation Farm Planning:

- The need for a compendium of C factor tables applicable to Ontario should be examined. Such a document would assist in standardizing the estimates used for modelling and farm planning purposes.

Indicators of Adoption:

. Indicators of adoption should be identified at the outset of a program so that appropriate baseline data can be collected.

ACKNOWLEDGEMENTS

The following lists the participating agencies and responsible individuals for components of this study:

Agriculture Canada	Dr. Greg Wall	Technical and Financial Direction
Environment Canada	Mr. Len Camp	Streamflow Monitoring at Watershed Mouths
Ontario Ministry of the Environment	Mr. Jim Eddie	Watershed Scale Water Quality and Meteorological Monitoring
Beak Consultants Limited	Mr. M. Holloran Mr. R. Walker	Project Management Environmental Program Management
Ecologistics Limited	Mr. D. Cressman Ms. J. Sadler Richards Mr. M. Fortin	Study Process Management Agronomic Program Management

1.0 INTRODUCTION

1.1 Background

The Soil and Water Environmental Enhancement Program (SWEEP) was initiated in 1986 with an overall mandate to:

- reduce Ontario's Non-Point Source (NPS) loadings of phosphorus to Lake Erie from agricultural sources by 200 tonnes; and
- maintain or improve the productivity of the primary agricultural sector in Southwestern Ontario by reducing or correcting soil erosion and degradation.

The Pilot Watershed Study (PWS) is a major SWEEP sub-program aimed at evaluating and demonstrating the benefits of established conservation farming systems at the watershed and smaller scales. Figure 1.1 shows the overall SWEEP organizational structure and the PWS sub-program relationship to the Program. Cooperating agencies; Environment Canada (EC), Agriculture Canada (AC), and the Ontario Ministry of the Environment (MOE) are identified. Beak Consultants Limited (BEAK) is the prime contractor responsible to AC and MOE. Ecologistics Limited (ECOLOGISTICS) is a sub-contractor to BEAK responsible for site selection and the agronomic program of the PWS.

The PWS started in 1987 with detailed study design, staffing, training, cooperator enlistment, and watershed selection. Farm plans were initiated in August, 1988 and environmental monitoring began later the same year.

Monitoring and evaluation were conducted from late 1988 until mid 1992.

Figure 1.2 shows the location of PWS subject areas within the Lake Erie Watershed. These are situated within different yet common agricultural and physical settings.

The PWS has the following key features:

- four year implementation and monitoring period;
- **test** (conservation oriented systems) and **control** (conventional systems) paired watershed design;

- pro-active agronomic management involving annual farm planning, cooperator compensation program, ongoing producer extension program, availability of conservation-type farm implements, detailed cooperator record keeping, crop scouting and productivity analysis, and farm level socio-economic evaluation;
- intensive and continuous environmental monitoring at plot, field and watershed scales;
- detailed soil survey and soil quality monitoring;
- extensive environmental monitoring program including meteorology, hydrology and water quality; and
- detailed evaluation involving the application of two modelling systems for farm planning and systems evaluation.

The paired watershed study design is a unique approach which relies upon direct comparisons between the **test** and **control** areas as the primary method of environmental and agronomic evaluation. The effects of scale, at whole watershed, farm, field and plot scales are also a fundamental aspect of the study design which systematically addresses the relationship between producer attitudes and adoption as well as between measurable benefits, complexity, and scale.

1.2 Objectives of the Pilot Watershed Study

Objective Regarding Study/Approach

To achieve a high level of adoption of the most appropriate soil and water conservation practices among farm operators utilizing lands in the **test** sub-watersheds.

Strategy

1. Develop and employ a watershed selection process which:

    a) optimizes the probability of farm operator adoption of desirable practices, and
    b) can be applied effectively to critical areas in the larger Lake Erie basin.

2. Develop and utilize improved soil and water conservation planning tools for application at the farm and watershed levels.

3. Develop and utilize contract arrangements with cooperating farm operators which specify and compensate for participation in the project without "buying" their participation.

Objective Regarding Effectiveness

To determine the nature and degree of changes in relevant soil and water quality parameters and crop yields as influenced by "basin-wide" soil and water conservation practices.

Strategy

1. Select pairs of watersheds which are as similar as possible in respect to physiography, hydrology, and farming systems.

2. Develop and apply mechanisms to encourage adoption of soil and water conservation practices throughout the life of the project in the **test** sub-watersheds and to discourage adoption in the **control** sub-watersheds.

3. Establish soil, water and crop yield baseline conditions and monitor changes in relevant parameters throughout the life of the sub-program.

4. Correlate changes in soil, water and crop yield parameters to soil and water conservation practices and systems.

5. Evaluate improvements to planning tools (models) achieved during the sub-program.

6. Evaluate factors that affect the adoption of soil and water conservation practices and that influence farmer attitudes towards both the practices and the goals of the sub-program.

Objective Regarding Information Dissemination

To prepare information about sub-program activities and results and to transmit this to participating farmers and other related SWEEP sub-programs.

Strategy

1. Collect and transmit, as required, to the SWEEP sub-program contractor responsible for the farm-level and basin-wide economic analysis.

2. Prepare information on activities and results for the communications sub-program contractor.

3. Prepare periodic reports to cooperating farmers on activities and results in written and meeting formats.

1.3 Report Structure

The overall PWS reporting has been sub-divided into the following categories:

- Report #1 - Study Area Selection, Description and Climate;
- Report #2 - Implementation of Conservation Systems;
- Report #3 - Evaluation of Conservation Systems, Social Factors;
- Report #4 - Evaluation of Conservation Systems, Soils and Crops;
- Report #5 - Evaluation of Conservation Systems, Hydrology;
- Report #6 - Evaluation of Conservation Systems, Water Quality;
- Report #7 - Modelling; and
- Report #8 - Executive Summary.

Each report is a stand alone document including a summary, descriptions of objectives, methodologies, observations, discussion, and summarized listings of relevant data where applicable. The Executive Summary is a compilation of summaries from all of the technical reports.

This report documents the modelling activities undertaken as part of the PWS.

1.4 Specific Objectives

The development and successful implementation of integrated phosphorus and soil management strategies in agricultural areas is a complex undertaking. Because climate and geology are not manageable parameters in most instances, management of nutrient export and soil erosion in the agricultural environment has focused on the structural and non-structural erosion control practices which can be implemented by individual farmers. The potential to reduce nutrient runoff, soil erosion and degradation, as well as factors including ease of implementation, farm community acceptance, agricultural productivity and agricultural cost must all be considered in developing workable control options.

As indicated in Figure 1.3 the implementation of conservation systems by test cooperators was a key component of the Pilot Watershed Study.

The components of the study documented in this report relate to the following objectives and strategies developed by the study contractors in keeping with the general objectives of the project.

* To achieve a high level of adoption of the most appropriate soil and water conservation practices among farm operators utilizing lands in the test watersheds.

  Strategy: Develop and utilize improved soil and water conservation planning tools for application at the farm and watershed levels.

  Develop and utilize contract arrangements with cooperating farm operators which specify and compensate for participation in the project without "buying" their participation.

* To determine the nature and degree of changes in relevant soil and water quality parameters and crop yields as influenced by "basin-wide" soil and water practices.

Figure 1.3. The Implementation Approach in Context

Strategy: Develop and apply mechanisms to encourage adoption of soil and water conservation practices throughout the life of the project in the test watersheds and to discourage adoption in the control watersheds.

Evaluate improvements to planning tools (models) achieved during the sub-program.

Evaluate factors that affect the adoption of soil and water conservation practices and that influenced farmer attitudes towards both the practices and the goals of the sub-program.

* To prepare information about the sub-program activities and results and to transmit this to participating farmers and other related SWEEP sub-programs.

Strategy: Collect and transmit, as required, to the SWEEP sub-program contractor responsible for the farm-level and basin-wide economic analysis.

Prepare information on activities and results for the communications sub-program contractor.

Prepare periodic reports to cooperating farmers on activities and results in written and meeting formats.

2.0 THE STRATEGIC APPROACH

To achieve the objectives of the PWS it was evident from the outset that a high degree of interaction between the project proponents and the landowners/farm managers operating within the targeted watersheds was required. Because the project proposed the adoption of conservation practices within the test watersheds a teaching or extension approach was necessary to first increase awareness and identification of the problems and then to encourage the successful adoption of suitable solutions. The strategy used to implement the study was guided by the proactive nature of the PWS and was formulated on the basis of an adoption incentive package and a recognition of the human dimensions to providing technical support in any extension program.

2.1 A Proactive Approach to Conservation Adoption

From an early stage it was recognized that the design of the study required a proactive approach to conservation adoption rather than a reactive approach. This one factor had a significant impact on all other implementation aspects of the study.

A reactive program, typically, is set up to address an identified a problem, is applied to a wide geographic area where the problem may exist (to varying degrees) and offers assistance only to those who request it regardless of actual severity of the problem on their land. The cooperators participating in the reactive program tend to take the initiative and seek out the offered assistance. The resulting group is therefore predisposed to adoption.

On the other hand as a proactive program, the PWS identified specific geographic areas where soil degradation/water quality problems were of interest and where adoption of soil conservation measures by local cooperators would have the greatest impact on soil erosion control and sediment delivery to water courses. In order to address the water quality improvement objectives of the program it was necessary for all operators with critical land within a watershed to participate in the project. As a result it was determined that the preferred scale of the target watersheds was approximately 400 ha where typically eight to ten cooperators might be found.

A key aspect of the proactive approach was that all potential cooperators within the identified target watersheds were included. Because geographic location of farmland was a key factor in determining who was a potential study participant the demographics and motivational needs of the target group were broader than may be expected in a group of cooperators typically identified within a reactive program.

In general, cooperators in a proactive program tend to range along the entire adoption scale from innovators to non-adopters while cooperators in a reactive program tend to range within the upper regions of the adoption scale.

From an educational standpoint the reactive program is easier to deliver and adoption is more likely to occur (provided the adoption incentive has a long term benefit). This kind of program however may not be the most cost-effective from a problem solving standpoint. In the Great Lakes watershed for example 80% of the eroded sediment and phosphorus load comes from 20% of the rural landscape. If resources are targeted to those producers farming this 20% of the landscape a higher payback to society may be achieved from the investment of public funds.

Because this kind of proactive program deals with small communities of cooperators in a concentrated geographic area, the impact from the adoption of a new practice may be felt more quickly by peers and neighbours. This may then increase the potential for early widespread adoption by locally targeted cooperators. In a reactive program delivered over a large geographic area, isolated cases of adoption may not have the same impact on local communities and may appear as an oddity for several growing seasons unless the change brought about has an immediate and positive effect that is easily observed by neighbours.

2.2 Incentive Package

Change does not occur without reason and the reasons for change are infinite in number. Incentives are reasons that can cause change to occur before it might otherwise take place. In the case of the PWS an incentive package was required to promote change (i.e. the adoption of conservation practices) and general cooperation within the time frame of the study so that the objectives of the study could be realized. The aim of the incentive package was to support the need for change without "buying" the cooperation of the producers involved. From a long term perspective "buying" cooperation in adopting conservation practices is not a viable option for widespread use within the Lake Erie basin because it is simply too expensive.

When matching human and financial resources with program implementation it is important to include an adoption incentive package designed to meet the broad range of motivational needs that might exist in potential cooperators. At least four components are essential (Table 2.1): access to information, experienced technical assistance, the appropriate tools (equipment) and grants. The emphasis on each depends on the nature of the problems being addressed.

Table 2.1. The Components of an Incentive Package

Incentive	Comments	Priority
Access to information	-promotes awareness of the problem, identifies solutions, discusses ramifications of change, encourages (or discourages) adoption	Critical
Access to experience	-supports information sources, provides firsthand insight into the anticipated results of change, must be accepted as a credible and reliable source to be most successful	Important
Access to specialized equipment	-promotes an increased rate of adoption (provided adequate technical support in its use is included)	Important
Access to grants	-promotes an increased rate of adoption	Importance depends on the risk and complexity of adopting the solution

Access to information is critical to the adoption process. Most cooperators will not even consider a change, however minor without some insight into the ramifications of such a move. As the complexity and risk (whether real or perceived) involved in the change increases, the need for detailed and trusted sources of information also increases.

Access to information goes hand-in-hand with access to the experience gained by others in adopting conservation practices. If the person promoting the practice can discuss its benefits and problems from firsthand knowledge then the likelihood of adoption increases; provided the person is credible and respected by the cooperator and the local community.

The incentive to adopt may also be enhanced when the program provides free of charge, access to specialized equipment required to successfully make the change. If a producer can gain experience using new equipment and practices without having to first make a significant capital investment the chances of him beginning the adoption process increase greatly. If this is done however, it is incumbent on the program to also provide the backup support to ensure the equipment is used properly. Adoption failures due to lack of adequate technical support in the initial stages of a program will generally cost far more in terms of credibility, and set back the fulfillment of program goals to a much greater degree, than the actual cost of providing adequate technical support at the outset of the program.

Finally grants to assist in off-setting the cost of adopting a new practice should be provided if necessary. The need for specific grants will depend on many factors including whether the target cooperators recognize the existence of the problem the program is designed to address, the cost of making the change in practice, the perceived risk and the financial capacity of the cooperators.

2.3 Technical Support

As indicated earlier the human factor is critical to the success of the program. The interaction between those promoting the program and those cooperating in it will determine the speed of progress. The character of the extension worker providing the technical support is particularly important if the program is proactive. Due to the potential range in target group demographics including motivational needs, the extension worker must possess excellent communication and technical skills if progress is to be maximized. If there is no adoption there is no effect and the problem remains unsolved. If trade-offs in resources must be made in the development of the program they should not be made at the expense of the quality of staff available to work directly with the cooperators. A good extension worker can make amazing progress with a little support but a poor extension worker will never effectively use whatever support may be at his/her disposal.

The astute extension worker will start with a non-threatening and patient approach to the task. In the first year of the program the main aim should be to obtain the confidence and respect of the cooperators. When asked or required, initial suggestions by the extension worker regarding adoption options should not only be based on technical expertise as to what would be effective in a given situation but on the assessment of the cooperator's attitude toward change, risk and his management skills. Often more progress can be made toward ultimate adoption of a practice if the extension worker underestimates the cooperator's desire to implement a new practice which leaves him at the end of the season, asking to do more next year. This approach is much more positive than overestimating the producer's interest, encouraging rapid change and perhaps causing him to pull back the next year.

The above approach was taken in the SWEEP Pilot Watershed Study. For example many cooperators were first encouraged to try modifying the shape of their moldboard ploughs as a relatively easy method of making a known practice more effective in controlling soil erosion. This was done rather than immediately promoting a system such as no-till which involves a significant change to known practices. Few farmers will take such a *leap of faith* without some prior experience.

To provide guidance the program mandate should be clearly communicated to all involved. This is particularly important for example during the implementation phase. A typical problem occurs when participants must determine what level of *experimental* work will be considered as part of the program. Is the program to focus on the adoption of proven practices (and thus minimize the risk of failures), the use of collective thought and experience to come up with innovative (and therefore experimental) ways to address a problem, or both? In setting limits it is important to recognize that suggestions from cooperators on alternate approaches to problem-solving should be encouraged. In fact when they occur it is generally a sign that the adoption process is working well, the cooperator is taking responsibility for what is happening and his interest level and therefore opportunity for success is high. One approach to satisfying the needs of those involved is to implement the proven practice and, on a smaller scale, implement the cooperator suggestion in order to the see the effect. This approach has been used with success in conservation programs in the provinces of Saskatchewan and Ontario.

Lastly, when setting up a program it is important to select measures that will be used to address the extent to which the goals and objectives were met. While physical adoption is an important indicator and an essential requirement if soil loss/degradation is to be reduced and water quality improvement achieved, changes in cooperator attitude must often occur first. There can be a buffering effect in the first few years of a program where cooperators are absorbing the ideas presented but little activity is evident in the field. Baseline and comparative data should be collected so that change, whether physical or attitudinal, can be documented for the program. The merits of that change can thus be better judged.

3.0 INFORMATION AND EDUCATION COMPONENT

As indicated in the previous section the strategy for implementing the PWS was guided by the proactive nature of the study which required a strong extension or teaching approach, and the need for incentives and reliable technical support to encourage the timely adoption of conservation practices. To support these aspects of the study a well defined information and education component was developed and integrated within the implementation phase of the project. The following section details the objectives, materials and methods, results and discussion and the conclusions related to the information and education component of the PWS.

Note that due to the integrated nature of the information and education component reference to various aspects of it are also found throughout the remainder of this report.

3.1 Information and Education Objectives

The information and education component was developed as part of the strategy to address the following PWS objectives:

- To prepare information about sub-program activities and results and to transmit this to participating farmers and other related SWEEP sub-programs.

  Strategy: Prepare information on activities and results for the communications sub-program contractor (of SWEEP);

  Prepare periodic reports to cooperating farmers on activities and results in written and meeting formats.

- To determine the nature and degree of changes in relevant soil and water quality parameters and crop yields as influenced by *basin-wide* soil and water conservation practices;

  Strategy: Develop and apply mechanisms to encourage adoption of soil and water conservation practices throughout the life of the project in the test sub-watersheds and to discourage adoption in the control sub-watersheds.

3.2 Elements of the Information and Education Component

The information and education component utilized a variety of techniques aimed at achieving the communication objectives.

3.2.1 Printed Material

An effort was made to supply relevant printed material to the cooperators through the distribution of the following:

i) PWS Newsletter

Sixteen issues of the newsletter *ConservAction* were produced during the PWS. They served as an important vehicle for ongoing contact with PWS cooperators and other interested parties. Initially a typeset newsletter layout was used, but, in response to cooperator feedback, a more casual (word processing done in-house) style was adopted. This decreased the cost per issue and increased the timeliness and frequency of publication.

After 1989 the newsletter was printed on 8.5 x 11 paper and contained, on average, 13 pages of information. Every issue of ConservAction included five sections:

i) Upcoming events
A list of relevant upcoming events.

ii) Watershed Status Reports
Each of the Watershed Technicians wrote one article per issue describing events in their basins including field work, data analysis, tours and workshops.

iii) Special Articles
These were feature articles written by individuals working on the PWS. Occasionally, articles were written about or by cooperators.

iv) Environmental Monitoring
A minimum of one article per issue on environmental monitoring was also included.

v) Reprints
An effort was made to reprint a minimum of one relevant technical article from another source. The purpose of this section was to inform cooperators of what other producers and researchers were doing and also to introduce cooperators to various publications.

To lighten the information load, cartoons, sayings and bits of trivia were regularly added.

For every issue of ConservAction, 165 copies were printed. The newsletter was mailed to all project cooperators, non-cooperators (those not participating in the program), landowners (generally those who rented land to cooperators in the program), the PWS's scientific advisors and interested organizations such as: Agriculture Canada, Ontario Ministry of Agriculture and Food, the SWEEP communications contractor, The Soil and Water Conservation Information Bureau at the University of Guelph and Conservation Authorities.

ii) *Successful Farming* Magazine

Each cooperator was given a one year subscription to this magazine at the beginning of the program. The purpose was to provide ready access to current information on a wide variety of conservation issues. The magazine provided an information source outside of the PWS and in many cases supported the concepts and technical changes the project teams were introducing to the cooperators as part of the PWS.

iii) PWS Information Binder

To assist cooperators in keeping all project information together and to provide a working document for future farm planning each cooperator was provided with a project binder. Several sections were allocated for annual working notes during the conservation farm planning process. Other sections included background information on the PWS, soil and water conservation issues, concepts, problems and solutions. Copies of the cooperator agreement and the project benefits package (adoption incentives) were included for future reference.

iv) Reprinted Articles

Reprinted articles appeared in every issue of the ConservAction newsletter. Cooperators were, at times, given reprints of articles to help answer to questions they had posed.

v) InfoSource

A copy of the most recent InfoSource (the Soil and Water Conservation Information Bureau newsletter) was mailed to each cooperator with the ConservAction newsletter.

vi) Resource Library

A small resource library was developed at each watershed field office. This library was accessible to the cooperators and contained magazines such a Country Guide and Ontario Farmer, newsletters from various organizations such as Conservation Authorities and local Soil and Crop Improvement Associations and a number of reprints from magazines, newsletters and research publications. New additions to the libraries were sometimes advertised in the ConservAction newsletter.

vii) Conservation Tillage Handbook

During SWEEP, a handbook on equipment modifications and practical tips for use was developed. To assist cooperators in further understanding and adopting conservation systems a copy of this handbook was distributed.

3.2.2 Technical Support

An important part of the information and education program was quick access to technical information and support that was specific and responsive enough to serve to individual cooperator needs in a timely manner. The technical support service was incorporated into three components of the cooperator Benefits Package (i.e. access to information, experience and equipment) and is fully described in Section 4.1.

3.2.3 Meetings Workshops and Tours

Many of the meetings described below were an essential part of the farm planning process and are described in greater detail in Section 6.4.2.

Throughout the PWS a number of group and individual meetings and tours were organized by study personnel for each watershed. On an annual basis a group farm planning session was held in August or September. Since tillage practices are typically initiated in the fall, a late summer meeting to begin planning for the next years activities was required. The purpose of this meeting was to foster a community approach to solving soil and water management problems. The group meeting was followed immediately by a series of individual planning meetings between the cooperator, the watershed technician and other project technical staff as required. At this meeting specific problems were discussed in detail.

During the winter one or two information workshops were organized for the cooperators. The most popular topic involved weed management in conservation systems. In late March or early April an annual meeting was held and an update on study activities presented.

Since producers showed a preference for tours as a method of obtaining information on new management systems at least one tour was organized during the summer to view conservation systems on farms in Ontario or the United States.

Cooperators were also encouraged to attend information/education sessions organized by other groups. PWS cooperators attended several of these including a number of county conservation field days, Conservation Farming 88, the Innovative Farmer Workshop and the SWEEP Technology and Evaluation Development conferences.

3.2.4 Social Gatherings

Social gatherings in the form of barbecues were organized to provide a forum for building community spirit and for information exchange between test and control cooperators and project staff. Cooperators in the Kettle Creek watershed organized a thank you barbecue for the project staff.

3.2.5 Liaison With The SWEEP Communications Contractor

Upon request project staff and cooperators provided information and advisory services to the SWEEP Communications Contractor. A minimum of two large scale tours and several reporting opportunities for the SWEEP newsletter were conducted.

3.2.6 External Communications

Several times project staff were called upon by outside interests for information on the project. These included speaking engagements with special interest groups, school groups and touring farmers from the United States. Cooperators also provided time and insight by discussing their project experiences during meetings and tours of their farms.

Special exhibits on the project were also prepared for conferences and meetings such as the SWEEP Technology Evaluation and Development (TED) conference and the No-till Ridge Till Workshop.

3.3 Results and Discussion

As indicated in Section 3.2 the information and education component of the PWS included a wide range of activities. Following is a discussion of the program and where available evaluation data are provided.

3.3.1 Printed Material

During the final cooperator survey in 1992 (Evaluation of Conservation Systems: Cooperator Attitude Change, PWS, SWEEP) the extent to which the newsletter was read by cooperators and the cooperators' level of interest in the various sections of the newsletter was investigated (Table 3.1).

Table 3.1. Frequency of Newsletter Readership by Cooperators. Pilot Watershed Study, SWEEP, 1992

Readership Frequency	Distribution of Watershed Readership (%)								
	Essex*		Kettle*		Pittock*		All Watersheds Combined*		
	Test	Control	Test	Control	Test	Control	Test	Control	All
Always	92	75	75	40	40	36	71	50	60
Sometimes	8	25	25	60	60	64	29	50	40
Never	0	0	0	0	0	0	0	0	0

* Number of Respondents: Essex Test - 13; Control - 8; Kettle Test - 12; Control - 5; Pittock Test - 10; Control - 11; Combined Test - 35; Control - 24.

An average 60% of the PWS cooperators always read the newsletter while 40% read it sometimes. From the response it is apparent that the newsletter provided an important opportunity to communicate with the PWS cooperators with the level of interest greatest in the Essex watershed followed by Kettle and least in Pittock.

This trend is further developed in Table 3.2 which indicates the level of interest by cooperators in different components of the newsletter. The watershed status reports and environmental monitoring reports appeared to be of most interest while the special articles appeared to arouse less interest. As may be expected the test cooperators indicated a greater general interest in the contents of the newsletter in comparison with the control cooperators.
The above results suggest that the newsletter was a good way to update the cooperators on study progress but was less effective as a means of providing technical information regarding conservation practices. These findings are in keeping with the original intent of the newsletter.

Although no evaluation data per se are available for the other printed material provided to the cooperators during the project several comments can be made which may be useful to future studies of this kind.

Providing each cooperator with a subscription to the magazine "Successful Farming" had many positive benefits. The articles in the magazine immediately allowed the cooperators

Table 3.2. Level of Interest Expressed by Cooperators in Newsletter Components. Pilot Watershed Study, SWEEP, 1992

Newsletter Components	Level of Cooperator Interest (%)									
	Very Interesting		Somewhat Interesting		Of Little Interest		Of No Interest		No Response	
	Test	Control	Test	Control	Test	Control	Test	Control	Test	Control
Essex*										
Upcoming Events	15	25	62	62	15	13	0	0	8	0
Watershed Status Reports	46	63	54	37	0	0	0	0	0	0
Special Articles	8	25	46	13	38	50	0	12	8	0
Environmental Monitoring	31	38	61	50	8	12	0	0	0	0
Specific Technical Input	31	13	61	50	0	37	0	0	8	0
Kettle*										
Upcoming Events	50	0	34	40	8	60	8	0	0	0
Watershed Status Reports	83	0	17	80	0	20	0	0	0	0
Special Articles	50	20	42	0	8	60	0	20	0	0
Environmental Monitoring	42	0	50	80	8	20	0	0	0	0
Specific Technical Input	58	0	42	40	0	40	0	20	0	0
Pittock*										
Upcoming Events	20	27	30	18	20	46	10	9	20	0
Watershed Status Reports	40	36	30	64	20	0	0	0	10	0
Special Articles	10	0	30	46	50	46	0	8	10	0
Environmental Monitoring	40	18	30	46	20	18	0	18	10	0
Specific Technical Input	30	9	40	64	20	18	0	9	10	0
All Watersheds Combined*										
Upcoming Events	29	21	42	38	14	38	6	4	9	0
Watershed Status Reports	57	38	34	58	6	4	0	0	3	0
Special Articles	23	12	40	25	31	50	0	13	6	0
Environmental Monitoring	37	20	49	54	11	17	0	9	3	0
Specific Technical Input	40	8	48	54	6	29	0	9	6	0

* Number of Respondents: Essex Test - 13; Control - 8; Kettle Test - 12; Control - 5; Pittock Test - 10; Control - 11; Combined Test - 35; Control - 24.

access to information on a wide range of conservation issues and practices. These articles also indirectly supported the objectives of the PWS and as a result added credibility to what project staff were saying with regard to soil and water conservation problems and solutions. To the authors knowledge many positive comments were made by cooperators about the magazine and several indicated that they intended to renew their subscriptions at their own expense. In addition to the above the author feels that the uniqueness of providing a magazine subscription at the beginning of the study also sent a positive signal to the cooperators that the study was indeed a pilot and that they might expect a delivery approach unlike what they had experienced from government programs in the past.

Another key piece of printed material provided to the cooperators was the PWS binder. During group and individual meetings it was observed by project staff that some cooperators did bring the binders with them and appeared to be using them as intended.

Of apparently little use to the cooperators were the resource libraries at the local watershed offices. While few cooperators accessed these it should be noted that the local watershed technicians used the library resource constantly.

3.3.2 Technical Support

While this aspect of the study is also addressed in Section 4.1 it should be noted that during the adoption of new practices it is important cooperators know that troubleshooting services are available during critical times in the season. The PWS provided this service and incorporated a strong backup system of experienced technical assistance to offset anticipated time constraints when too many requests came in at the same time.

3.3.3 Meetings, Workshops, Tours, Social Events

Farm planning and update meetings were held on an annual basis throughout the project. It was found that as the study progressed attendance at these meetings tended to decline. Study staff believe this was due to increased familiarity with the problems being addressed through the PWS and a general awareness of what needed to be done. In addition to this there was regular contact with the cooperators through the watershed technicians and the newsletter. In retrospect attendance in the latter years may have increased if the content of the meetings had not been so predictable i.e. perhaps the addition of a social event or a guest speaker would have maintained the interest in group meetings.

Workshops and tours with a particular theme were certainly well received by the cooperators attending. A highlight of these was a trip to the BASF Agronomic Development Centre (an actual conservation farm run by the landowner and used by BASF for outdoor educational purposes), Illinois and the Purdue University Cooperative conservation program in Indiana. Twenty-six cooperators and four other family members went on the tour. On a scale of 5 (very worthwhile) to 1 (not worthwhile) 87% and 83% of the participants assigned a four or five rating to the BASF and the Purdue tour stops respectively.

Participants were also asked whether they felt they could apply the information they received, to their farm. The BASF tour appeared to be the most relevant,with 70% responding *yes*, compared with 50% *yes* response to the Purdue research. The types of information found useful ranged from all aspects of no-till farming (timing of planting, equipment attachments, fertilizer and residue management, etc.) to weed management and grass waterway establishment and maintenance. The Pittock cooperators appeared to have the most difficulty applying the information to their own farms, with three of the seven (43%) indicating they could apply the BASF information and only one of the seven (14%) indicating they could use the Purdue information. Twenty-eight of the participants (93%) indicated they would be interested in attending other tours in the future.

In August 1990, a total of 15 PWS cooperators (6 - Essex, 7 - Kettle Creek and 2 - Pittock) met at the University of Guelph's Woodstock Research Station to tour no-till, cover crop, nitrogen cycling and herbicide use research plots. Although no formal evaluation was carried out, participants informally expressed appreciation for conservation ideas arising from the tour. Cooperators for Pittock expressed interest in seeing research conducted on manure handling in no-till or cover cropping situations.

3.3.4 SWEEP Liaison and External Communications

Positive internal and external communication activities in relation to the PWS served to create positive peer support. It was felt that the more this was done the better for the adoption process. The contributions of key cooperators were monitored and care was taken to spread out the requests as much as possible so that no one person was overburdened with requests and other less vocal cooperators were given the opportunity to host visitors and discuss their conservation activities.

3.4 Conclusions and Recommendations

Conclusions:

- The project newsletter was critical to keeping all cooperators and other interested parties informed about the project on a regular basis. Survey results indicated that all cooperators read the newsletter at least sometimes with a majority of these reading it always.

- The provision of printed material about conservation practices and issues from a variety of sources increased the interest of cooperators and advanced the adoption process. Provision of a one year subscription to the magazine *Successful Farming* caused many favourable remarks from the cooperators and resulted in renewed subscriptions paid by the farmers themselves.

- A responsive technical support system is important to maintaining cooperator interest in adopting conservation practices.

- Meetings, workshops and tours were very important educational tools in the PWS. When asked for input producers indicated a preference for tours to see solutions in practice and meetings with a specific management theme using recognized speakers. During and following the above an increased enthusiasm and interest in conservation practices was often observed amongst the attending cooperators.

- Social functions incorporated in the PWS were useful but not critical to building a working relationship between project staff and cooperators. Socializing between project staff and cooperators occurred during meetings, workshops and especially tours. Although the aim of the social functions that were organized early in the PWS was to foster a family and community involvement in the project the absence of these appeared not to be missed during the latter stages of the study in two of the three pairs of watersheds.

- Community interest increased as the project proceeded. Study staff and cooperators were asked to give presentations and host visitors.

Recommendations:

. Educational material should be provided and/or available from a variety of sources including both the project, the scientific literature and the popular press. This will expose the cooperators to a range of viewpoints and should add supporting evidence to the ideas promoted by the project.

. Information material regarding the project should be current, relevant and frequent enough to maintain the interest of the participants. A clear language writing style is important to enhance communication. A project newsletter can serve this purpose well.

. Technical support must be responsive to cooperator needs especially regarding specific information (e.g. what herbicide to use under certain circumstances) and timeliness (e.g. when a question is raised a response or recommendation is often required immediately). For best results an "on-call" technical support system is desirable.

. Input from project cooperators regarding the content of the information and education component is recommended. Producers will identify those areas of interest and methods of learning that are of most use to them. This input allows the cooperators to guide the project in addressing their changing concerns about adopting conservation practices. It also gives project staff insight into what practices cooperators may initially be most responsive to adopting.

. Whenever possible visits to farm operations practicing conservation measures should be encouraged. In contrast experienced conservation farmers should be invited to meet with cooperators on a regular basis to discuss their specific needs. If possible this should be done at least once during a walk over the farm.

. To help ensure adequate attendance at general project meetings the reason and need for the meeting should be well defined. A special interest event or guest speaker in conjunction with the meeting will also encourage attendance.

. If resources allow social events should be incorporated into those programs where the target group of cooperators is well defined. These events however could be organized in conjunction with other project activities; for example a banquet or barbecue held in conjunction with the annual meeting.

- If a project is visible community interest will exist. Satisfying requests and even seeking out opportunities to discuss the study can build a sense of achievement in the participants and provide a forum for positive feedback. It is recommended that these opportunities be recognized for their value in aiding the adoption process and if resources permit a proactive community information component be incorporated into the project plan. At the very least resources should be allocated to serving community requests when they occur.

- When asking cooperators to give presentations and host visitors on behalf of the project, care should be taken to distribute the requests across a number of cooperators. The tendency is to repeatedly call on the natural leaders in the group instead of giving the less outspoken an opportunity to participate in this experience.

4.0 BENEFITS PACKAGE

It was recognized at the outset that many of the recommended conservation practices would be new to most of the PWS cooperators. A benefits package was therefore developed to provide monetary and other incentives to cooperators in order to:

- lessen the risk or perceived risk associated with new management practices:
- encourage cooperators to be as open as possible to a variety of new practices which were consistent with their own conservation objectives and farm management systems; and
- compensate for project-related learning, inconveniences, and potential out-of-pocket costs.

A conscious effort was made to ensure that incentives to participate in the study were provided to both test and control cooperators and that these incentives did not distort the basic economic motivations that govern farm operations by "buying" participation.

4.1 Elements of the Benefits Package

The benefits package gave cooperators access to:

- information,
- experience,
- conservation equipment, and
- financial assistance.

4.1.1 Access to Information

Through project staff, cooperators in both the test and control watersheds were provided with access to the following information:

a) daily weather records including rainfall, wind speed and accumulated corn heat units (PWS Report: Study Area Selection, Description and Climate);
b) soil fertility, crop scouting and crop yield results (PWS Report: Evaluation of Conservation Systems - Soils and Crops);

c) a detailed soil survey of land within the watershed which included information such as soil texture, soil organic matter content, topography, drainage and erosion phases (ESP, 1990);
d) a conservation plan for their land within the watersheds (test only) (see also Section 6.0);
e) educational group and individual activities (see also Section 3.0);
f) reports, newsletters, magazine subscriptions, handouts at meetings (see also Section 3.0).

4.1.2 Access to Expertise and Experience with Conservation Systems

One study staff member (watershed technician) was assigned to work with cooperators in each pair of watersheds. To increase the watershed technicians' familiarity with conservation crop production practices and equipment, a hands-on farm workshop was organized in May 1989 and repeated in April 1990. Two watershed technicians were enrolled in a short course and received certificates in crop scouting and integrated pest management from Michigan State University .

A team of three technical advisors with working knowledge in conservation farming systems provided support to the technicians and was on call for assistance to the cooperators. The team included:

- an agronomist and farm planning leader; in addition to a farm background this person had more than ten years experience delivering soil conservation programs and conducting soil conservation related research;
- a project engineer and computer analyst; this person had a farm background and experience in advising farmers on conservation farming systems;
- a well known and respected conservation farmer; this person had experience in adopting a complete package of soil conservation measures including conservation tillage and conservation crop production systems.

To accommodate demand during peak periods (especially at planting) additional backup assistance for cooperators was arranged for. This was accomplished through a number of experienced conservation farmers who, on occasion, were hired to work directly with cooperators in a troubleshooting capacity. The project team also included a number of research scientist who assisted with developing project plans and were available to farmer cooperators through study personnel. The disciplines covered by these *scientific advisors* included hydrology, soils, crop production, crop diseases, crop insects, weed control and rural sociology.

4.1.3 Access to Equipment

i) Equipment choices

The conservation equipment selected for the project was expected to help reduce soil erosion and sediment transport to water courses. Priority was given to increasing crop residue levels on or near the soil surface with the help of conservation tillage and planting equipment since long term changes in crop rotations (ultimately the best conservation solution) could not be achieved within the short term nature of the PWS.

From the outset of the PWS, it was clear that use of conservation tillage by participating farmers depends mainly on the extent to which it was *user-friendly*. Other factors influencing the choice of equipment for each watershed included local soil conditions, equipment size requirements and local preference for equipment brands and types. Cooperator familiarity with equipment was considered a significant factor in ensuring its maximum use.

Tillage and tillage-related equipment selected for the project were adapted so that all commercial fertilizer was placed in bands below the soil surface, thus maximizing the potential for use-efficiency and minimizing the potential for run-off loss of fertilizer phosphorus.

Cooperators in each watershed had access to the following equipment roster:

- moldboards to modify (cut-off) for individual ploughs
- two coulter-or disc-chisel ploughs
- one conservation grain drill
- one conservation row crop planter
- one weigh wagon and grain moisture meter
- one tractor to move equipment from site-to-site.

Other equipment was rented as needed; this included nitrogen applicators equipped for high residue, a stalk chopper and a modified moldboard plough.

ii) Cooperator introduction to equipment

Equipment options and availability were outlined to potential cooperators at the initial early meetings when watersheds were being selected for the project. Each subsequent meeting with the cooperators included discussion of the merits of various conservation tillage and cropping options.

During the farm planning sessions for the 1989 and 1990 crop production years, many farmers indicated a desire to try some new conservation tillage equipment. Subsequently, at meetings in the early spring of 1989, 1990 and 1991, project staff outlined to small groups of cooperators the kinds of critical factors that are essential to the successful use of specific conservation tillage systems (recognizing that equipment is only part of the *system*).

Arrangements were made in September 1989 for tours of farms where a full range of conservation tillage equipment was being used successfully. Follow up trips were taken to Illinois, Indiana and, in 1990, to the University of Guelph's Woodstock research station and, in 1991, to the Don Lobb farm.

iii)   Equipment update requirements

It was just as necessary to update equipment on a continuing basis for the PWS as it is in a normal farm operation to take advantage of improving technology and to fine-tune equipment to suit changing needs. It was an objective of the PWS to use the best available soil conservation technology.

The 1989 equipment updates included improved fertilizer attachments on the conservation row crop (corn/soybean) planters to reduce residue plugging, improved levelling bars on chisel ploughs to leave a more uniform soil surface and the addition of attachments on chisel plough sweeps in Essex to increase residue cover. In 1990, improved grass seed attachments were added to the Pittock conservation drill and the seed metering devices were updated on the conservation row crop planters. Plough moldboards required further reduction in size to leave more residue on the soil surface.

A larger (4.6 m) conservation seed drill was leased for Essex in the spring of 1990 to satisfy a local need for more planting capacity. This was in place for the remainder of the PWS. This drill was equipped with a bracket so that extra weight could be added for the 1991 crop season. The tillage coulters and presswheels were also changed to insure more accurate seed placement and coverage in the hard Essex clay soils. Covering harrows were ordered for the Essex drill for 1991, but were not available for use until the spring of 1992.

As cooperator priorities changed it became necessary to exchange the conservation row crop planters between Kettle (four row capacity) and Pittock (six row capacity).

4.1.4 Access to Financial Assistance

It was anticipated in the project design, from the outset, that cooperators receive monetary as well as non-monetary benefits for participating in the PWS. It was felt that financial incentives would help attract farmers and maintain their interest for the duration of the project. It was also felt that cooperating farmers should be compensated for inconvenience and personal time required, i.e. they were required to fill out questionnaires, keep field management records and attend meetings.

In developing the specific financial assistance plan we created a priority list of practices which would most benefit the PWS and would most likely be used by the farmers within the time frame of the study, and secondly, took into account the compensation programs of other similar projects enlisting the cooperation of farmers. Grants were available for field and farm management records, conservation tillage and cropping practices and conservation structures.

i) Field and farm management records

Because of the requirement to supply certain basic data to the PWS economic contractor farmers were asked to keep field management records. We felt that the project should therefore compensate the farmers for the time spent completing these records.

Since fields often change size on an annual basis, a clear definition of fields was required; record keeping was paid for only on fields that were five acres or more in size. A ceiling for the number of field management records per cooperator in a watershed was also established. If, however, a cooperator had fields in both the test and control watersheds he was paid the maximum for his fields in the test and the maximum for fields in the control. In instances where farmers had more fields than the PWS could compensate for, a field priority list based on potential for soil erosion and sediment delivery (high potential = high priority) was developed.

Since record keeping requirements for improved pasture or established hay fields were less than for annually cropped fields and the economic data were of lower priority field management record grants were lower.

The following rules were adopted as a guide for determining record keeping grants to cooperators:

- total field record keeping grants could not exceed $2000 per cooperator per year
- minimum acreage per field was five acres
- a grant of $400/field/year for the maintenance, completion and submittal of complete field management records
- a grant of $100/field/year for maintenance, completion and submittal of field management records on established hay or improved pasture fields.

Conditions:

- a field consisted of a clearly delineated block of land planted to one crop (with or without an underseeded forage crop) and subject to separate and distinct management practices
- unimproved pasture, trees and rough land were excluded
- in the test or control watershed, the above conditions were waived where mutually agreed-upon check strips (less than five acres) were established within a field
- in the year of establishment of hay or improved pasture, the cooperator received the full $400/field grant for the maintenance and completion of field management records; in subsequent years, a grant of $100/field applied.
- in the third year of the project we decided that if we had field records on a field from the outset of the project and that in the third year a split in the field caused the maximum in total field grants to be exceeded, the cooperator still received compensation so that we could have complete field data for the duration of the project

To satisfy additional needs of the economic contractor for SWEEP discussions were also held with cooperators to determine interest and suitability for <u>whole</u> <u>farm</u> economic analysis. Few producers showed interest or met the basic criteria for maintaining whole farm management records. Further action in this area was therefore not possible.

ii) Conservation tillage and cropping practices

Since the objective of the PWS was to assess the impact of proven conservation practices a list of these and a working definition of each, was drawn up. Financial assistance was determined for each practice based on potential effectiveness in controlling soil erosion and the perceived or real level of risk involved in rapidly adopting the practice within the time frame of the PWS (Table 4.1).

In anticipation of more than one tillage or cropping practice in any one field during a single cropping season, a maximum per acre compensation amount for conservation tillage and cropping practices was established. The amount of money paid for various practices generally reflected the potential impact of that practice on the soil and water conservation goals of the PWS. The total per acre grant combination was not to exceed $15/acre in any field.

Following the 1988/89 cropping season a residue bonus was included in the program. Cooperators who met after planting soil residue cover targets received a premium payment of $5/acre over and above the total per acre grant. This bonus was in effect for the 89/90 and 90/91 growing seasons.

Financial compensation for buffer strips and critical areas seeded down to hay were included in the benefits package to increase the potential direct impact of conservation practices on sediment delivery to water courses.

Table 4.1. Definitions and Grants Available for the Conservation Tillage and Cropping Practices Cooperators Were Encouraged to Adopt, Pilot Watershed Study, SWEEP, 1988-1992

Conservation Tillage or Cropping Practice	Definition	Grant ($)
Adjusted moldboard plough	• a moldboard plough adjusted to plough the soil at a depth of 6" or less. Trashboards are removed, and plough bottoms set to plough a furrow width of 16" or less; fall plough, 1X; spring disc or cultivate with harrows attached, 2X	5/ac
Modified moldboard plough	• a plough fitted with *cut-off* moldboards and set as for the adjusted moldboard plough except that furrow width is optional; fall plough, 1X, spring disc or cultivate with harrows attached, 2X	10/ac
Disc/coulter-chisel plough	• a plough fitted with twisted shovels or sweeps and adjusted to till the soil to a 6" depth or less; fall plough, 1X; spring disc or cultivate with harrows attached, 2X	10/ac
No fall tillage	• all tillage is done only in spring with adjusted or modified moldboard plough or disc/coulter-chisel plough with sweeps attached, 1X; spring disc or cultivate with harrows attached, 2X	10
Disc or cultivate (+ chisel plough between cereal crops)	• a) one pass with a disc or cultivator, with or without harrows attached, prior to seeding a winter cereal and following a row crop such as silage corn or beans; or b) a maximum of two passes with a disc/coulter-chisel plough, disc or cultivator, with or without harrows attached, prior to seeding a winter cereal and following a spring or winter cereal crop	5/ac
No-till	• the planting of a crop with no tillage of any sort occurring on the cropland before planting. It includes the use of a conservation row crop planter, a conservation seed drill or ground or aerial broadcast of seed	15/ac
Winter cover crop grown for crop	• a grain or forage crop retained over the winter for the purpose of harvesting as a crop the following year	5/ac
Winter cover crop tilled in the spring	• a grain or forage crop planted in the preceding growing season and killed in the spring by tillage or a herbicide spray, in order to make way for another crop	10/ac
Cereal underseeded to red clover	• the red clover seeded under a cereal crop is allowed to grow after the harvest of a cereal and is tilled in the fall with an adjusted or modified moldboard plough or a disc/coulter-chisel plough; one pass only	5/ac
Buffer strip	• a strip of land mutually agreed upon by the PWS staff and cooperator as being adjacent to a watercourse and seeded down to hay	100/ac
Critical areas seeded down to hay	• areas mutually agreed upon by the PWS staff and cooperator as being critical to their potential soil erosion and water quality impacts on the PWS	100/ac
Bonus grant for meeting the minimum target for soil residue cover after planting	• 1989-90 season: applies to row crops and cereals . 1990-91 season: applies only to spring seeded row crops such as corn, sunflower, beans (e.g. white, kidney, soy) and peas. . Minimum after plant residue target per watershed: Essex - 20%; Kettle - 30%; Pittock - 25%	5/ac

iii) Conservation Structures

The need for conservation structures was determined on a case-by-case basis. Test cooperators were invited to suggest where structures may be required on their land and in some cases within the watershed. The project engineer and the watershed technicians also inspected each test watershed. Identified problems areas were prioritized with the highest priority sites being those where PWS goals would be most directly addressed. Cost estimates were developed for potential solutions. Funding sources for the structures included the Ontario Ministry of Agriculture and Food's (OMAF) Ontario Soil Conservation and Environmental Protection Assistance Program (OSCEPAP), the PWS and the cooperators.

In most cases where structures were implemented cooperators received between 50 to 100% funding (total funding was provided only under rare circumstances) through a combination of the OSCEPAP and the PWS. To encourage cooperator ownership of the structure at least some of the cost was absorbed by the landowner.

4.2 Results and Discussion

Through the project, test and control cooperators gained access to soil fertility, weather and crop scouting information. As indicated in Table 4.2 this information was generally used more by the test cooperators than the control cooperators. The soil fertility information appeared to be used most often, followed by the crop scouting information. The weather data available through the project appeared to be accessed the least. In the same light the soil characterization results were also of only moderate to little use to the cooperators (Table 4.3). While the above information was generally required to meet the monitoring objectives of the study it is apparent that care should be taken not to overestimate cooperator interest and/or use of this information. As expected, test cooperators tended to have more use of the above information than the control cooperators.

When asked cooperators indicated an interest in tours to see conservation practices in place. Table 4.4 shows a relatively high participation and satisfaction level amongst cooperators in the Essex and Kettle watersheds with regard to farm and research station tours. Pittock had the lowest participation rate. It should be noted that both Kettle and Pittock included

Table 4.2. Cooperator Rating of Selected Information Sources Provided to the Cooperators. Pilot Watershed Study, SWEEP, 1992

Information	Cooperator Rating (%)									
	Frequently		Sometimes		Seldom		Never		No Response	
	Test	Control	Test	Control	Test	Control	Test	Control	Test	Control
Essex*										
Use of Soil Fertility Results	31	0	69	88	0	0	0	12	0	0
Access Weather Records	0	0	46	37	23	13	31	50	0	0
Use of Crop Scouting Results	0	0	31	37	31	25	38	38	0	0
Kettle*										
Use of Soil Fertility Results	42	20	58	60	0	0	0	0	0	20
Access Weather Records	0	20	25	20	33	0	42	60	0	0
Use of Crop Scouting Results	17	0	66	60	0	20	17	20	0	0
Pittock*										
Use of Soil Fertility Results	10	18	50	64	30	0	10	9	0	9
Access Weather records		9	20	0	20	18	60	73	0	0
Use of Crop Scouting Results	10	9	60	36	10	36	20	18	0	0
All Watersheds Combined*										
Use of Soil fertility Results	29	13	60	71	8		03	8	0	8
Access Weather records	0	4	31	17	26	17	43	62	0	0
Use of Crop Scouting Results	9	4	51	42	14	29	26	25	0	0

* Number of Respondents: Essex Test - 13; Control - 8; Kettle Test - 12; Control - 5; Pittock Test - 10; Control - 11; Combined Test - 35; Control - 24.

Table 4.3. Cooperator Usefulness Rating of Soil Characterization Results. Pilot Watershed Study, SWEEP, 1992

Information	Cooperator Usefulness Rating (%)									
	Very		Somewhat		Seldom		Never		No Response	
	Test	Control	Test	Control	Test	Control	Test	Control	Test	Control
Essex*										
Soil Characterization Results	15	0	62	87	15	0	8	13	0	0
Kettle*										
Soil Characterization Results	17	0	42	20	42	20	0	60	0	0
Pittock*										
Soil Characterization Results	10	0	40	46	40	18	10	18	0	18
All Watersheds Combined*										
Soil Characterization Results	14	0	49	54	31	13	6	25	0	8

* Number of Respondents: Essex Test - 13; Control - 8; Kettle Test - 12; Control - 5; Pittock Test - 10; Control - 11; Combined Test - 35; Control - 24.

Table 4.4. Participation and Effect of Farm and Research Station Tours Sponsored by the Pilot Watershed Study, SWEEP

Response	**Participation in Tours (%)**							
	Essex*		*Kettle		Pittock*		Combined*	
	Test	Control	Test	Control	Test	Control	Test	Control
Yes	69	50	58	40	30	27	54	37
No	31	50	42	60	70	73	46	63
	Effect of Tours on Conservation Farming Decision-making. (% Response)							
Very Helpful	31	25	42	40	20	9	31	21
Somewhat Helpful	31	25	16	0	10	18	20	17
Slightly Helpful	0	0	0	0	0	0	0	0
Not at All Helpful	0	0	0	0	0	9	0	4
No Response	38	50	42	60	70	63	49	58
	Number of Tours (% Response)							
More	23	25	17	0	20	0	20	8
Same Number	39	50	50	60	40	45	43	50
Fewer	0	0	0	0	0	0	0	0
No Response	38	25	33	40	40	55	37	42

* Number of Respondents: Essex Test - 13; Control - 8; Kettle Test - 12; Control - 5; Pittock Test - 10; Control - 11; Combined Test - 35; Control - 24.

livestock operations (dairy, swine) which can limit cooperator participation in events away from home due to the responsibilities of daily chores.

Annual meetings were another method by which cooperators gained access to information about the PWS and conservation practices. Table 4.5 indicates that cooperator attendance and satisfaction with meeting content were high in Essex and Kettle watersheds and moderately high in the Pittock watershed. (No response was generally given by those not attending annual meetings.)

Access to experience was a key component of the PWS benefits package. Overall, 88% of the test cooperators and 67% of the control cooperators rated the technical support from good to very good (Table 4.6). The higher rating given by the test cooperators may indicate the higher priority placed by the PWS on working with these cooperators when time constraints were a problem. In general, Essex cooperators were most satisfied with the technical support, followed by Kettle and then Pittock. It should be noted that in Pittock staff turnover in the watershed technician position (four technicians in four years) inhibited the establishment of a positive and continuous relationship between the PWS and the cooperators.

To assist in the adoption of new practices the PWS provided specialized equipment and technical support when needed. In the final survey, test cooperators were very positive in their response to questions about equipment availability, maintenance and technical support (Table 4.7). Control cooperators expressed less satisfaction with the above. This may be due to the priority placed on having test cooperators implement conservation measures in the test watersheds. Control cooperators were allowed to use the equipment on land outside the control watershed when the equipment was not being used by a test cooperator. The relatively high equipment availability ratings given by the Pittock cooperators may reflect the lesser demand for the equipment experienced in that watershed. Maintenance and technical assistance ratings were similar for both Pittock and Kettle watersheds. Since the highest equipment and technical demands were felt in Essex it is understandable that cooperator ratings would be somewhat less positive than the other two watersheds.

Financial support in the form of grants was provided to the cooperators in the PWS. In the final survey test cooperators were asked to give their opinions on the adequacy of the grants for each practice (Table 4.8). (If a cooperator did not receive a grant for a particular practice then "no response" was given.) In general for those cooperators responding most

Table 4.5. Annual Meeting Attendance and Information Quality, Pilot Watershed Study, SWEEP

Meeting Attendance (%)								
Response	Essex*		Kettle*		Pittock*		Combined*	
	Test	Control	Test	Control	Test	Control	Test	Control
Yes	100	75	92	60	60	64	86	67
No	0	25	8	40	40	36	14	33
Did Meetings Provide an Update and Monitoring Results of the Project and Encourage Communication Between Cooperators and Project Staff. (% Response)								
Always	23	25	42	40	20	0	29	17
Sometimes	77	37	42	20	50	55	57	42
Seldom	0	0	0	0	0	0	0	4
Never	0	0	0	0	0	9	0	0
No Response	0	38	16	40	30	36	14	37

* Number of Respondents: Essex Test - 13; Control - 8; Kettle Test - 12; Control - 5; Pittock Test - 10; Control - 11; Combined Test - 35; Control - 24.

Table 4.6. Cooperator Ratings of Technical Support Received Throughout the Project, Pilot Watershed Study, SWEEP, 1992

Information	Cooperator Rating (%)											
	Very Good		Good		Fair		Poor		Not Used		No Response	
	Test	Control	Test	Control	Test	Control	Test	Control	Test	Control	Test	Control
Essex*												
Technical Support	23	38	77	38	0	12	0	12	0	0	0	0
Kettle*												
Technical Support	67	0	25	60	8	40	0	0	0	0	0	0
Pittock												
Technical Support	50	28	20	36	10	18	10	0	10	9	0	9
All Watersheds Combined*												
Technical Support	45	25	43	42	6	21	3	4	3	4	0	4

* Number of Respondents: Essex Test - 13; Control - 8; Kettle Test - 12; Control - 5; Pittock Test - 10; Control - 11; Combined Test - 35; Control - 24.

Table 4.7. Cooperator Response to Equipment Availability, Maintenance and Technical Assistance to Conservation Equipment Provided by the Pilot Watershed Study, SWEEP

Question	Cooperator Response (%)											
	Always		Most Times		Only Sometimes		Never		Did Not Use Equipment		No Response	
	Test	Control	Test	Control	Test	Control	Test	Control	Test	Control	Test	Control
Essex*												
Equipment available when needed?	0	13	77	37	15	13	0	0	8	37	0	0
Equipment adequately maintained?	8	25	69	13	15	25	0	0	8	37	0	0
Technical assistance available when needed regarding equipment?	54	25	38	38	0	0	0	0	8	37	0	0
Kettle*												
Equipment available when needed?	33	0	58	40	0	0	0	0	9	60	0	0
Equipment adequately maintained?	58	40	33	0	0	0	0	0	9	60	0	0
Technical assistance available when needed regarding equipment?	83	40	17	0	0	0	0	0	0	60	0	0
Pittock*												
Equipment available when needed?	40	27	40	37	10	9	10	0	0	27	0	0
Equipment adequately maintained?	60	37	30	27	0	0	0	9	10	27	0	0
Technical assistance available when needed regarding equipment?	80	37	0	18	0	0	0	0	20	27	0	18
All Watersheds Combined*												
Equipment available when needed?	23	17	60	38	8	8	3	0	6	37	0	0
Equipment adequately maintained?	40	33	46	17	6	8	0	4	8	38	0	0
Technical assistance available when needed regarding equipment?	71	33	20	21	0	0	0	0	9	38	0	8

* Number of Respondents: Essex Test - 13; Control - 8; Kettle Test - 12; Control - 5; Pittock Test - 10; Control - 11; Combined Test - 35; Control - 24.

Table 4.8. Test Cooperator Opinions on the Adequacy of the Financial Assistance Program, Pilot Watershed Study, SWEEP

Action	Rate ($)	Essex Test (n=13)				Kettle Test (n=12)			
		More Than Adequate (%)	Adequate (%)	Inadequate (%)	No Response (%)	More Than Adequate (%)	Adequate (%)	Inadequate (%)	No Response (%)
Adjusted moldboard plough	5/ac	8	38	0	54	25	42	0	33
Modified moldboard plough	10/ac	15	62	0	23	25	42	0	33
Disk/coulter-chisel plough	10/ac	8	69	0	23	25	50	0	25
No fall tillage	10/ac	8	69	8	15	17	58	8	17
Disc or cultivate	5/ac	8	69	0	23	9	58	0	33
No-till	15/ac	15	62	0	23	9	83	0	8
Winter cover crop grown for crop	5/ac	8	38	23	31	8	75	0	17
Winter cover crop tilled in spring	10/ac	8	38	8	46	17	33	8	42
Cereal underseeded to red clover	5/ac	23	31	0	46	50	25	0	25
Buffer strip	100/ac	8	31	0	61	8	50	8	34
Critical areas seeded down to hay	100/ac	8	23	8	61	0	33	17	50
Field Records (row crops)	400/yr	15	77	8	0	50	42	0	8
Field Records (pasture/hay)	100/yr	8	15	8	69	25	25	0	50
Bonus for specified soil residue cover after planting (1990,1991)	5/ac	8	38	23	31	17	33	17	33

Table 4.8. Test Cooperator Opinions on the Adequacy of the Financial Assistance Program, Pilot Watershed Study, SWEEP (cont'd)

		Pittock Test (n=10)				All Test Watersheds Combined (n=35)			
Action	Rate ($)	More Than Adequate (%)	Adequate (%)	Inadequate (%)	No Response (%)	More Than Adequate (%)	Adequate (%)	Inadequate (%)	No Response (%)
Adjusted moldboard plough	5/ac	10	40	0	50	14	40	0	46
Modified moldboard plough	10/ac	20	70	0	10	20	57	0	23
Disk/coulter-chisel plough	10/ac	20	60	0	20	17	60	0	23
No fall tillage	10/ac	20	50	10	20	14	60	9	17
Disc or cultivate	5/ac	10	50	0	40	9	60	0	31
No-till	15/ac	10	30	10	50	11	60	3	26
Winter cover crop grown for crop	5/ac	20	40	10	30	11	51	11	26
Winter cover crop tilled in spring	10/ac	10	50	0	40	11	40	6	43
Cereal underseeded to red clover	5/ac	20	40	10	30	6	37	23	34
Buffer strip	100/ac	20	20	20	40	11	34	8	46
Critical areas seeded down to hay	100/ac	10	20	10	60	6	26	11	57
Field Records (row crops)	400/yr	10	80	10	0	26	65	6	3
Field Records (pasture/hay)	100/yr	10	50	30	10	14	29	11	46
Bonus for specified soil residue cover after planting (1990,1991)	5/ac	10	50	10	30	11	40	17	32

Source: Winter 1991/92 Cooperator Survey.

indicated that the grants provided were adequate to more than adequate. Overall, test cooperators expressed least satisfaction with the grants given for a cereal underseeded to red clover and the after planting residue bonus. Grants for structural measures were not included in this question.

Table 4.9 shows the opinion of the control cooperators regarding the adequacy of the grants for maintaining field records. For those providing record books the majority opinion was that the grants provided were adequate to more than adequate.

4.3 Conclusions and Recommendations

Conclusions:

. See Section 3.3 and PWS Report: Evaluation of Conservation Systems - Cooperator Attitude Change.

. In the PWS, as a proactive, targeted project where results were required within a relatively short adoption time frame, an incentives component including access to information, experience, specialized equipment and financial assistance was required.

  Without the above tools to encourage immediate cooperator participation in the PWS project staff felt that several more years would have been required to achieve the objectives of the project.

. The objectives and time frame of the project influenced the allocation of resources between and within the different incentives.

  For example achieving a change in crop rotation patterns was not feasible within the PWS and was therefore not emphasized. Significant resources were allocated to providing a complete technical support service to cooperators in order to reduce potential short term adoption risks. In a longer term project the emphasis on these and other items in the incentive component would shift.

Table 4.9. Control Cooperator Opinions on the Adequacy of the Financial Assistance for Field Records. Pilot Watershed Study, SWEEP

Action	Rate ($)	More than Adequate (%)	Adequate (%)	Inadequate (%)	No Response (%)
Essex Control (n=8)					
Field Records (row crops)	400/yr	25	63	12	0
Field Records (pasture/hay)	100/yr	0	0	0	100
Kettle Control (n=5)					
Field Records (row crops)	400/yr	0	100	0	0
Field Records (pasture/hay)	100/yr	0	40	0	60
Pittock Control (n=11)					
Field Records (row crops)	400/yr	9	82	0	9
Field Records (pasture/hay)	100/yr	0	27	0	73
Control Watersheds Combined (n=24)					
Field Records (row crops)	400/yr	13	79	0	8
Field Records (pasture/hay)	100/yr	0	21	0	79

. Having completed the implementation phase of the original study, the allocation of resources was appropriate to meet the objectives.

Comments provided by the cooperators and project staff indicated a general satisfaction with the benefits package. (See also Section 4.0 and PWS Report: Evaluation of Conservation Systems - Cooperator Attitude Change.)

Recommendations:

. See Section 3.3 and PWS Report: Evaluation of Conservation Systems - Cooperator Attitude Change.

. The benefits provided to cooperators should be categorized into those required to meet the projects objectives and those required to meet the cooperators' objectives. Each category should be annually evaluated as to the ongoing usefulness of each. In some cases this would result in project resources being reallocated or decreased if apparent usefulness or effectiveness is low.

For example the PWS newsletter included conservation article reprints as a way to continue introducing conservation ideas and practices to cooperators. In the final survey however cooperators did not find this service useful (see Section 3.3.1). Crop scouting services were provided to help cooperators meet their objective to adopt conservation practices with as little risk as possible. Apparently however few farmers used the information provided on a frequent basis. Crop scouting services provided on a request basis would have serve the needs of those wanting the service and allowed either a reallocation of resources or a decrease in project costs.

. Project staff working directly with the cooperators should possess at least three years experience working as an extension specialist promoting the adoption of conservation farming systems. A farm background would be an asset. The credibility and practicality of the "front line" personnel are key to the success of the project.

. Backup technical assistance should be allowed for to maintain the timeliness of response to cooperator needs.

. Project staff turnover can have a negative effect on project progress from a technical support standpoint. This potential problem should be recognized and efforts made to minimize its occurrence and/or impact.

5.0 COOPERATOR AGREEMENTS AND COMPENSATION PAYMENTS

5.1 Letter of Agreement

The cooperator Letter of Agreement was a contract which outlined the responsibilities of the cooperator and the project team. The Agreement also included four schedules:

- Schedule A: Cooperator Field Map - This varied from year-to-year as the field boundaries changed.
- Schedule B: PWS Plan of Action - The plan outlined the conservation tillage and cropping practices and record keeping the cooperator planned to do in each field each year. It listed the materials (record books) and equipment supplied by the PWS, the compensation rate per practice, the total grant and a payment schedule. Annual amendments were initialled by the cooperator, the watershed technician, and the agronomic program manager.
- Schedule C: Schedule of Payment - This schedule summarized the detailed schedule of payments listed in the Plan of Action (Schedule B).
- Schedule D: Definition of Terms - This schedule changed very little during the study. A few additions helped to clarify the practices listed but no formal update was included as an amendment to the agreement.

The Letter of Agreement was only signed once by the cooperator, the spouse or partner(s), and representatives of the project team. Every cropping year the Agreement was updated via amendments to Schedule A, B and C and signed by the same parties. Table 5.1 summarizes the change in the status of the above Letters of Agreement between the cooperators and the PWS.

5.2 Compensation Payments

Payments for the field management records were divided into three installments: January/July/January (Table 5.2). Field record books were completed and collected after fall tillage, after planting and after harvesting. Payments were staggered to encourage submission of records for a complete growing season.

Table 5.1. Change in the Status Letters of Agreement Between Cooperators and the Pilot Watershed Study, SWEEP, 1988-91

	Number of Cooperators								
	Essex			Kettle			Pittock		
Agreement Status	88/89	89/90	90/91	88/89	89/90	90/91	88/89	89/90	90/91
Signed Letter of Agreement	22	24	21	18	16	16	22	22	22
Letter of Agreement was in progress	1			1	1				
Cooperative but would not sign an Agreement	1	1	4	2	2	2			
Non cooperative	3	3	2	2	2	2	4	4	4
Total number of cooperators	27	28	27	23	21	20	26	26	26

All conservation tillage and cropping payments were paid in either one or two installments depending on when the practice would have its most critical impact on controlling soil erosion and sediment delivery. The first instalment was in January and the second in July. For example, a winter cover crop grown for crop provided soil crop cover during the fall, winter and spring runoff periods. Once in place in the fall the practice would provide benefit to the project even if the producer ripped it up in the spring (for whatever reason). Therefore a full grant payment was made in January to the cooperator. For no-till however the maximum benefit would be realized after planting in the spring. Therefore if a cooperator was compensated for no-till, he received 30% of the payment in January and 70% of the payment in July. Thus, if he changed these plans and decided to spring till, the total grant and July payment could be reduced to reflect the change in practice.

Payments for conservation structures were made on a case-by-case basis, generally once the work was completed and the final cost calculated.

Table 5.2. Schedule of Installments for Compensation Payments to Cooperators Pilot Watershed Study, SWEEP, 1988-1992

Action	Compensation Rate/Yr ($)	Payments Installments		
		1st: January($)	2nd: January ($)	3rd: January ($)
Field records (row crops) Field records (pasture/hay)	400/yr 100/yr	100 30	100 30	200 40
Adjusted moldboard plough Modified moldboard plough Disk/coulter chisel plough No fall tillage Disc or cultivate No-till	5/ac 10/ac 10/ac 10/ac 5/ac 15/ac	2 4 4 4 5 6	3 6 6 6 9	
Winter cover crop grown for crop Winter cover crop tilled in spring Cereal underseeded to red clover Bonus for adequate soil residue cover after planting	5/ac 10/ac 5/ac 5/ac	5 5	5 5 5	
Buffer strip Critical areas seeded down to hay	100/ac 100/ac		100 100	
Conservation structures	Case-by-case basis			

5.3 Discussion

Due to the number of cooperators involved in the PWS (from 70 to 80) a significant amount of time was required to track agreement and compensation payment status. Since no legal and only a few monetary issues arose between the PWS and the cooperators, with regard to the implementation activities described in this report, the author feels this time was well spent. By avoiding legal and compensation conflicts those involved maintained a positive focus on the objectives of the PWS.

While no formal evaluation data exist the author feels that the study implementation process described herein created the greatest sense of commitment to the project and the adoption of new practices when compared to the impact of the agreement alone on the cooperators. The agreement however did ensure that spouses were all involved in the commitment made to the project since they were required to sign the original agreement and initial subsequent amendments (annual plans of action). In addition to this benefit the agreement was required to offset the liability concerns of both parties.

5.4 Conclusions and Recommendations

Conclusions:

. The agreement and compensation schedule used in the PWS were appropriate for the purposes they were intended to serve. The initial content and format of the agreement, amendments and compensation schedule changed very little throughout the PWS and few problems arose between the cooperators and the study.

. When compared to the cooperator commitment created through the project implementation process the agreement was much less useful in this regard. The agreement did serve to involve spouses and offset liability concerns.

Recommendations:

. Care should be taken to keep formal agreements as simple as possible while ensuring they fulfil the purpose for which they were intended.

. Compensation payments made on an annual basis will save time and resources when compared to payments made on an instalment basis. This saving likely offsets the early financial benefits (or incentive) cooperators receive for participating in the study when the instalment plan is used.

6.0 CONSERVATION FARM PLANNING

6.1 Purpose and Objectives

From the outset of the PWS it was recognized that cooperators needed assistance in preparing and implementing a soil conservation farm plan for each farm field within the test watersheds. The purpose of this conservation farm planning exercise was to develop conservation plans which identified the management techniques that would be used to maintain soil productivity and improve water quality in the associated test watersheds.

More specifically, the objectives for preparing conservation farm plans were to:

1. assess the extent and severity of soil erosion, soil degradation and water quality impairment on a field, farm and watershed basis;

2. estimate the physical effects of conservation practices on those soil and water conditions identified in objective (1) and incorporate related farm management dynamics including economic and crop production factors;

3. recommend a Plan of Action (POA) aimed at initially upgrading and ultimately maintaining acceptable levels of soil productivity and water quality;

4. document and provide for the annual revision and ratification of a Plan of Action amendment to the study Agreement signed between concerned parties; and

5. provide a basis for monitoring the extent and severity of soil erosion, soil degradation and water quality impairment and the effects of adopting conservation practices.

6.2 General Approach

The conservation farm planning process was key to the PWS implementation strategy. As such it also involved an approach that allowed the integration of watershed computer modelling used to predict the impacts of current watershed management practices with farm and field level conservation planning. This integration effectively made the watershed modelling tool into a planning tool that could be used to estimate the potential combined effects of individual farm plans on the watershed before any work was done on the ground. With this information a unique opportunity to adjust the plans in order to meet watershed soil erosion and sediment delivery targets was available.

To facilitate the above approach the selected watershed computer model (GAMES) was modified and the add-on software called Farm Planning Model (FPM) was developed. In addition to this, a two level approach involving first, a background analysis step and second, a field discussion step was used. A schematic of the approach is found in Figure 6.1. The following sub-sections detail the conservation farm planning process used in the PWS.

6.3 Computer Modelling as a Conservation Planning Tool

The approach taken in conservation farm planning in the PWS is unique relative to conventional approaches. Traditional conservation farm planning treats farm boundaries as the edge of management influence. In the pilot watershed study however, it was necessary to predict the effects of individual farm management decisions on both long-term farm productivity and on water quality at the mouth of the study watershed. To achieve this objective, the study team used a modified version of the USLE-based watershed computer model called GAMES (Guelph model for evaluating the effects of Agricultural land Management systems on Erosion and Sedimentation, Cook, Dickinson and Rudra, 1985).

GAMES was selected from a list of available erosion modelling tools for the following reasons:

1. it is a watershed based model;
2. it is based on the USLE which was the current standard used in farm planning (Wishmeier and Smith, 1978);
3. data input requirements are relatively minor and readily available from data collected through other components of the PWS;
4. modification to he software could be made as required for this unique application;
5. it estimates annual delivery of sediment to the watercourse.

Figure 6.1. The conservation farm planning process used in the Pilot Watershed Study, SWEEP, 1988-1992

6.3.1 The GAMES Model and its Adaptation to Conservation Planning

GAMES adapts the USLE for use in watershed applications. The watershed is sub-divided into cells or polygons and the number of polygons within a watershed is dependant on the complexity of the study area. Polygon maps are produced by overlaying the following maps:

- soil survey (including soil texture and topographic information (slope gradient));
- land use including field boundaries; and
- watershed drainage network.

An example of the resulting polygon map is presented in Figure 6.2.

A polygon on the final polygon map represents an area of landscape in the watershed that has a uniform soil type, topography, land use (crop), and drainage pattern. Thus a landscape with numerous soil types, complex topography and small acreage farms, will produce more polygons than a landscape having uniform soils and topography and large acreage farms. For each polygon soil erodibility (K), slope length and gradient (LS), and land management (CP), erosion estimates can be determined.

Because GAMES models soil erosion on a watershed basis, it also calculates the delivery of the USLE-derived gross erosion from each polygon to the watershed's outlet. To do this GAMES uses a delivery ratio approach to estimate sediment transport from the source polygon to the watershed outlet. The equation for estimating the delivery ratio is as follows:

$$DR = a[1/n*S0.5*Hc/L]B$$

where:
- DR is the micro delivery ratio from one polygon to another in a watershed
- n is the Manning's surface roughness co-efficient (user supplied)
- S is the slope gradient of the soil surface (user supplied)
- L is the length of the surface drainage flow path between locations (user supplied)
- Hc is the number indicating the capability of a soil to generate runoff under a selected land use for a particular season
- a,B are constants.

Figure 6.2. Typical GAMES Polygon Map (Pittock 1988/1989 crop year)

The constant"a" is user-supplied when the GAMES model is operated in predictive mode. "B" is based on the slope length and gradient values entered for the polygons. If sediment load at the outlet is known, the parameters "a" and "B" can be optimized for a watershed through an objective function embedded in the GAMES program. The value for the Hc is also calculated internally for each polygon using the input data as the basis for its calculation.

During the development of GAMES it was assumed that the slope length for a polygon is identical to the slope and gradient of the concentrated flow path which surface runoff follows. In the large majority of cases, however, this is a poor assumption. By definition, USLE's "L" factor is measured from the top of the eroding slope to the point where deposition starts (Wishmeier and Smith, 1978). Typical topography then would suggest that slope length be measured along the hillside as it slopes to a concentrated flow pathway, for they are often much steeper and can be shorter than the concentrated flow pathway which runoff water then follows as it traverses through the polygon to the outlet (see Figure 6.3).

In an effort to improve the modelling of soil loss and delivery pathways *pseudo cells*, that is polygons having negligible area but a slope gradient and slope length more representative of the pathway actually followed by run-off water, were established as part of the GAMES dataset. Pseudo cells were created sketching the primary concentrated flow pathways throughout the watershed and then splitting them up into a series of segments or pseudo cells. For the Essex watershed, the field scrape ditches installed by the farmers were regarded as the concentrated flow pathways. These pathways or pseudo cells were not shown on the final polygon map, but the slope, length and Mannings "n" data associated with them were incorporated into the GAMES dataset for a purpose of sediment delivery calculations. This modification to GAMES input requirements enabled the entering of more realistic values for L and S for the polygons used in calculating delivery ratios.

In addition to the above adjustment in preparing the GAMES input data, a few modifications were also necessary to the GAMES program itself in order to customize it to the farm planning task for the watersheds. First, modifications were made to attach the field and farm number associated with each polygon. The system of field and farm numbering was identical to that used in the farm field record books maintained by the cooperators. Second, in order to facilitate the more detailed field level data collected from the study areas, compared to more conventional application of GAMES the allowable number of C-factors and Manning's "n" values was expanded from 9 to 100 and the number of allowable K factors was increased

Figure 6.3. Flow Pathways Versus Field Slopes

from 9 to 20. Finally, source code was added to enable the creation of a pass file that could then be used as input for a new software program (the Farm Planning Module - FPM). This additional software was developed to assist in the analysis of the GAMES results and assist in the selection of remedial conservation measures for each field and farm in the watershed. It was at this level that the PWS conservation planning ultimately took place (see Section 6.4.2).

6.3.2 GAMES Input Dataset Preparation

To manage the GAMES input data more effectively, a GIS system was developed to accompany the GAMES program. Maps showing surface drainage, soil types and field/farm boundary locations were first digitalized and then overlayed to form the final polygon map. To account for slight digitizing errors and to simplify the final polygon map, all polygons less than 0.4 hectares (one acre) in size were collapsed after each overlay procedure. Through this overlay procedure the attributes (e.g. soil K factor) associated with each overlay map were combined, ultimately forming a set of attributes describing each unique polygon.

Following productions of the final polygon map and its associated polygon attribute file, the attribute data were imported to a Lotus spreadsheet as a format the GAMES program could read. At this point a significant amount of manual input was normally required to enter the remaining GAMES input data and to prepare the dataset to be received and read by the GAMES model.

6.3.3 GAMES Model Runs Used in Farm Planning

GAMES can be run in two modes, the predictive mode and the analytical mode. The predictive mode is used when no water quality data from the outlet of the watershed being modelled are available. Parameter values are estimated using assumptions. For the PWS, these values were selected following a review of water quality values chosen for other watersheds having similar hydrological conditions and modelled by GAMES in the past. The analytical mode takes advantage of available water quality data to calibrate the sediment delivery component of the GAMES model. Water quality data for the PWS were not available until the third year field season. Consequently, GAMES was run in the predictive mode for the first two seasons of farm planning. When they became available, the water quality data were used as a check of the previous year's modelling results.

Throughout the PWS the number of GAMES runs varied from year-to-year. For the first two years of farm planning (1988/89 and 1989/90 crop years) the following two GAMES analyses were used:

i) GAMES run based on fallow field conditions over the entire watershed and
ii) GAMES run based on each farm's tillage and cropping practices of the previous three years (1986 - 1989).

The *fallow field condition* run was used to identify inherently erodible areas in the watershed due to factors such as soil type and topography which could not be altered simply through management changes. This altered run was invaluable since it identified those areas on the farms that required special conservation tillage and cropping management considerations.

The *past three-year rotation* GAMES run gave the project an overview of current soil loss and sediment loading rates in the watersheds. When these values were compared with the common reference point of fallow conditions, it gave an indication of the relative effort currently employed between the various watershed farmers to reduce erosion rates.

For the third and fourth years (1990/91 and 1991/92 crop years) a new series of GAMES datasets was prepared which included the following:

iii) GAMES run based on 1989 actual field management practices; and
iv) GAMES run based on the predicted field management practices had the PWS <u>not</u> been influencing the area's activities.

The fallow condition run was also still valid as a base point of reference.

6.4 Farm Planning Methodology

A *two level approach* was used in the farm planning process in order to make use of the data output from GAMES and yet maintain the one-to-one contact between the farmer and PWS field staff involved in developing each plan. The two levels can be described as follows:

<u>Planning Level A - Background Analysis:</u> This was an office activity which consisted of compiling and organizing all the relevant background information and GAMES output data for each farm.

Planning Level B - Field Discussions: This involved meetings (group and/or individual) between the farm cooperator and field staff to review and discuss the GAMES modelling results to identify those conservation management practices which could meet the plan recommendations suggested by the output data from GAMES and to further discuss and plan which measures would be adopted by the cooperator.

6.4.1 Planning Level A - Background Analysis

As a watershed-based model used by planners and scientists, the GAMES output was originally formatted in relation to polygons and hydrologic units. But to use GAMES output as a planning tool it was necessary to present the information with reference to the fields and farms in the watershed since these were the basic planning units for farm cooperators and field staff.

To achieve the above conversion the PWS developed add-on software called the Farm Planning Model (FPM) to accompany the GAMES program . This software was capable of sorting and summarizing the GAMES soil loss and sediment delivery output data for each farm and field in the watershed. This was achieved by identifying and manipulating the erosion data for all the polygons which together formed a field or farm of interest. This software also provided the users with a general list of tillage rotation options which could meet the user-supplied target soil erosion rates for the field or farm being considered. Such a listing gave the conservation planners (cooperator and field staff) a good indication of the range of tillage practices, residue levels and/or crop rotation options available to meet the target erosion rate for each field. A summary of each farm's estimated soil erosion and sediment delivery potential was prepared on a Lotus spreadsheet during Planning Level A and then used at meetings during Planning Level B. An example of such a spreadsheet prepared previously to farm planning field level discussion is shown in Table 6.1.

In the top left corner of the spreadsheet the farm number, watershed and cooperator name were listed. The left side of the spreadsheet provided descriptors for the numbers entered to

Table 6.1. Example Spreadsheet of GAMES data prepared for the Conservation Planning Exercise

the right in columns each of which represented a farm field. Those entries associated with the descriptors on the left having an asterisk (*) besides them could be altered by the spreadsheet users to determine the effect of a management changes on estimated soil erosion on the field and subsequent delivery to the stream. The spreadsheet incorporated formulas to provide an immediate estimate of the effect of a proposed management change.

Farm totals and relevant target levels were presented to the far right of the spreadsheet for quick reference. In the middle of the spreadsheet, the values for soil loss and delivery calculated by GAMES for the 1989/1990 crop season assuming the pilot watershed study had no influence in the management decision of the farmer, (i.e. Base Condition (1989 *IF* condition) were presented for comparison purposes. The bottom lines of the spreadsheet showed the percent reduction in erosion and sediment delivery from each field in the current planning session relative to the base condition (1989 *IF* condition). This information was shown as a means of encouraging (or challenging) farmers in the PWS to make progress during the study years in terms of reducing soil loss.

Selecting an appropriate target rate for erosion and sediment delivery for the farms proved difficult. In the initial year of conservation planning (1988/89), the targets, or tolerable levels, for soil erosion and sediment delivery rates were set at 6.25 tonnes/ha/year and 1.25 tonnes/ha/years respectively, based on the GAMES manual recommendations (Cook, Dickinson and Rudra, 1985). It became evident, however following the first year's modelling and conservation planning exercise, that such general guidelines for the three sets of paired watersheds in this study were not appropriate. Alternatively, Ontario Ministry of the Environment (MOE) phosphorous loading guidelines, when back-calculated to the field and farm level, were too restrictive. More site specific targets were needed.

An alternative approach was used for planning the 1990/1991 crop year. Since the results of the 1989 season's water quality results were then available, these data were used to calibrate the GAMES model for the 1989 year. By calibrating the GAMES model, coefficients used in the model's equation could be adjusted so that GAMES sediment delivery estimates from the watershed matched those loadings actually measured at the watershed outlet.

With the GAMES calibration complete, the model was applied to the two different watershed scenarios described earlier (Section 6.3.3). The first scenario modelled the conditions actually existing in 1989 (see PWS Report: Evaluation of Conservation Systems - Soils and Crops), while the second modelled the situation which would have been present in the watershed without the influence of the PWS. Note that by 1989, the majority of the structural measures ultimately adopted by the producers were in place. The adoption of conservation tillage and cropping systems, however, was still in its infancy as many of the cooperators, by this point in the project, had only one crop season of experimentation with conservation systems. These earlier shifts towards conservation farming were relatively minor in relation to future trends, with many farmers in that first year willing to try modifications to moldboard ploughs or perhaps try no-till winter wheat into soybean stubble as a first step towards adopting a conservation tillage program. This left room to progress in subsequent years if the results from the first year proved favorable.

The difference in modelled erosion and sediment loadings at the watershed mouth, between the 1989 actual condition and the 1989 condition that would have been present without the influence of the PWS in the area, gave an estimate of the long-term reductions in erosion and sedimentation possible through continued use of the conservation practices implemented in 1989 alone. With information on what the landowners had achieved through their efforts in the first year and, keeping in mind the inherent erodibility of the watershed, a reasonable target was set for the 1990/91 crop season. The final targets selected are presented in Table 6.2.

Incorporating data obtained from a watershed-based model such as GAMES into the farm planning process made the PWS approach to farm planning unique. Using this modified version of GAMES the farm planners maintained an awareness of how the management of any particular field could effect the water quality results at the mouth of the watershed, although the complete picture of how the combination of treatments could ultimately affect the loadings at the outlet was not calculated until all the action plans were made in the watershed.

However, the planners did have enough information available to them at the time the management decisions were being made, to select solutions that would ensure that the actions taken would be quite close to that desired at the watershed outlet. The solutions were selected primarily for their ability to reduce gross erosion rates. The software had the capability to list tillage and cropping practices that would achieve tolerable erosion rates. Reducing gross erosion would reduce sediment delivery since the latter is dependant on the former. The planners also took note of the delivery ratio estimated for each field. Fields

Table 6.2. Soil Loss and Water Quality Targets Considered in the PWS

Watershed	Soil Productivity Targets (tonnes of erosions/ha/year		Water Quality Targets (tonnes of sediment/ha/year		
	Rule-of-Thumb[1]	From calibrated GAMES Runs[2]	Rule-of-Thumb[1]	MOE Guidelines[3]	From 1989 Water Quality Data[4]
Essex	6.25	3.05	1.25	0.0248	0.31
Kettle	6.25	3.10	1.25	0.0115	0.13
Pittock	6.25	4.56	1.25	0.0051	0.036

[1] Rule-of-Thumb often used by soil conservation planners and as provided in the GAMES Users Manual.
[2] Based on GAMES - estimated gross erosion reductions achieved in first year of study and what could be potentially realized from a practical point-of-view by 1991.
[3] Derived from 1989 flow-data from watershed, MOE Guidelines of 0.03 mg P/1 and average phosphorous enrichment ratios (PER's) for each watershed.
[4] Based on GAMES - estimated sediment delivery reductions achieved in first year of study and what could be potentially realized from a practical point-of-view by 1991.

with high delivery were assigned a lower tolerable soil loss level if tillage and cropping systems were selected as the means of erosion control. Filtering (structural) approaches, such as grass filters and temporary ponding systems, were available for high delivery areas on a farm where cropping and tillage options were too restrictive for the farmer.

The planning process was iterative with transitions being made from a watershed level to a field level and back again. Use of common sense and intuition by the farm planner could bring the number of iterations required to a minimum (i.e. one).

Target selection was a key component in developing sound methodology for in-field conservation planning discussions. The availability of in-site field measurements of flow and sediment concentrations at the mouth in 1989 made this possible. Consequently, more confidence in the GAMES output for use in planning erosion and sedimentation control measures was possible, although the field staff's and landowner's experience was still a critical and highly beneficial component to the planning exercise and the achievement of satisfactory results for both the landowner and the PWS.

6.4.2 Planning Level B - Field Discussions

The field level planning discussions were divided into two parts:

1. group meetings in each watershed pair;
2. individual cooperator meetings.

The following sections describe the purpose, organization and material presented at these meetings.

6.4.2.1 Group meetings

Group meetings were organized in each of the sets of paired watersheds at various stages in the study. The group meetings were categorized as either public meetings or information meetings.

i) <u>Public Meetings</u>
All public meetings included a component where the benefits of adopting soil and water conservation measures were discussed. This commenced with the first public meeting in January 1988 when the PWS proposal was introduced to the residents of all those watersheds being considered for final inclusion in the study.

A second public meeting, held when watershed selection was finalized, introduced the concepts associated with conservation farm planning and the Universal Soil Loss Equation (USLE), along with an Agreement and Benefits Package which would be integral components of each Plan. At this point cooperators were given an opportunity to review and comment on air photos and watershed maps regarding field boundaries and other pertinent information. Cooperators were also provided with a PWS binder (see Section 3.2) which included reference material and, as a storage location for all information of the cooperators activity related to this project, was intended to serve as a working document for future farm planning.

Annual public meetings were held during the winters of 1989, 1990 and 1991, to update the cooperators on developments within the project and to reinforce the need to adopt conservation measures so that meaningful information would be obtained from the project. This was also one opportunity for cooperators to provide feed-back regarding their concerns and ideas for of the project.

The annual public meetings thus provided a forum where adoption strategies were introduced and the importance of crop production "systems" was repeatedly emphasized. This latter point is best summarized in the following explanation.

> *SYSTEMS APPROACH: The implementation of conservation practices is best achieved within the conservation farm planning process. Within this process cooperators adopt new practices to improve soil and water conservation on their farms and in the case of the PWS, on a watershed basis. Success in adoption occurs most often when a cooperator realizes that change is generally required for several components within a system rather than for one or two isolated practices. An example of this occurs when cooperators understand that the change from conventional moldboard ploughing to no-till involves not only a change in equipment, but also a change in seed variety, soil fertility, pest control and individual attitude. The "systems" approach to adopting conservation measures therefore involves a complete examination of management activity and skills with adjustment made to accommodate the requirements of new technology.*

ii) Information Meetings

Group information meetings focused on the technology required for the successful adoption of conservation farm plans. For example, during individual farm planning meetings in August/September 1989, some cooperators expressed interest in group meetings which would focus on reduced pesticide use. Dr. C. Swanton, a scientific advisor, to the PWS addressed this topic in each pair of watersheds in the winter of 1990. Similarly, in response to increasing interest in no-till crop production, a workshop was held in each pair of watersheds in the spring of 1990. Further conservation technology was acquired during cooperator tours of practicing conservation farms and research sites during 1989, 1990 and 1991. Each meeting and trip had a significant impact on the planning process with interest expressed in adopting more and more effective practices; this was particularly true in the Kettle and Essex watersheds.

6.4.2.2 Individual cooperator meetings

Meetings were held at the individual cooperator level to carry out three different activities:

i) to collect background information and material for farm planning, attitude change assessment and other monitoring;

ii) to plan at the farm/field level for the adoption of soil and water conservation measures. It was at this level where the actual decisions were made about what practices would be adopted; and

iii) to amend the Letters of Agreement (see Section 5.0).

i) Information Collection

Data were collected throughout the study. Data used in farm planning were first obtained during the watershed selection phase of the project when surveys were completed . These surveys established baseline conditions with regard to cooperator attitudes, current level of adoption of conservation measures, unique farm characteristics, scale of farm operations and equipment availability. This information was continually updated through watershed technician contact with cooperators, farm sessions planning and follow-up meetings.

After watershed selection field operation and production information were collected in field record books which were provided to cooperators and collected three times per year. Soil and topographical information was gathered on all watersheds (ESP, 1990). Soil fertility samples were taken and residue cover monitoring was done. In the summer of 1988 field visits to first establish the need for conservation structural measures and then how best to design and construct them, were completed by PWS staff, cooperators and qualified erosion control contractors.

ii) Planning at the Farm/Field Level

a) 1988/1989 Test Cooperators

Conservation Tillage and Cropping Measures

During August/September of 1988 and 1989 farm visits were arranged to include the farm cooperator(s), the area's watershed technician and either of the project agrologist or conservation farming advisor (J. Sadler Richards or Don Lobb). Prior to this meeting, the field staff reviewed all the relevant Level A background material on the farm operation to familiarize themselves with the present field management practices, soil erosion rates and environmentally sensitive areas of the property. A summary was prepared for each farm showing on a field-by-field basis the gross erosion and sediment delivery rates under current management as output from the GAMES and FPM software. A map of the watershed was also prepared showing the relative erodibility of the landscape within the test basin. The map, based on the fallow conditions, enabled the planners to see the relative effect of implementing conservation measures across the watershed and on a field-by-field basis.

In the first two years of farm planning, the planners did not have the benefit of watershed water quality results to verify the erosion and sediment delivery estimates obtained through GAMES. Consequently, the field staff in these initial years concentrated most on encouraging farmers to attempt to meet the gross erosion target of 6.25 tonnes/ha/year. In instances where more than one polygon was involved in a field and when erosion rates varied across a field, the planners were faced with two options. Recommendations could be prepared based on the requirement of the most severe polygon erosion characteristics or, alternatively on general field characteristics with special treatment encourage for those parts of fields that had unique extra requirements. Both approaches were used. The larger the difference between the highest erosion rate and a field's general erosion rate the more appealing special treatment of the field became.

The field staff with the benefit of the USLE and practical experience, prepared two or more alternative crop production programs which would meet the 6.25 tonnes/ha/year target. These were discussed with the farm cooperators. Plans were recorded and requirements for project supplied equipment and other project support were noted.

A discussion of the project benefit package including financial assistance, for implementing measures was used as an added incentive to encourage the adoption of conservation measures. The cooperators were encouraged in these meeting to use their own judgement, with the support of project staff, in choosing measures to adopt. They were also encouraged to go beyond basic recommendations or to implement alternative measures where applicable. By doing so, the cooperator felt some *ownership* in his contribution to the project and adoption of conservation practices.

Where cooperators were reluctant to move toward adoption of new and unfamiliar practices, they were encouraged to at least try minimal measures such as modifying the moldboard plough.

The planning strategy from the outset was to build on success. Project staff encouraged cooperators to start with practices which had a high success potential, and then to progressively adopt more effective practices as confidence was gained. This approach was taken rather than encouraging producers to begin with very unfamiliar practices which increased the risk of failure. The aim was to avoid a failure which might undermine the confidence of the cooperator, the credibility of the project and the potential for achieving the objectives of the PWS.

Conservation Structures

Some cooperators indicated a preference to use engineered measures such as sediment control basins to control surface water runoff. This required follow-up visits and investigation by the project's soil and water conservation engineer. Implementation of these plans was necessary early in the study in order to allow for an evaluation of their effect on water quality.

Implementation of the structural measures was linked with the farm planning activities and followed a series of steps. Due to the site specific nature of erosion problems that are severe enough to require structural forms of erosion control, the approach must be site and landowner specific. Structural solutions are best for addressing severe rill or gullying problems caused by concentrated surface water flow. Since these forms of erosion are quite noticeable, landowners are typically quite aware of the erosion problem. As well a limitation of the GAMES Model is that it does not model gully erosion - the common form of erosion requiring structural erosion control measures.

The first step in identifying areas requiring structural erosion control was simply to ask landowners to pinpoint on an aerial photo problem areas on their farm where they thought work was needed. This initial assessment of structural requirement was completed during the test watershed cooperator meetings held in May, 1988.

For the purposes of formulating solutions to the erosion problems occurring on the sites identified by the cooperators, each site was inspected in the field. At the same time, the remainder of the watershed was walked, and problem sites not identified by the cooperating landowners, but evident to the project soil conservation engineer, were located and mapped. In identifying problem areas not mentioned by the farm owners, a degree of practicality was necessary on the part of the project staff. The problem areas and potential solutions identified, were based on what the staff considered to be realistic for implementation given previously identified sociological and economic constraints. A theoretical approach, which identified every site in which a structural measure "could" be applied, was deemed impractical. The actual level of implementation ultimately differed even from the original perceived practical level. Through further discussions with each landowner and coordination of the structural measures with the tillage and cropping plans decisions were ultimately made as to the installation of structures.

Following identification of the problem areas conceptual solutions were developed, and these ideas were presented on an individual basis to the landowners. Each landowner's response and the approach taken by project staff varied somewhat depending on the circumstances. For those sites which were initially identified as problem areas by the landowners, the watershed technician and the project engineer met with the cooperator to outline the potential solutions and the advantages, disadvantages and costs of each. For those sites not initially identified by the landowner as a problem, but observed during the field inspection,the watershed technician informed the landowner of the potential problem site and asked if he/she was interested in having a preliminary cost estimate prepared for potential solutions.

All landowners who were interested in reviewing these structural options were given information on financial assistance available through the OSCEPAP program. This program covered two thirds of the cost of the work to a maximum grant of $10,000. The landowner was then able to make a decision as to whether or not he/she would request that the study team prepare detailed design drawings to accompany a submission to OSCEPAP and a more detailed cost estimate. Following approval for funding from the OSCEPAP program construction commenced. See Section 7.0 for a list of proposed and implemented structures per watershed.

b) 1988/1989 Control Cooperators

<u>Conservation Tillage, Cropping and Structural Measures</u>

The principal thrust of the project with cooperators in the control watersheds was to monitor field activities as they would be carried out without incentive to adopt soil and water conservation measures. Background information was assembled similar to that for the "Test" farms, and in August/September of 1988 and 1989 a cross section of these farms were visited by field staff always including the local technician and sometimes including the project agrologist or conservation farming advisor and so that cooperator intentions would be recorded.

c) 1990/1991 Test Cooperators

<u>Conservation Tillage and Cropping Measures</u>

The 1990 and 1991 one-to-one farm planning discussions differed from the previous two years. The changes were made to take advantage of the water quality data which was available for the watersheds and used to calibrate the GAMES model. Also the Test cooperators were becoming more comfortable with the PWS program and the new management practices they had been using over the past two crop seasons. Both changes gave a solid framework on which to develop a farm plan capable of meeting targets.

As was described previously in Section 6.3.3, two input data sets were prepared:

- input data based on 1989 actual field management practices; and
- input data based on predicted field management practices had the PWS not been influencing the area activities.

The purpose of modelling these two conditions with GAMES was to determine the erosion and sediment delivery rate on each farm during the past cropping year and also to encourage (or challenge) the landowner in adopting conservation management measures. Comparing the results of the two GAMES runs would give both the PWS field staff and cooperator a quantitative description of the progress made in the previous years. The presence of water quality data to enable calibration of the GAMES model and the selection of suitable target erosion and sedimentation rates (see Table 6.2) provided an opportunity to address through the adoption of different tillage/cropping and structural practices those areas still needing improvement.

The GAMES derived Lotus spreadsheets (see Table 6.1) were used during the meetings. PWS objectives and cooperator concerns were discussed and then the cooperator indicated his preference of tillage and cropping practices for the following years. These preferred option and their associated C-factors, and Mannings "n" or structural effect factors were entered by the watershed technician into the spreadsheet. Using these supplied factors, the spreadsheet automatically calculated the effect such measures would have on soil erosion and sedimentation rates at the field, farm and watershed level. These values were then compared to the target rates and if the targets were not met, other crop production practices were suggested by the cooperators and/or PWS staff members changes were again tested in the spreadsheet to determine if they met PWS objectives for erosion control. Other aspects, such as effects on crop yields, feed supply for livestock, and farm income, were not considered by the spreadsheet. These areas had to be dealt with on an individual basis between the farmer and the field staff. With all factors considered, the cooperator then chose to implement practices which most closely met project objectives and his production requirements and preferences. In order to access the computer for recalculating the spreadsheet cooperators were invited to meet with field staff at the local watershed office.

Given the pilot watershed study's priority on evaluating the potential for farm-applied conservation techniques to reduce phosphorous to the Great Lakes system, phosphorous loading and, indirectly, sediment loading targets we selected as being of prime importance during the final stages of conservation planning. If soil delivered from a farm was under the allowable limit for the farm, then the landowners were also asked to consider the long-term productivity of their land base. Reducing the soil losses to at least the rule-of-thumb limit on each field, was encouraged. If this level was met, then cooperators were challenged to reduce it to the GAMES-estimated target. For Kettle Creek, the rule-of-thumb estimate was lower then the GAMES-estimated target. Consequently, landowners were encouraged to bring levels down to the GAMES target level and then challenged to bring their soil loss to the rule-of-thumb level.

Table 6.3 shows a typical example of the outcome of the 1990 conservation planning exercise described above using the spreadsheet presented earlier in Table 6.1.

Note that it was possible in all cases to reduce delivery rates to the target level without exceeding the level of risk that the cooperator was willing to accept in applying unfamiliar conservation techniques. From a planning standpoint, many landowners did, however, meet the targets set for their farms. Implementation of those plans was the next task.

6.4.3 Servicing and Implementing the Plan

In December 1988, "Letters of Agreement" were signed by cooperating farmers and the PWS to help clarify the responsibilities and commitment of both parties (see Section 5.0). This instrument was necessary to establish equipment use liability, other project liability and to establish the terms by which the project could pay cooperators for prescribed activities within the project. The signing of this document formally began implementation of the conservation farm plans (although updates to the plan continued on a regular basis). Following signing of the Letters of Agreement, conservation activities were certified on completion of spring and fall field operations and farm plan variances noted. Compensation payments could then follow. Provision was included to bring the letters of Agreement up to date as circumstances changed throughout the life of the project.

Ongoing cooperator/PWS field staff interaction allowed many opportunities to provide technical support in the planning and implementation of conservation practices. The use of backup scientific advisors insured that cooperator questions could be answered with the benefit of the most up-to-date research information. Structural measures were installed using the services of qualified erosion control contractors. Maintenance checks of the structural measures were carried out each spring by the watershed technicians and any necessary repairs were made. On-farm evaluation of tillage and crop management practices was encouraged and these were followed with interest by everyone. This cooperator support strategy gave each producer the opportunity to build on last year's experience and to do so

Table 6.3. Example Spreadsheet of GAMES Data Following The Conservation Planning Exercise

with a minimum of risk. The establishment of cooperator confidence in the project and its staff as a result of good technical information and support was the key factor in making the farm planning process productive, and ultimately, in the adoption of conservation measures.

6.5 The Planning Approach In Review

Using a conservation farm planning approach which considered both on-site (farm level) and off-site (watershed level) erosion and sedimentation impacts was a unique feature of the approach used in the PWS. In implementing such a novel approach weaknesses and strengths of the method used were more fully realized. Where possible, weaknesses in the techniques used were addressed as they became apparent while strengths were improved upon as experience in the planning procedure was gained.

6.5.1 Planning Level A - Background Analysis

Weaknesses

Weaknesses in the background analysis work in general centred around characteristics of the GAMES model and the selection of appropriate target erosion rates. They include the following:

1. GAMES, through its use of the USLE could model sheet and rill erosion losses only. Modelling gully erosion was not possible with GAMES. Neither was it capable of modelling erosion by tillage displacement of soil, which current research in Ontario has shown to be a significant factor in affecting soil productivity. (Lobb, David A., 1991).

2. As a result of using the USLE factors it was difficult to model subtle changes landowners made in cropping/management practices. For example, converting from a fall moldboard plough system to a full modified moldboard plough (cut-offs) system was a positive measure taken by cooperators increase soil residue cover, but it was difficult to model this change in residue simply through the C-Factor.

3. Only erosion and sedimentation components of the planning process were considered by the analysis model. The economic and other aspects were left to the planners to evaluate using other tools and/or their own experience.

4. Defining the target erosion and sediment delivery rates proved difficult.

The weakness of GAMES in not being able to model gully erosion and thus the effectiveness of structural measures was overcome somewhat by making crude assumptions in the effectiveness of a structure and adjusting sediment delivery pathways to reflect this assumption. For example, terraces which were designed to pond water were assumed to be 100 percent effective in settling out sediment. This was based on research in Iowa which found such basins to be more than 90 percent effective (Laflen, et al., 1972). On the other hand, catchbasins were assumed to have no settling affect and would actually improve delivery once the water entered the tile system. GAMES allowed only two choices, 100 percent effectiveness, or 0 percent effectiveness.

A series of tables were prepared for determining C factors for a variety of crops and residue levels to better model the small changes in residue level remaining on the fields following planting. The complete set of C factor tables used can be found in Appendix A. If residue levels were between the levels provided on the C factor sheets, an interpolated C factor was used.

To consider other factors such as economics in the conservation planning process, the approach relied on the experience of the cooperator and the PWS field staff.

Target erosion rates were better defined once the 1989 water quality data became available. The exercise of selecting appropriate targets for all watersheds illustrated the inappropriateness of a single *rule-of-thumb* target for erosion and sediment delivery in consideration of variety of landscapes in Ontario.

Strengths

Strengths in the background analysis included the following:

1. The GAMES analysis gave planners important background data with which to initiate farm planning discussions. Because of the capacity to model on a specific polygon basis, it was possible for planners to address erosion sensitive areas as well to plan on a field-by-field basis.

2. The Lotus spreadsheet derived from GAMES and FPM output allowed quick comparisons of alternative conservation solutions so that cooperators could test their preferences and more easily adjust the effect of practices, for example chisel points vs chisel sweeps could be compared by simply adjusting the residue levels which could be expected.

3. The GAMES analysis allowed users to test the effect field management decisions would have on water quality at the watershed outlet. The presentation of the data however remained at the field scale - the management unit.

4. The 1990 and 1991 Lotus spreadsheet approach provided an efficient means of recording conservation plans for the next crop year.

5. The approach used computer analysis tools but left it with the one-to-one contact between the cooperator and PWS field staff to make experienced decisions. This avoided cookbook solutions and encouraged innovation.

6.5.2 Planning Level B - Field Discussions

Weaknesses

The primary weakness at the field discussion level of planning was the sensitivity gap between knowing precisely what field situations were versus what was reported in the GAMES information. The field staff who were making recommendations to the farmer cooperator had been provided with a great deal of helpful information but lacked the familiarity and experience with the land that the cooperator possessed. It was therefore occasionally difficult to answer questions raised by cooperators and sometimes required time consuming (but necessary) additional site specific visits to the area (polygon) of concern.

Strengths

Field discussions in conservation farm planning are an obvious necessity. In this project they had some additional peripheral benefits as well:

1. They provided an opportunity for cooperators to raise, and often resolve, concerns about the use of new practices.
2. They provided an opportunity for PWS field staff to establish a common identity with cooperators in addressing the objectives of the project.
3. They provided an opportunity for cooperators to discuss or suggest ways to make the project more acceptable, a necessary first step if an effective plan was to follow, and an opportunity for cooperators to gain ownership in the project.

A copy of the GAMES software following modifications as well as the accompanying farm planning module (FPM) is provided in Appendix B.

7.0 INDICATORS OF ADOPTION

The adoption process involves a complex interrelationship between social, economic and physical (agronomic) factors. Within these disciplines a number of indicators of adoption may be used to assess the impact of the implementation phase of the PWS.

In the PWS the social indicators of adoption were monitored by documenting the attitudinal change experienced by the cooperators. The reader is referred to PWS Report: Evaluation of Conservation Systems: Cooperator Attitude Change for more information.

With regard to the short term economic indicators of adoption in the PWS, these were embodied in the planning and adoption decisions of the cooperators. The PWS included a benefits package in the program to offset real and perceived risks associated with the adoption of conservation practices. It was emphasized throughout the project however that the final decision regarding plans and actual implementation was the producer's. In this way the producer maintained control over his operation and could account for all influencing factors, including economic. It may be assumed that continued adoption of a given practice meant that in the short term the cooperator had not experienced a large enough negative impact, including economic, to cause him to change his mind about proceeding. It was also recognized and accepted by the cooperators that the real economic benefits of adopting conservation practices are generally realized over the long term. The above approach was taken because a full economic assessment of management decisions was not possible within the resources of the PWS.

With regard to physical indicators of change an obvious approach was to determine the annual change in area affected by conservation tillage and cropping practices and the change in incidence of conservation structures and special practices (buffers, critical areas seeded down to hay) during the lifetime of the project. Positive trends in the test watersheds when compared to the control watersheds should indicate actual adoption.

Of interest too was the difference between what cooperators planned to do with regard to continuing to use or adopting new conservation practices and what was actually implemented. A review of cooperator files indicated that changes in plans occurred for many reasons with weather and the related agricultural conditions generally having the most frequent impact. An understanding of the difference between identified, planned for and completed conservation actions is also a useful indicator of adoption since it helps to characterize the intentions of the cooperators during the planning phase.

An inventory of physical change does not however indicate how effectively the changes were implemented with resulting impacts on soil movement and water quality. The reader is referred to PWS Report: Evaluation of Conservation Systems - Water Quality for more information on these aspects of the study.

7.1 Cooperator Intentions

Table 7.1 documents the number of existing and new conservation actions (excluding structures) identified, planned for and completed on an annual basis during the PWS.

Across all test watersheds the number of potential conservation actions identified during the planning sessions each year ranged from 51 to 72 discrete actions. With fewer and larger fields and a cash crop system based on soybeans and winter wheat, Essex had on average fewer individual actions identified (55) during the initial conservation planning sessions. On the other hand the greater number of fields and variety of crop and livestock systems in the Kettle and Pittock test watersheds allowed for a greater number of individual actions to be identified in each (Kettle-64; Pittock-66).

Over the three years documented it is interesting to note that on average approximately half of the identified actions were planned for at the beginning of each crop year (August/September). On an annual basis the percentage of actions planned for increased over the three years but only in Kettle did this occur at a steady rate. The remaining identified actions were either rejected outright by cooperators or left for future consideration (undecided/incomplete). The high degree of uncertainty in making plans reflects mainly the impacts of weather and the effect this has on farming activities. Many producers were unwilling to make a commitment they were unsure of keeping.

This reality is borne out in the final number of conservation actions completed during each cropping year. Without exception across all years and watersheds the percentage completed was greater than what was planned for. Pittock had the widest range including a 27%

Table 7.1. A Comparison of Conservation Actions Identified, Planned For and Completed On An Annual* Basis by Test Cooperators, Pilot Watershed Study, SWEEP, 1988-1991

Watershed	Year	Conservation Actions				
		Identified (%)	Planned			Completed (%)
			Yes (%)	No (%)	Undecided/ Incomplete (%)	
Essex	88/89	100 (51)+	51	22	28	75 (51)++
	89/90	100 (58)	41	12	47	74 (53)
	90/91	100 (55)	55	27	18	82 (55)
	3 yr average	100 (55)	49	20	31	77 (53)
Kettle	88/89	100 (64)	33	9	58	70 (63)
	89/90	100 (61)	44	8	48	70 (58)
	90/91	100 (67)	54	33	13	90 (67)
	3 yr average	100 (64)	44	17	40	80 (63)
Pittock	88/89	100 (58)	48	31	21	90 (58)
	89/90	100 (72)	39	28	33	93 (72)
	90/91	100 (67)	66	30	4	84 (67)
	3 yr average	100 (66)	51	30	19	89 (66)

* Conservation structures not included.

( ) + indicates the actual number of potential conservation actions identified during initial farm planning sessions each year (percentage calculations for "Identified" and "Planned" columns are based on these numbers).

( ) ++ indicates the number of potential conservation actions that remained viable options by the end of each year (percentage calculations for "Completed" column are based on these numbers).

increase in 1990/91 and a 138% increase in 1989/90. Essex and Kettle watersheds experienced increases from 47% to 80% and 59% to 112% respectively.

With the exception of Pittock the trend toward completing identified conservation actions appears to increase in a positive direction.

The above observations suggest that future program planners may anticipate an increase in actual adoption when compared with initial indications obtained through the planning process. This finding is interesting since it had been anticipated that plans would have to reflect more than what was necessary to implement to ensure adequate adoption occurred on an annual basis to meet project objectives.

7.2 Change in Management Practices

7.2.1 Primary Tillage

Tables 7.2 to 7.4 indicate the annual change in area and type of primary tillage per watershed. Within the PWS several tillage systems were recognized as having conservation benefits (see Section 4.0) and cooperators in the test watersheds were encouraged to adopt them.

In Essex there was a definite general shift during the project toward the use of conservation tillage systems. Most dramatic was the shift from moldboard ploughing to no-till. In 1989 approximately 54% of the reported area (362 ha) was ploughed and 2% of the area was no-tilled. By 1992 the moldboard plough was not used on any of the area reporting (369 ha) while no-till was practiced on 43% of the same area. In contrast in the control watershed use of the moldboard plough remained relatively high ranging from 71% of the area reporting in 1989 to 50% of the area reporting in 1992.

Similar trends occurred in the Kettle test watershed. By 1992 the moldboard plough was used on approximately 7% of the area reporting (317 ha) in contrast to 1989 when 54% of the area reporting (329 ha) was ploughed. Most of the shift in tillage system acreages went into no-till which by 1992 was practiced on 52% of the area reporting in contrast to the 3%

Table 7.2. Annual Change In Primary Tillage, Essex, Pilot Watershed Study, SWEEP, 1988-1992

	Essex Watershed							
Primary Tillage System	Test				Control			
	1989	1990	1991	1992	1989	1990	1991	1992
	(%)*				(%)			
Moldboard Plough	34	20	5	-	71	81	62	50
Adjusted + Modified Moldboard Plough	20	27	24	-	-	-	-	-
Chisel Plough**	12	22	20	16	3	2	-	2
Cultivator	11	13	6	22	-	15	14	29
Disc	8	5	6	9	24	-	-	10
No Fall Tillage	8	11	28	9	-	1	23	9
No-till	2	-	10	43	-	-	-	-
Hay/Pasture (No Tillage)	5	2	1	1	2	1	1	-

† Primary tillage operations completed in the fall prior to the year stated i.e. primary tillage for the 1989 data completed in fall of 1988.

* Values are a percent of total area reported each year.

Essex Area Reported (ha):	1989	1990	1991	1992
Test	362	386	382	369
Control	206	263	243	265

** Includes disc-or coulter-chisel plough with sweeps or twisted shovels.

Table 7.3. Annual Change Primary Tillage Systems, Kettle, Pilot Watershed Study, SWEEP 1988-92

	Kettle Watershed							
Primary Tillage System†	Test				Control			
	1989	1990	1991	1992	1989	1990	1991	1992
	(%)*				(%)			
Moldboard Plough	37	35	12	2	29	67	42	65
Adjusted + Modified Moldboard Plough	17	13	5	5	5	4	6	5
Chisel Plough**	15	20	31	19	12	9	5	7
Cultivator	4	-	-	3	26	-	3	8
Disc	5	3	3	-	-	-	4	6
No Fall Tillage	9	8	8	11	12	1	26	6
No-till	3	17	36	52	-	2	2	1
Hay/Pasture (No Tillage)	10	4	5	8	16	17	12	2

† Primary tillage operations completed in the fall prior to the year stated i.e. primary tillage for the 1989 data completed in fall of 1988.

* Values are a percent of total area reported each year.

Kettle Area Reported (ha):	1989	1990	1991	1992
Test	329	326	335	317
Control	356	356	348	338

** Includes disc- or coulter- chisel plough with sweeps or twisted shovels.

Table 7.4. Annual Change In Area Per Pittock, Primary Tillage System, Pilot Watershed Study, SWEEP, 1988-92

Primary Tillage System†	Pittock Watershed							
	Test				Control			
	1989	1990	1991	1992	1989	1990	1991	1992
	(%)*				(%)			
Moldboard Plough	25	9	22	7	28	43	42	52
Adjusted + Modified Moldboard Plough	43	29	23	22	5	4	-	2
Chisel Plough**	8	12	3	22	-	2	-	7
Cultivator	-	2	-	-	-	2	-	-
Disc	-	1	4	-	-	-	4	-
No Fall Tillage	6	20	27	27	52	39	49	33
No-till	-	1	6	10	-	-	-	-
Hay/Pasture (No tillage)	17	17	15	12	15	10	5	6
Other‡	-	9	-	-	-	-	-	-

† Primary tillage operations completed in the fall prior to the year stated i.e. primary tillage for the 1989 data completed in fall of 1988.

* Values are a percent of total area reported each year.

Pittock Area Reported (ha):	1989	1990	1991	1992
Test	306	311	310	310
Control	266	313	324	318

** Includes disc- or coulter- chisel plough with sweeps or twisted shovels.

‡ Includes paratill plough.

documented in 1989. In the control watershed the moldboard plough continued throughout the PWS to be the main tillage implement of choice.

In the Pittock watershed the nature of the adoption trends for conservation tillage systems are less clear. While the moldboard plough acreage declined from 68 to 29% of the area reporting between 1989 and 1992 concurrent changes in other tillage system acreages (chisel plough, no fall tillage, no-till) may be due in part to the normal crop rotation management practices used in this livestock and cash crop based watershed. While the magnitude of real change is unknown there is little doubt that a positive shift occurred in the adoption of conservation tillage systems. In the control watershed use of the moldboard plough and no fall tillage remained high throughout the project.

7.2.2 Crop Type

When discussing the merits of various conservation tillage and cropping systems it was emphasized that crop rotation with a frequent mix of cereal and hay crops was the best method for controlling soil erosion. However it was understood from the outset of the discussions with cooperators that the PWS was too short in duration to include dramatic shifts in crop type and rotation as a viable option for controlling soil movement. Instead cooperators were encouraged to grow the crops required to support their operation but if possible to consider rotating more cereals and hay crops into those fields within the watershed in order to assist in achieving PWS objectives.

Tables 7.5 to 7.7 indicate the annual change in area and type of crop for each watershed. While PWS staff experience indicates that some accommodation of project needs was made by individual farmers this did not show up as a clear trend within or between any of the test or control watersheds.

7.2.3 Buffers, Critical Areas and Structures

During the early assessments of the test watersheds the need for grass/legume buffers areas along water courses, seeding down hay in larger critical areas with a high sediment delivery potential and adjacent to water courses and conservation structures was determined (see Section 6.0). These measures were aimed mainly at controlling sediment delivery and improving water quality on a point source basis within the test watersheds.

Table 7.8 indicates the incidence and area affected by buffer strips and critical areas and Table 7.9 lists the type and number of conservation structures proposed and implemented in the test watersheds. In most cases the PWS acted as the catalyst and/or means by which cooperators were able to implement the above conservation practices. The continued

Table 7.5. Annual Change In Crop Acreage, Essex, Pilot Watershed Study SWEEP, 1988-92

	Essex Watershed							
Crop Type	Test				Control			
	1989	1990	1991	1992	1989	1990	1991	1992
	(%)*				(%)			
Corn and Sunflower**	16	13	22	9	26	20	33	65
Beans and Peas†	58	70	73	72	49	54	59	10
Winter Wheat	16	13	3	18	22	25	7	21
Spring Cereals‡	5	-	-	-	2	-	-	-
Hay	5	4	1	1	1	1	1	-
Fallow	-	-	1	-	-	-	-	4

* Values are a percent of total area reported each year.

Essex Area Reported (ha):	1989	1990	1991	1992
Test	362	386	382	363
Control	263	263	263	170

** Includes field and sweet corn.

† Includes soya, white, natto, cranberry, snap and brown beans.

‡ Includes oats, barley and mixed grain.

Table 7.6. Annual Change In Crop Acreage, Kettle, Pilot Watershed Study SWEEP, 1988-92

	Kettle Watershed							
Crop Type	Test				Control			
	1989	1990	1991	1992	1989	1990	1991	1992
	(%)*				(%)			
Silage Corn	-	-	-	-	2	2	-	6
Corn and Sunflower**	43	37	44	40	29	42	65	25
Beans and Peas†	31	36	27	35	28	26	16	40
Winter Wheat	8	16	20	16	24	11	3	17
Spring Cereals‡	6	4	3	3	3	2	2	5
Hay	7	2	1	2	7	10	6	-
Pasture	3	3	3	4	7	7	8	7
Fallow	2	2	2	-	-	-	-	-

* Values are a percent of total area reported each year.

Kettle Area Reported (ha):	1989	1990	1991	1992
Test	338	332	334	304
Control	356	356	348	311

** Includes field and sweet corn.

† Includes soya, white, natto, cranberry, snap and brown beans.

‡ Includes oats, barley and mixed grain.

Table 7.7. Annual Change In Crop Acreage, Pittock, Pilot Watershed Study, SWEEP, 1988-92

	Pittock Watershed							
Crop Type	Test				Control			
	1989	1990	1991	1992	1989	1990	1991	1992
	(%)*				(%)			
Silage Corn	5	1	1	-	2	12	1	-
Corn and Sunflower**	26	44	55	51	58	42	61	70
Beans and Peas†	25	19	16	19	13	21	11	-
Winter Wheat	7	11	2	11	-	9	8	3
Spring Cereals‡	22	5	8	3	4	7	9	10
Hay	15	17	16	10	23	10	10	15
Pasture	1	2	2	3	-	-	-	-
Research Plots	-	2	-	3	-	-	-	2

* Values are a percent of total area reported each year.

Pittock Area Reported (ha):	1989	1990	1991	1992
Test	346	309	294	274
Control	300	313	322	308

** Includes field and sweet corn.

† Includes soya, white, natto, cranberry, snap and brown beans.

‡ Includes oats, barley and mixed grain.

Table 7.8. Incidence and Areas Affected by Buffer Strips and Critical Areas Seeded Down to Hay in the Test Watersheds, Pilot Watershed Study, SWEEP, 1988-92

	Essex			Kettle			Pittock		
Conservation Practice	Number	Yrs in Existence *	Area (ha)	Number	Yrs in Existence	Area (ha)	Number	Yrs in Existence	Area (ha)
Buffer Strip (grass/legume)	2	1990-92 1988-92	0.4 1.0	1	1990-92	0.4	1	1988-92	0.8
Critical Area Seeded to Hay	0			1	1988-92	3.6	3	1989-92 1989-92 1990-92	1.2 2.0 2.1

* Post project status unknown

Table 7.9. Type and Incidence of Conservation Structures In The Test Watersheds, Pilot Watershed Study, SWEEP, 1988-92

Structure Type	Essex				Kettle				Pittock			
	# Proposed	# Installed			# Proposed	# Installed			# Proposed	# Installed		
		1989	1990	1991		1989	1990	1991		1989	1990	1991
Tile Outlet Protection/Repair	10	1	1		2	2			2	2		
Rock Chute	15	5	2		15	5			7	4		
Catch Basin Improvement					1	3			2		1	
Channel Terrace					14	11		1	2			
Diversion Waterway/Buffer	8	1			1							
Grassed Waterway					1	1			2	1*		
Ditch Bank Repair					1			1				
Buffer Area					1		1		2	2		
Low Level Crossing												

* One grass strip installed was initially undertaken entirely on landowner's initiative. However it was removed in 1990 and had to be reinstalled with use of program incentives in 1990 because of its significance as a strategic erosion control measure for the watershed.

presence of these control practices to the end of the project and beyond (especially with regard to the structures) serves as a useful indicator of adoption. Figures 7.1 to 7.3 show where in each of the test watersheds, the various structural erosion control measures implemented during the course of the project were installed.

In general those buffers and critical areas considered important to achieving PWS objectives were implemented by cooperators. The list of proposed structures included all those cases where a structure could be installed, whether it was important to project objectives or not. The prioritization of the structures for project purposes meant that cooperators were more likely to install high priority structures first. The greatest adoption in this regard was achieved in the Kettle watershed, with Essex and Pittock cooperators where the visual impact of the problems was less striking, implementing less than half of the structures suggested.

Figure 7.1. Structural Measures Implemented in the Essex Test Watershed

Figure 7.2. Structural Measures Implemented in the Kettle Test Watershed

Figure 7.3. Structural Measures Implemented in the Pittock Test Watershed

8.0 CONCLUSIONS AND RECOMMENDATIONS

Conclusions:

- The approach and process used during the implementation phase of the PWS was appropriate. Results indicate that study objectives were met.

- See specific conclusions for each section.

Recommendations:

- Future proactive and targeted programs should incorporate all of the elements of the incentive package described herein.

- Future proactive and targeted programs should ensure that staff working directly with producers are knowledgeable and experienced in the adoption of conservation farming systems.

- See specific recommendations for each section.

9.0 REFERENCES

Cook, D.J., N.T. Dickinson and R.P. Rudra. 1985. GAMES The Guelph model for evaluating effects of Agricultural Management systems on Erosion and Sedimentation - User's Manual Technical Report 126-71. University of Guelph School of Engineering, Guelph

Laflen, J.M., H.P. Johnson and R.C. Reeve, 1972. Soil Loss for Tile-Outlet Terraces. Journal of Soil and Water Conservation. Vol. 27:74-77.

Lobb, David A., 1991. Tillage Translocation and Tillage Erosion. Department of Land Resource Science, University of Guelph, Guelph.

Ecological Services for Planning. 1990. "Soil Survey of the Pilot Watersheds - southern Ontario Soil and Water Environmental Enhancement Program". Agriculture Canada.

Wischmeier, W.H. and D.D. Smith. 1978. Predicting Rainfall Erosion Losses: A Guide to Conservation Planning. Agr. Hdbk. No. 537. Sci. Education Admin., U.S. Dept. Agr., Wash., D.C.

APPENDIX A

C-Factors and Mannings "n" Values Used for PWS Conservation Plan Modelling

C-FACTORS FOR GRAIN CORN

Condition: Residue removed 1/ OR reduced 2/ in the fall after harvest

Crop Sequence	Conventional Tillage		Reduced Tillage
Corn for grain	Spring Plow 3/	Fall Plow	Percent Cover 10 30 50 70
After Hay			
1st Year	.17	.21	.19 .11 .09 .07
2nd Year	.31	.40	.33 .21 .16 .12
3rd Year or more (Continuous corn)	.34	.41	.36 .23 .17 .12
After small grain	.35	.41	.37 .23 .17 .12
After soybeans	.41	.42	.41 .34 * *
After vegetables	.42	.45	.42 .34 * *
After sweet corn	.36	.42	.36 .23 .17 .12

* ! Condition does not exist in the field
1/ ! Residue removed by baling or chopping stover for bedding
2/ ! Residue reduced by fall tillage
3/ ! If cover crop follows removing stover, use "Spring Conventional Tillage - with Cover Crop" from page 1.

C-FACTORS FOR GRAIN CORN

Condition: Crop residue left on the soil surface; spring tillage

Crop Sequence	Conventional Tillage (spring plow and disk)		Reduced Tillage Spring Chisel or Disk								No-Till		
Corn for grain	No Cover Crop	With Cover Crop	No Cover Crop Percent Cover				With Cover Crop Percent Cover				Percent Cover		
			10	30	50	70	10	30	50	70	30	50	70
After Hay													
1st year	0.17	0.15	0.15	0.10	0.07	0.05	0.12	0.09	0.06	0.04	0.01	0.01	0.01
2nd year	0.30	0.27	0.27	0.17	0.12	0.08	0.24	0.15	0.10	0.07	0.11	0.08	0.05
3rd year or more (continuous)	0.34	0.30	0.30	0.20	0.13	0.09	0.26	0.16	0.10	0.07	0.14	0.09	0.06
After Small Grain 1/	0.30	0.29	0.29 3/	0.24 3/	0.17 3/	0.09 3/	0.27 3/	0.18 3/	0.15 3/	0.07 3/	.20 3/	.14 3/	0.09 3/
After Small Grain 2/	0.36	0.32											
After Soybeans	0.41	0.39	0.38	0.33	0.22 4/	0.12 4/	0.36	0.29	0.18 4/	0.08 4/	0.22	0.14	0.09
After Vegetables	0.42	0.38	0.37	0.34	0.23 4/	0.13 4/	0.34	0.30	0.19 4/	0.09 4/	0.22	0.14	0.09
After Sweet Corn	0.36	0.31	0.32	0.20	0.13	0.09	0.30	0.17	0.10	0.07	0.14	0.09	0.06

1/ Straw not removed
2/ Straw removed - stubble remaining
3/ Only one value - use appropriate percent cover if straw is left on the field or removed
4/ Value to be used only where mulch or manure has been added to obtain percent cover

C - FACTORS FOR SWEET CORN

Crop Sequence	Conventional Tillage			Reduced Tillage				No-Till					
	Spring Plow		Fall Plow	Spring Chisel/Disc (Assumes 30% Residue)		Fall Chisel/Disc		w/o CCR			w/CCR		
								% Cover			% Cover		
	w/o CCR*	w/CCR**	w/o CCR	w/o CCR	w/C Cr	w/o CCR	w/C CR	30	50	70	30	50	70
After Sod 1st Year	0.23	0.18	0.28	0.11	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.1
2nd Year	0.40	0.30	0.47	0.21	0.18	0.21	0.21	0.21	0.14	0.07	0.11	0.08	0.05
3rd Year 1/ (Continuous Corn)	0.42	0.32	0.51	0.27	0.21	0.21	0.21	0.23	0.17	0.08	0.16	0.14	0.08
After Small Grains	0.40	0.30	0.47	0.22	0.19	0.22	0.22	0.21	0.14	0.07	0.11	0.08	0.05
After Soybeans	0.45	0.39	0.53	0.41	0.27	0.41	0.28	0.30	0.30	0.30	0.25	0.25	0.25

* w/o CCR = without cover crop
** w/CCR = with cover crop
1/ Use this line for sweet corn following grain, silage or sweet corn. Use appropriate percent cover if no-till is used.

C-FACTORS FOR CORN-RIDGED

Condition: Grain or silage corn, ridged

Crop Sequence	Grain Corn	Silage
1st year after meadow; Spring plow, June ridged Fall plow, June ridged	0.13 0.18	0.20 0.27
2nd year after meadow; Ridges maintained	0.07	0.20
3rd year or more (Continuous corn); Ridges maintained	0.08	0.23

C-FACTORS FOR PEAS (SWEET GARDEN)

Crop Sequence	1st Year	2nd Year	3rd Year or More Years
Conventional Tillage			
After sod - 50% residue	0.19	0.30	0.33
After sod - 20% residue	0.35	0.55	0.61
After silage corn grain corn	0.61 0.33	0.61 0.33	0.61 0.33
After sod, followed by no-till forage seedings	0.14	0.26	0.31
No-Tillage			
No-till into killed rye cover crop <u>or</u> small grain stubble	0.09	0.09	0.09

C-FACTORS FOR SOYBEANS AND DRYBEANS

Condition: 1. Beans planted in the spring, May-June

Crop Sequence	Conventional Tillage			Reduced Tillage				No - Till		
BEANS	Spring Plow		Fall Plow	Spring or Fall				Spring		
	w/o CCr1/	w/ CCr2/		Percent Cover 10	30	50	70	Percent Cover 30	50	70
After corn	0.29**	0.24	0.52	0.44	0.25	0.15	0.07	0.23	0.12	0.05
After small grain	0.29**	0.24	0.52	0.44	0.25	0.15	0.07	0.23	0.12	0.05
After vegetables	0.34**	0.29	0.54	0.55	0.25	0.20	0.10*	0.23	0.15*	0.09*
After beans	0.36**	0.31	0.58	0.55	0.25	0.20*	0.10*	0.23	0.19*	0.09*
After sod			0.24							

* = Use only when mulch or cover crop residue remains on soil surface.
1/ W/o CCr = Without cover crop.
2/ W CCr = With cover crop.
** = Would want to double check these values

C-FACTORS FOR SMALL GRAIN

Condition: Spring seeded small grains.

Crop Sequence	Conventional Tillage		Reduced Tillage			No-Till	
	Spring Plow	Fall Plow	Percent Cover 30 1/	50	70	Percent Cover >50 2/	>50
Years after meadow							
1 year	0.08	0.10	0.12	0.10	0.08	0.01	0.10
2 year	0.17	0.24	0.14	0.12	0.09	0.03	0.12
3 year	0.19	0.29	0.18	0.14	0.10	0.05	0.14
After small grain	0.22	0.33	0.18	0.14	0.08	0.05	0.14
After corn silage or grain	0.22	0.33	0.18	0.13	0.10	0.05	0.13
After soybean	0.37	0.44	0.23	0.18	0.17	0.15	0.18
After vegetables	0.37	0.44	0.23	0.18	0.17	0.15	0.18

1/ If less than 30% cover exists after tillage, use spring plow column.
2/ If percent cover is less than 50%, use values in Reduced Tillage - 50% column.

C - FACTORS FOR SMALL GRAIN

Condition: Fall seeded small grains - winter wheat, barley, rye.

Crop Sequence	Conventional Tillage (Fall Plow) >30% cover	Conventional Tillage (Fall Plow) <30% cover	Reduced Tillage (Fall)		No-Till (Fall)	
After Small Grain	0.13 1/	0.30 2/	0.18 3/	0.25 4/	0.10 3/	0.15 4/
After corn	0.13 1/	0.27 2/	0.18 3/	0.25 4/	0.10 3/	0.24 4/
After vegetables	0.23 1/	0.32 2/	0.25	0.25	0.19	0.19
After soybeans	0.23 1/	0.32 2/	0.25	0.19	0.19	0.19
After hay						
1st year	0.11 1/	0.14 2/	0.12	0.12	0.01 (90% cover)	0.01
2nd year	0.16 1/	0.17 2/	0.10	0.10	0.05	0.05
3rd year or more	0.24 1/	0.30 2/	0.15	0.15	0.08	0.08

1/ = Fall plow to establish small grain; small grain straw removed after grain harvest; stubble remains until next crop year. (Approximately 18 months without tillage.)

2/ = Fall plow to establish small grain; fall ploughed after grain harvest.

3/ = Straw or corn stover from previous crop not removed. (Minimum of 30% cover.)

4/ = Straw or corn stover from previous crop removed. (Less than 30% cover.)

C - FACTORS FOR FORAGE SEEDINGS

Condition: 1. Spring seeding of legumes, grasses or grass-legume mixtures with a companion crop (therefore, actually mix grain underseeded as an example).

2. Established hay values.

Crop Sequence	Conventional Tillage		Reduced Tillage		No-Till	
Forage Seeding	Spring	Fall	Percent Cover 30% or Less	>30%	Percent Cover ≤30%	>30%
After Sod	0.08	0.10	0.08	0.03	0.04	0.01
After Corn						
Grain	0.13	0.17	0.10	0.06	0.05	0.05
Silage	0.19	0.21	0.14	N/A	0.09	0.05
After Small Grain	0.13	0.17	0.10	0.06	0.09	0.05
After Vegetables	0.37	0.43	0.2	N/A	0.2	N/A
After Soybeans	0.37	0.43	0.2	N/A	0.2	N/A

N/A = Not Applicable

Established Hay

1. Grass/Legume

Yield = 3-5 T/ac C-Factor = 0.007
2-3 T/ac C-Factor = 0.01 } Average = 0.02
1-2 T/ac C-Factor = 0.02

2. Legume Only

Yield = 3-5 T/ac C-Factor = 0.012
2-3 T/ac C-Factor = 0.02 } Average = 0.02
1-2 T/ac C-Factor = 0.02

C-FACTORS FOR FORAGE SEEDINGS

Condition: August seeding of legumes, grasses or grass-legume mixtures without a companion crop.

Crop Sequence	Conventional Tillage	Reduced Tillage			No- Till		
Forage Seeding	Plow - Disk	Percent Cover			Percent Cover		
		30[1]	50	70	30	50	90
After sod	0.19	0.19	0.19	0.19	0.03	0.02	0.004
After corn - Grain	0.25	0.12	0.06	0.05	0.12	0.06	0.004
Silage	0.30	0.12	0.06	0.05	0.12	0.12	0.12
After small grain	0.25	0.12	0.06	0.05	0.12	0.06	0.004
After vegetables	0.29	0.29	0.29	0.29	0.29	0.29	0.29
After soybeans	0.29	0.29	0.29	0.29	0.29	0.29	0.29

[1] If less than 30% cover remains after tillage, use Conventional Tillage - Plow - Disk column.

C-FACTORS FOR PERMANENT PASTURE & IDLE LAND

PASTURE & IDLE LAND CATEGORIES	C-FACTOR
1) Fallow (0 - 30% cover)	0.75
2) Fallow (30 - 70% cover)	0.50
3) Overgrazed	0.05
4) Good cover (75% or more)	0.005
5) Goldenrod/ mixed grasses/ shrubs/ trees	0.01
6) Good Pasture (many grasses)	0.02

MANNINGS "n" FACTORS USED FOR PWP MODELLING

CROP	PRIMARY TILLAGE PRACTICE			
	Fall Conventional Tillage and Modified and Adjusted Mouldboards	Reduce Tillage (e.g. Fall Chisel or Disk)	No-Tillage	Spring Conventional Tillage
DRYBEANS (whites, soys, kidneys)	0.014	0.021	0.013	0.01
PEAS	0.014	0.019	0.013	0.011
CORN (grain, silage, sweet)	0.014	0.021	0.027	0.028
WINTER CEREALS	0.014	0.029	0.030	--
SPRING CEREALS	0.024	0.030	0.034	0.026
HAY (ALFALFA)	0.046	--	--	--
PASTURE	Good 0.046 Fair 0.032	--	--	--
WINTER CEREAL (underseeded)	0.029			
SPRING CEREAL (Underseeded)	0.030	--	--	0.032
CORN (Underseeded)	0.021	--	--	0.030
BUSH	0.046	--	--	--
BUILT-UP	0.032	--	--	--
FALLOW	0.013	--	--	--

APPENDIX B

Modified GAMES Software and the Farm Planning Module (FPM)