AGRICULTURAL WATERSHED STUDIES

GREAT LAKES DRAINAGE BASIN

CANADA

SEMI-ANNUAL SUMMARY PROGRESS REPORT

1975-1976

CO-OPERATING AGENCIES

Agriculture Canada

Ontario Ministry of Agriculture & Food

Ontario Ministry of Environment

TASK GROUP C (CANADIAN SECTION) ACTIVITY 1

INTERNATIONAL REFERENCE GROUP ON GREAT

LAKES POLLUTION FROM LAND USE ACTIVITIES

October 1975

BACKGROUND

Article VI of the Great Lakes Water Quality Agreement, 1972, requested that the International Joint Commission inquire into and report on "pollution of the boundary waters of the Great Lakes System from agricultural, forestry and other land use activities, in accordance with the terms of reference attached to this agreement". The International Joint Commission (I.J.C.) established the International Reference Group on Great Lakes Pollution from Land Use Activities (PLUARG) to plan and implement the requested study.

In March, 1973, PLUARG submitted to the International Joint Commission a study plan to assess pollution of the Great Lakes from land use activities. This preliminary study plan outlined four main tasks including assessment of the problem (Task A), inventory of land use activities (Task B), watershed studies (Task C) and lake studies (Task D). A "Detailed Study Plan to Assess Great Lakes Pollution from and Use Activities" was prepared (February 1974) and formed the basis for the PLUARG study.

Task C was described as, "Intensive studies of a small number of representative watersheds, selected and conducted to permit some extrapolation of data to the entire Great Lakes Basin, and to relate contamination of water quality, which may be found at river mouths on the Great Lakes, to specific land uses and practices".

Activity 1 (Canada) of Task C called for "Pilot Agricultural Watershed Surveys". The objective of this activity was "to obtain data on the inputs of pollutants into the Great Lakes Drainage System which have their origins in the complex land use activities known as agriculture".

In February, 1974, the Agricultural Sub-Committee of the Task C Technical Committee, PLUARG, prepared a "Detailed Plan for the Study of Agricultural Watersheds in the Great Lakes Drainage Basin - Canada - 1974-1975". This plan called for a preliminary phase consisting of a monitoring programme and additional studies for collection of background data. The second and intensive phase would consist of detailed studies of pollutants associated with agricultural land use.

During the preliminary phase of the Task C Agricultural Watershed Study, 1974-75, it was concluded that a two-phase study (a monitoring phase and a detailed study phase) was required to meet the overall objectives of PLUARG. This would be followed by a third phase to consider future requirements.

The results of the preliminary phase of the Agricultural Watershed Study, including requirements and objectives identified for the second phase of the study, are reported in "Agricultural Watershed Studies - Great Lakes Drainage Basin - Canada - 1974-1975". This report also presents an outline of the projects included in the 1975-1976 Programme.

Reports are available from the I.J.C. Regional Office, 100 Ouellette Avenue, Windsor, Ontario. N9A 6T3.

INTRODUCTION

The 1975-1976 programme for the Agricultural Watershed Studies (Task C - Activity 1 (Canada), International Reference Group on Great Lakes Pollution from Land Use Activities (PLUARG) was described in the report "Agricultural Watershed Studies - Great Lakes Drainage Basin - Canada, Annual Report 19741975, April 1975". This programme consists of a two-phase study (a monitoring phase and a detailed study phase), and was developed to meet the following objectives:

Phase I (Monitoring Programme):
To measure the ambient concentration and loading rates for various potential pollutants that occur with agricultural land use.

Phase II (Detailed Studies Programme):

1) To determine the effects of the soil, land use and associated practices on ambient concentrations and loading rates of selected pollutants from agriculture.

2) To derive information on the mechanics of transport and storage of these pollutants within the selected agricultural watersheds.

3) To develop relationships so that the information derived can be utilized in a predictive sense and extrapolated to other areas.

Phase III (Future Requirements)
To develop remedial measures where significant problems are identified.

Eleven agricultural watersheds were selected for inclusion in the monitoring programme, and six of these were identified as sites for the detailed studies. (Table I-1 and Map I-1). The 1975-1976 programme was initiated April 1, 1975, and consists of twenty-two individual projects (Figure I-1).

A Semi-Annual Progress Report and an Annual (Final) Report, including a summary report, are required by Task C, PLUARG. Due to the fact that most projects within the Agricultural Watershed Studies were not initiated until April 1975, the 1975 Semi-Annual Progress Reports were to emphasize field problems and progress. Sufficient information to allow preparation of a Detailed Study Plan was to be included. The summary report was to provide a brief statement of progress. Although future summary reports will include data analysis and findings, these were not generally included in the 1975 Semi-Annual Summary Progress Reports except for those studies initiated prior to April 1975.

The Semi-Annual Summary Reports for the individual projects within the Agricultural Watershed Studies are contained in this report. Modifications have been made in some reports and summaries prepared of other reports to provide uniformity throughout the report.

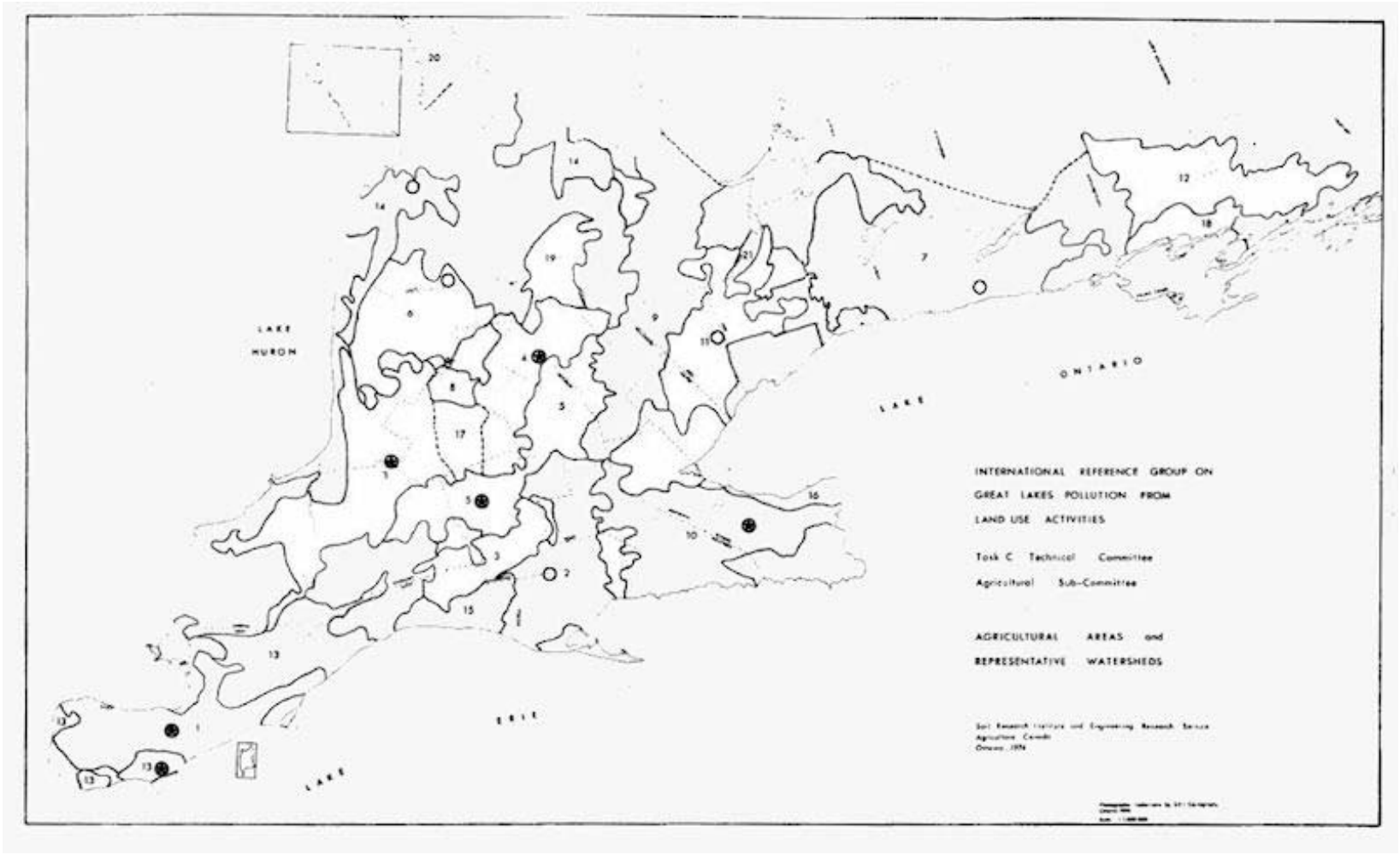
Table I-1. A. AGRICULTURAL WATERSHEDS - PHASE 1 (MONITORING PROGRAMME)

(For locations, see Map I-1)

AG- 1	Big Creek Tributary of the Thames River (Essex County)
AG- 2	Venison Creek tributary of Big Creek (Norfolk County)
AG- 3	Upper Little Ausable River (Huron County)
AG- 4	Upper Canagagigue Creek (Wellington and Peel Counties)
AG- 5	Holiday Creek tributary of the Middle Thames River (Oxford County)
AG- 6	Unnamed tributary of the Maitland River (Huron & Wellington Counties)
AG- 7	Shelter Valley Creek (Northumberland County)
AG-10	North Creek Branch of Twenty-Mile Creek (Lincoln County)
AG-11	Salt Creek tributary of the West Humber River (Peel County)
AG-13	West Branch of Hillman Creek (Essex County)
AG-14	Upper Mill Creek, tributary of the Saugeen River (Bruce County)

B. AGRICULTURAL WATERSHEDS - PHASE II (DETAILED STUDIES)

AG- 1	Big Creek Tributary of the Thames River (Essex County)
AG- 3	Upper Little Ausable River (Huron County)
AG- 4	Upper Canagagigue Creek (Wellington & Peel Counties)
AG- 5	Holiday Creek tributary of the Middle Thames River (Oxford County)
AG-10	North Creek Branch of Twenty-Mile Creek (Lincoln County)
AG-13	West Branch of Hillman Creek (Essex County)



MAP I-1. AGRICULTURAL WATERSHEDS — TASK C (CANADIAN SECTION) — PLUARG

○ PHASE I Monitoring Study)
● PHASE II (Detailed Studios)

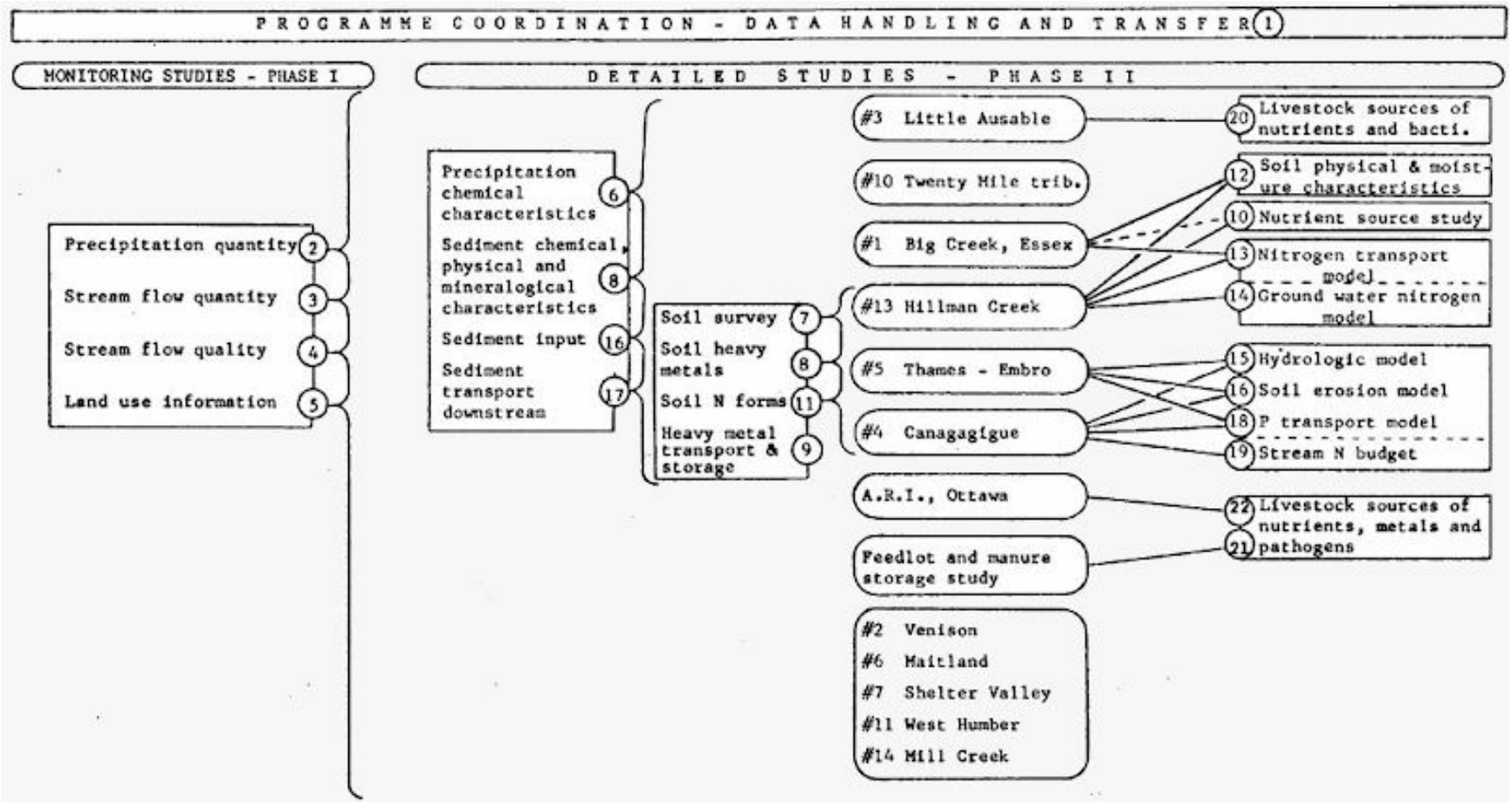


Figure I-1. INTERNATIONAL REFERENCE GROUP ON GREAT LAKES POLLUTION FROM LAND USE ACTIVITIES, I.J.C., TASK C, CANADA, AGRICULTURE, 1975-76

OVERALL PROGRAMME:

PROJECT 1

CO-ORDINATION; DATA HANDLING AND TRANSFER

Project Leaders: D.R. Coote, under contract to
Engineering Research Service,
Agriculture Canada, Ottawa, Ontario.

E.M. MacDonald, Soil Research Institute,
Agriculture Canada, Ottawa, Ontario.

Associate: R. Leuty

Objectives and Approach:

The programme this year consists of four main areas:

1) Coordination of the 20 Agricultural Watershed Study projects, as outlined in the "Proposed Programme - 1975-76";
2) Centralizing, storing, and releasing to Programme Participants data from the monitoring part of the Agricultural Watershed Study, and from the Detailed Studies;
3) Quality Control;
4) Preparation of Reports.

Progress:

1. Coordination: This aspect of the study has involved meetings with project leaders; relaying information requests; assisting with the selection of monitoring sites; assisting with the land use study; and the collection, review and assembling of progress reports. Information regarding the Agricultural Watershed Studies has been relayed to the Task C Sub-Group as required and to the administrative personnel responsible for the study.

2. Data Handling and Storage: To date, arrangements have been made with NAQUADAT (National Water Quality Data Bank) of the Department of the Environment, for the confidential storage of all Agricultural Watershed Study Data, including the monitoring data from the mouths of the 11 small agricultural watersheds. The monitoring data is expected to be up to date shortly. All pesticide data is up to date. Within the next few weeks, most of the Agricultural Watershed Study Project Leaders will be contacted to submit data for storage.

3. Quality Control: Assistance has been provided with the establishment and implementation of a quality control programme which will evaluate and ultimately assure compatibility of data from a large number of sources and collected by a variety of techniques and methods.

4. Preparation of Reports: Completion of the Annual Report for Agricultural Watershed Studies (1974-75) was accomplished at the beginning of the period covered by this report. A summary of the data collected in the preliminary phase of the study (1974-75) was also compiled.

MONITORING PROGRAMME:

PROJECT 2

STREAM FLOW QUANTITY

Project Leaders: R.C. Hore, R.C. Ostry,
Water Resources Branch,
Ontario Ministry of the Environment,
135 St.Clair Street West,
Toronto, Ontario.

Associates: D. Onn

Objectives and Approach:

The primary objective is the selection and instrumentation of sites, and collection of water quantity data at the outflow points for the selected agricultural watersheds.

Progress:

Streamflow gauging stations were established at the outlets of Watersheds AG-1, 3, 5, 10 and 13 in 1974. Watersheds AG-2, 4 and 7 had existing gauges operated by the Canada Water Survey. The installation of gauging stations at the remaining three sites (AG-6, 11 and 14) was completed in the early summer of 1975.

Each new site was selected from possible alternatives which met land use and soil criteria established by the Agricultural Sub-Committee (Task C Technical Committee). Sites were selected which were suitable for gauging without artificial stream section stabilization. Each site has been equipped with a Stephen's A-71 water level recorder, heated stilling well and intake and a shelter. Rating curves are being constructed from periodic metering.

PHASE I - MONITORING PROGRAMME

PROJECT 3

STREAM FLOW QUALITY - (A) ROUTINE WATER AND SEDIMENT QUALITY

Project Leader: R.C. Hore, Water Resources Branch,
Ontario Ministry of the Environment,
135 St.Clair Avenue West,
Toronto, Ontario

Associates: R. Ostry, D. Onn, F. Dieken

Objectives and Approach:

The selection of sites, instrumentation and collection of water quality data at the outflow points from the selected agricultural watersheds.

Progress:

The sites for the sampling of stream water quality were selected from alternatives suggested by the Agricultural Sub-Committee (Task C Technical Committee, Canada). Many of these were the same sites which had been used in the Preliminary Phase studies; others required careful site selection to enable stream flow gauging to be established.

By the beginning of April, all sites were selected, and sampling started on an approximately twice per week basis. All of the sites were instrumented for stream flow gauging by mid-summer, and the six detailed study sites equipped with shelters and intake points designed for the installation of automatic samplers. The automatic samplers (C.A.E. Aircraft Ltd., Model 304PWS3) have now all been installed at these sites, and should be operational throughout the next spring runoff period.

Core parameter analyses are conducted on water samples from each sampling date. In addition, one complete runoff event was monitored intensively at the AG-4 site (Canagagigue Creek) on the night of September 11-12, 1975. This involved sampling throughout the event period at approximately hourly intervals.

Results of all analyses are stored in the M.O.E.-E.D.P. system and also forwarded to the Agricultural Watershed Study Coordinator for NAQUADAT storage, distribution to project participants and eventual interpretation.

MONITORING PROGRAMME:

PROJECT 4

STREAM FLOW QUALITY-(B) PESTICIDES

Project Leader: R. Frank,
Pesticide Residue Testing Laboratory
Ontario Ministry of Agriculture and Food
University of Guelph, Guelph, Ontario

Associates: H. Braun, G. Sirons, M. Holdrinet

Objectives and Approach:

The objective of this project is to scan selected samples from the monitoring programme for organochlorine and organophosphorus insecticides, phenoxy and triazine herbicides, and other organo-pollutants.

Progress:

Between February and July, 232 samples were analyzed for DDT type insecticides, cyclodienes, organophosphorus insecticides and organo pollutants representing 928 analyses; 272 samples were analyzed for chlorophenoxy and chlorobenzoic herbicides; and 255 samples were analyzed for triazines. This represents a total of 749 samples and 1,445 analyses.

The results from these analyses have been summarized. (Table 4.1).

TABLE 4-1. SUMMARY

	Pesticide Presence		Pesticide per Watershed	
Pesticide	Total Waters (%)	Watersheds (#)	Range of Mean Residues (ppb)	Highest Residue (ppb)
DDE (211)	91.0	11	0.003 - 0.023	0.520
TDE (33)	14.2	9	ND - 0.002	0.035
DDT (28)	12.0	8	ND - 0.019	0.129
Σ DDT	91.0	11	0.003 - 0.031	0.218
Dieldrin (40)	17.2	8	ND - 0.01	0.12
Endosulfan (33)	14.2	8	ND - 0.011	0.052
Heptachlor epoxide (5)	2.2	2	ND - 0.015	0.37
Chlorpyriphos (1)	0.4	1	ND - 0.007	0.15
Diazinon (10)	4.3	2	ND - 2.04	48.0
Ethion (2)	0.9	2	ND - 0.001	0.042
PCB	100	11	0.05 - 0.08	0.30
2,4-D (33)	12.6	9	ND - 9.0	320.
2,4,5-T (10)	3.8	3	ND - 0.2	1.1
MCPA (4)	1.5	4	ND - <0.1	0.5
Dicamba (1)	0.4	1	ND - Tr	Tr
PCP (11)	4.2	3	ND - <0.1	2.7
Atrazine (222)	87.1	11	Tr - 3.8	41.1
Simazine (34)	13.3	8	ND - <0.1	0.1
Metribuzin (7)	2.3	3	ND - <0.1	1.
Cyanazine (1)	0.4	1	ND - 0.6	18.
Alachlor (1)	0.4	1	ND - 0.3	9.

MONITORING PROGRAMME

PROJECT 5

LAND USE INFORMATION

Project Leader:	R. Frank, Pesticide Residue Testing Laboratory Ontario Ministry of Agriculture and Food University of Guelph, Guelph, Ontario
Associates:	Agricultural Representatives, Ontario Ministry of Agriculture and Food

Objectives and Approach:

The objective of this project is to collect detailed information on land use practices.

Progress:

A questionnaire of four pages was developed between May and July to collect information on cropping practices, fertilizer, manure, sludge and pesticide use, and numbers of livestock in the eleven agricultural watersheds. Aerial photographs were supplied to each county office to assist in the survey. Local knowledgeable persons were selected in each watershed to carry out the survey. Between August and October 1975 surveys will be undertaken. Agricultural representatives prepared lists of all owners of land in each of the watersheds.

A second questionnaire was prepared to determine the amount of land not used in commercial agriculture. Completed survey sheets should be received by November 1975.

PHASE I - MONITORING PROGRAMME

PROJECT 6A

PRECIPITATION QUANTITY

Project Leader: M. Sanderson, Department of Geography, University of Windsor, Windsor, Ontario

Associate: C.V. Ramasastry

Objectives and Approach:

The objectives of the study are to provide accurate hourly data of precipitation on the watersheds.

Since the PLUARG intensive measurements of precipitation and runoff probably will be carried out for two years only, it is necessary to determine how representative these two years are in the precipitation-runoff history of the area.

Since about 20% of the area of Southern Ontario does not have gauged runoff, and most measured runoff records are of relatively short duration, it is necessary to use climatic precipitation-runoff models to obtain information on the past frequency of runoff in the area.

Progress:

A graduate student at the University of Windsor, C.V. Ramasastry, has been working on climatic water balance models for Southern Ontario. He has used the Thornthwaite-Mather water balance model to estimate monthly and annual runoff, since it requires input data of monthly temperature and precipitation only. This model, as well as a modification especially for Southern Ontario, by D.W. Phillips, of the Atmospheric Environment Service, was tested for a 10-year period in the Duffin watershed, a well instrumented watershed east of Toronto. Correlations with measured monthly runoff were not found to be high with either model, but seasonal correlations using the Phillips modified model were good.

Mr. Sastry will probably complete the study by December, 1975. The Thornthwaite-Mather water balance model, modified by Phillips, will be used on the 30-year records of some 60 stations in Southern Ontario to obtain seasonal climatic values of runoff. Maps will be constructed of the frequency of various amounts of seasonal runoff. Seasonal runoff was found to have a normal distribution in Southern Ontario.

The measurement of precipitation on the 10 watersheds AG-1, 3, 4, 5, 6, 7, 10, 13 and 14 was begun in April and May, 1975. Because of the small size of the watersheds and the need for economy, it was decided that one recording gauge be installed as nearly as possible in the middle of each watershed. Obtaining a reliable observer was also an important consideration. Installation of all the gauges was completed by May 15, 1975.

The type of gauge chosen was the Belfort weighing type gauge. It has the advantage of recording both rain and snow with an accuracy of .5 mm. It requires no electricity, makes use of a clock mechanism, and is relatively inexpensive. The weighing mechanism was calibrated on installation. The observers' duties are to change the charts 3 times weekly and to send these to the University of Windsor. He also sees that the pen and clock mechanism are working properly and that the precipitation collector is emptied when necessary. Oil is added to the water surface in warm weather to prevent evaporation, and antifreeze during the cool season to prevent freezing. Clocks are operated on standard time throughout the year. There have been problems with some of the clocks, usually caused by overwinding, and these have been replaced. It has occasionally been necessary to estimate times of precipitation from nearby climatological stations. However, total amounts of precipitation are correct.

The charts are read at the University of Windsor and a computer program used to print hourly and daily values of precipitation (in mm). The first month of complete record was June. Monthly printouts are sent to some 12 PLUARG research groups.

PHASE II - DETAILED STUDIES

PROJECT 6B

PRECIPITATION CHEMICAL CHARACTERISTICS

Project Leader: M. Sanderson, Department of Geography, University of Windsor, Windsor, Ontario

Associates: R. Osborne, D. Smith

Objectives and Approach:

The objective of this project is to determine the types and amounts of dry and wet precipitation associated pollutants falling on the watersheds.

Progress:

In the six watersheds which are being studied intensively, AG-1, 3, 4, 5, 10 and 13, precipitation chemistry is examined. Bulk precipitation samplers, of a type originally obtained from the Canada Centre for Inland Waters, were built at the University of Windsor and installed in the six watersheds near the Belfort gauges, during the first two weeks in May, 1975. The collecting orifice of the gauge is 19 cm in diameter and the collecting bottle has a 3-litre capacity. The precipitation samples are collected at the end of each month. The amount of the sample collected, of course, varies with the amount of precipitation. Until the beginning of October, in only one case, AG-13 for September, was the sample size too small to permit all the tests.

Precipitation samples are analyzed for the following parameters:-total nitrogen, total phosphorus, calcium, magnesium, sodium, potassium, chloride, sulphate, sulphite, conductivity, suspended solids, and volatile suspended solids. Analytical methods are in accordance with the requirements for quality control determined by PLUARG.

Samples from all 6 installations for June, July and August were taken to Guelph for analysis by the Food Pesticide Residue Laboratory for the presence of pesticides and PCB's.

In order to obtain larger samples of the precipitation - (1) to permit samples to be sent to the Ontario Ministry of the Environment for analysis for the presence of heavy metals and (2) to obtain precipitation samples of individual storms, to test for the relative amounts of chemicals in wet and dry fallout, the collecting orifice of the gauges will be enlarged to approximately 30 cm diameter. The methodology for obtaining samples from individual storms will be tried first at the two Leamington stations.

PHASE II - DETAILED STUDIES

PROJECT 7

SOIL SURVEY

Project Leader: C.J. Acton,
Ontario Soil Survey Unit,
Agriculture Canada, Guelph, Ontario

Associate: G. Patterson

Objectives and Approach:

The objectives of the study are:

1) To provide a basic soils inventory for selected areas at a scale of 1:25,000;
2) To interpret the mapping units for pollutant transfer potential to surface water and groundwater. (See Agricultural Watershed Study Plan Canada 1974-75 pp 14-15);
3) To provide samples of major soil *series* for various PLUARG investigations.

Progress:

Six representative agricultural subwatersheds ranging in size from about 7 to 20 square miles have been selected for study in Southwestern Ontario. Two of these areas have been mapped to date (AG-4, Canagagigue; and AG-5, Holiday Creek) while a third (AG-13, Hillman Creek) is in progress. The remaining three (AG-1, Big Creek; AG-3, Little Ausable; and AG-10, North Branch of Twenty Mile Creek) will be covered in the 1976 mapping season.

For mapping purposes, landscape units are identified on air photos (1:15,840) and transferred to 1:25,000 NTS topographic sheets. Field work involves the identification of parent materials, profile development, drainage, slope, stoniness and erosion for each unit with the information being coded on the Cansis (Canadian Soil Information System) format.

Major soil units are sampled subsequent to mapping and samples provided for: (1) routine analysis at Guelph (particle size, pH, % organic matter, $CaCO_3$ equivalent, cation exchange capacity and extractible iron); (2) clay mineralogy (Project 8); (3) heavy metal analysis (Project 9); (4) organic matter characterization (Project 9); and (5) nitrogen transformation analysis (Project 11).

Three sites in each AG-4, 5 and 13, and two in AG-1 are being studied to determine seasonal variability in selected soil properties. Surface infiltration rates are measured at three times during the year. Triplicate bulk density measurements are taken on each major horizon.

Samples have been collected from major horizons for various engineering properties including Atterburg limits, plasticity index and shrink-swell characteristics. Vane Shear field measurements have been taken for each major horizon.

PHASE II - DETAILED STUDIES

PROJECT 8

THE NATURE AND ENRICHMENT OF SEDIMENTS IN AGRICULTURAL WATERSHEDS - A MINERALOGICAL AND PHYSICAL CHARACTERIZATION

Project Leader: G.J. Wall
Ontario Soil Survey Unit
Agriculture Canada, Guelph, Ontario

Associate: K.L. LaHay

Objectives and Approach:

The purpose of this phase of the study is to determine the physical characteristics of the sediments in Watersheds AG-1, 3, 4, 5, 10 and 13 in order to determine the potential of the streams to carry pollutants out of the watersheds.

In order to achieve this end the following analyses are performed on soil samples, bottom sediments and suspended sediments from within each watershed: particle size determination, pH, amorphous content, Fe content, organic matter, carbonates, cation-exchange capacity and clay mineralogy.

Progress:

The required soil samples are collected from the major soil types within each watershed as part of the Soil Survey (Project 7). So far we have received soil samples from Watershed AG-4. By the end of this fall we should have soil samples from Watersheds AG-5 and 13.

Samples of suspended sediments were taken from near the mouths of Watersheds AG-4 and 10 during the spring. The samples were taken after heavy rainstorms which contributed to surface run-off.

Samples from the other four watersheds were not collected for a variety of reasons. The required equipment was not available in April. Once the equipment had arrived, sampling was delayed due to lack of major storms. Three of the streams tend to clear up relatively quickly after storms and sampling had to be done during, or immediately after heavy rainstorms. The sampling procedure is tediously slow, and a collection crew of two is required. These samples are, and will continue to be, the trickiest to collect.

The bottom sediments were collected at low flow periods at or near the suspended sediment sites with a sediment corer. A number of cores were taken across the bottom sediments in order to obtain a representative cross section. Samples were collected from all six watersheds.

For future reference the following measurements are taken in the field: air temperature, water temperature, stream pH, dissolved oxygen and free CO_2. These parameters are measured for both suspended and bottom sediments.

Sampling methodology has been refined during the summer and is now satisfactory and conducive to good laboratory analysis. Fall sampling of the bottom sediments will be collected, with collection of suspended sediments dependent upon the weather. All lab analysis of samples collected before December 1975 will be completed for the spring report.

PHASE II - DETAILED STUDIES

PROJECT 9

AGRICULTURAL SOURCES, TRANSPORT AND STORAGE OF METALS

Project Leaders: A.J. MacLean, M. Schnitzer
Soil Research Institute,
Agriculture Canada, Ottawa, Ontario.

M. Ihnat, Chemistry and Biology Institute,
Agriculture Canada, Ottawa, Ontario

J.D. Gaynor, Harrow Research Station
Agriculture Canada, Harrow, Ontario

Associate: L.M. Whitby-Costescu

Objectives and Approach:

1) To assess, develop and adapt analytical methodology for the determination of trace and ultratrace levels of selected metals in sediment, soil and water samples from selected watersheds.

2) To determine total and/or extractable quantities of heavy metals in water and bottom sediments, suspended sediments and in the soils from which these sediments originate.

3) To assess the relationship between metal concentrations in the sediments and soils; to estimate the quantities of metals associated with the organic matter in sediments and soils.

4) To determine the quantities and characteristics of the humic and fulvic acids in sediments and soils and to examine the metal complexation capacities of these organic fractions; to determine sources of the humic material.

5) To study metal transport and storage mechanisms particularly for copper, zinc, cadmium and lead, and to correlate mineralogy, amorphous content, total carbon, and organic matter characterization of sediments and soils with metal content.

6) To identify agricultural sources of heavy metals by the analysis of fertilizers, animal wastes and sewage sludges, and from estimates of their respective extents of application.

Progress:

The development and adaptation of analytical methods to the study of trace metals and organic matter in bottom sediments, suspended sediments, soils and water was one of the major objectives of this project. All investigators have made advances in this area. Further methodological

investigations remain for the analysis of water and suspended solids for trace metals and organic matter.

Analyses of bottom sediments (spring 1975 samples) from 6 agricultural. watersheds (AG-1, 3, 4, 5, 10 and 13) were carried out for cadmium, chromium, copper, lead, manganese, iron, nickel, zinc and aluminum. The results from these analyses have been summarized. Sediment samples are presently being analyzed for mercury, selenium and arsenic. Soils from 4 watersheds (AG-1, 4, 5 and 13), 3 major soil types in each, are presently being analyzed for the same trace metals.

Preliminary experiments indicate the feasibility of detecting levels of selected metals in water. After further testing of these analytical procedures is complete, filtered and unfiltered samples of water from Watersheds AG-4, 5 and 13 will be analyzed for copper, zinc, cadmium and lead.

Concentrations of the more readily extractable quantities of trace metals in sediments and soils will be determined during the next six months. All soil and sediment samples have been assayed for total carbon, inorganic carbon (calcite and dolomite), total Kjeldahl nitrogen, total sulphur, organic sulphur and pH.

The contribution of fertilizers to trace metals in soils has been evaluated. Additional sources of trace metals to agricultural lands will be identified during the winter.

Fulvic and humic acids have been extracted from bottom sediments from 6 watersheds (AG-1, 3, 4, 5, 10 and 13) and from 3 soils of Watershed AG-4. Carbon, hydrogen, nitrogen, and sulphur contents were determined in these samples by microanalytical techniques. Chemical characterization of these samples will proceed over the winter. Extraction and purification of organic matter from the soils of the remaining watersheds and the fall sediment samples, as well as the suspended sediment samples, will be emphasized during the next six months.

PHASE II - DETAILED STUDIES

PROJECT 10

SOURCES OF NUTRIENTS AND HEAVY METALS IN HILLMAN CREEK

Project Leaders: J.M. Fulton, J.D. Gaynor
Harrow Research Station,
Agriculture Canada, Harrow, Ontario

Associate: R.J. Walker

Objectives and Approach:

To measure inputs of nutrients, minerals and metals from a section of Hillman Creek (AG-13) which crosses agricultural land as well as two strip housing developments.

Progress:

Inputs of nitrogen, phosphorus, suspended solids, potassium, sodium, calcium, magnesium, iron, aluminum, copper, zinc, chromium, cadmium and lead to the southwest branch of Hillman Creek (AG-13) arising from the areas occupied by strip housing are being measured. Also a comparison of these inputs to those from the strictly agricultural portion of the watershed is to he made.

Standard sampling procedures were used and methods of chemical analysis developed to accommodate the project goals. Water samples were collected at the selected sites on a weekly basis, with an attempt made to collect extra samples when a significant event occurred in the watershed.

With respect to the primary objective of the project, a great deal of data has been obtained. The project was successful in initiating sampling early enough so that a full year of study was made possible. At this point certain generalities concerning trace metals can be formed. Levels of lead, cadmium and chromium were too close to detection limits to allow any statistical evaluation but the negative evidence of their input from both strip housing developments as well as agriculture is gratifying. Copper, zinc and iron levels were high enough to allow an evaluation to be done.

The fact is that neither strip housing development nor agriculture can be pinpointed as major sources of these elements. Some spurious results of copper and zinc may warrant further study as to their source. The major find is that sources of phosphorus and salts (Mg, Na, K) may be originating in the small tributary entering the main stream. Further data on this site will hopefully alleviate some of the doubts concerning this source. An immediate statement concerning the inputs of suspended solids and nitrogen forms cannot be made. At the end of the year more statistical evaluation dealing with correlations and regression equations may be possible.

Data on the selected parameters have been subjected to statistical analysis. The interpretation of this data and its analysis has resulted in some minor improvements which in the

remaining time scale of the project should prove fruitful. Some of the conclusions reached, as well as the trends that have been formed, have provided a degree of success for the overall outlook of the project to date.

PROJECT 11

NITROGEN TRANSFORMATION PROCESSES IN WATERSHED SOILS

Project Leader: C.G. Kowalenko,
Soil Research Institute,
Agriculture Canada, Ottawa, Ontario

Objectives and Approach:

The objective of this study is to systematically examine how various soil types and horizons behave with reference to N transformations under controlled environmental conditions. This is to be done by measuring inorganic N components in a series of incubation systems where a variety of temperature and moisture conditions of soils represent several watershed areas. This is viewed as providing information for a mathematical model of N transport and transformation in the unsaturated soil zone in order to contribute to an understanding of the N storage and release characteristics of selected agricultural soils in the watersheds (Project 13).

Progress:

A number of soil samples have been collected for the incubation studies, of which a majority represent sites associated with plot work in Project 13. Two general systems have been established for studying denitrification and nitrification-mineralization. Several soil samples have been completed with the "anaerobic" system where denitrification would dominate, but no conclusions as yet can be reached. More thought is needed on this set-up to determine if the data is in a useful or convenient form and whether modifications to the system would be useful. Incubation of soils under "aerobic" conditions favoring nitrification-mineralization has been reasonably established, but as yet no data is available. From previous studies (related to SRI activities), this incubation system appears satisfactory for providing input information into a N transformation model. Incubations of a greater variety of soil samples are planned and a system for including N fixation is being set up.

PHASE II - DETAILED STUDIES

PROJECT 12

PHYSICAL PROPERTIES OF THE SOILS OF AGRICULTURAL WATERSHEDS 1 and 13 WHICH CONTROL MOISTURE STORAGE AND TRANSPORT

Project Leader: G.C. Topp, Soil Research Institute,
Agriculture Canada, Ottawa, Ontario

Objectives and Approach:

The objectives of this study are to measure in situ and to characterize the soil physical properties which govern the storage and transmission of water solutions.

This study is also intended to provide the physical transport parameters required as input to the model in Project 13.

Progress:

The field work included measurement of saturated hydraulic conductivity, sampling for soil-water content, taking cores of undisturbed soil for laboratory determination of water content versus pressure head relationships and bulk density. The measurement sites were located in Watersheds AG-13 and AG-1 in conjunction with Projects 11 and 13.

Reliable data for hydraulic conductivity using the air-entry permeameter in Watershed #13 were obtained in situ for depths to 45 cm at the three chosen sites. High water tables and wet soil impeded most measurements at greater depths. The macrovoids in soil in Watershed #I were an insurmountable problem, however some measurements of in situ hydraulic conductivity were accomplished and appear reliable. An alternative permeameter (crust-top) technique was introduced to enhance progress. The laboratory measurements on soil cores of bulk density, and water content-pressure head relationships are underway and will continue. Alternative field techniques must be developed and introduced next field season to overcome the encountered problems in both watersheds.

PHASE II - DETAILED STUDIES

PROJECT 13

MATHEMATICAL MODEL OF NITROGEN TRANSPORT IN THE AGRICULTURAL WATERSHED SOILS

Project Leader: D.R. Cameron
Soil Research Institute
Agriculture Canada, Ottawa, Ontario

Associate: C. Chang

Objectives and Approach:

The primary objective of this study is to develop, test and apply a nitrogen and water transport simulation programme to predict nitrogen levels entering groundwater supplies from various cropping and fertilizing practices on agricultural soils.

The work of Topp (Project 12) will provide the necessary physical data to parameterize some of the transport mechanisms, while the work of Kowalenko (Project 11) will be useful in quantifying some of the nitrogen processes taking place in this soil. In addition, a monitoring program has been established on the tile drained clays of Watershed #1 and the sandy loam soils of Watershed #13, both near Leamington, Ontario, in order to collect nitrogen disposition data from some current agriculture practices and to obtain data useful for calibrating and testing a computer model.

Progress:

Three sites (wheat, corn, soybean fields) have been established on Watershed #1 and three sites (potatoes, tobacco, and soybeans) have been established on Watershed #13. Once the plots were established, the soils and crops were sampled periodically throughout the growing season. The soil and plant samples were shipped to Ottawa where the soils were analyzed for NO_3-N and NH_4-N and the plants for Kjeldahl N. In August-September various instruments including water table wells, suction lysimeters, neutron access tubes, and thermographs were installed in some of the plots to help monitor winter processes. Two problems are apparent in the monitoring aspect:

1. It has been labor intensive and has required much more time than previously anticipated and,

2. The preparation and extraction of the soil after shipment to Ottawa has been delayed due to lack of manpower.

Basic transport models have been developed for vertical water and salt. movement. However, the following information must be incorporated and/or developed:

1. Physical transport parameters (Topp, Project 12);

2. Nitrogen and transformation processes (Kowalenko, Project 11);

3. Daily weather information;

4. Root uptake; and,

5. Boundary conditions.

Our future plans involve attempting to incorporate this information.

Two examples of the type of results that might be expected from this study using preliminary data have been completed.

PHASE II - DETAILED STUDIES

PROJECT 14

STUDIES OF AGRICULTURAL POLLUTION OF GROUNDWATER AND ITS INFLUENCE ON STREAM WATER QUALITY IN TWO AGRICULTURAL WATERSHEDS

Project Leaders: E.O. Frind, J.A. Cherry
Department of Earth Sciences,
University of Waterloo, Waterloo, Ontario

Associates: R. W. Gillham
P. Fritz
R. Blackport
M. Sklash

Objectives and Approach:

The objectives of the investigations are:

1) To determine the contaminant distribution and the processes related to the storage and transport of contaminants in areas of different agricultural land use and soil types in segments of the two watersheds.

2) To determine the rates at which contaminants move from the groundwater zone into streams draining from the basins in the Great Lakes.

3) To develop extrapolation procedures.

Progress:

Field investigations of groundwater contamination from agricultural sources were begun in the Hillman Creek (PLUARG No.13) and Holiday Creek (PLUARG No.5) watersheds in May, 1975. Detailed study areas have been selected in each of the basins.

A multi-technique approach is being used in the investigation. This includes geologic test drilling and sampling, geophysical surveys, installation of observation well networks, monitoring of groundwater levels, testing of wells for permeability, sampling of wells for analysis of nutrients, pesticides, and major ions and for analysis of the naturally-occurring isotopes ^{18}O, D, and ^{3}H, topographic surveying, inventory of land use and fertilizer use, and integrated data interpretation using digital simulation models. The emphasis is on determining the sources and subsurface movement of agriculturally-derived contaminants in considerable detail in one or two segments in each of the watersheds. Only skeleton monitoring networks will be operated in the other segments of the two basins.

Results:

Hillman Creek

A total of 43 observation wells have been installed in the detailed study area in the Hillman Creek basin. Nearly all of the wells are in sand and gravel at depths less than 10 in below ground surface. From water-level measurements in the wells, the groundwater flow pattern from a topographic upland to Millman Creek has been mapped. Water samples from the wells have been analysed for NO_3^--N and NH_4^+ concentrations and at Waterloo for oxygen-18 and tritium concentrations.

Nitrate concentrations expressed as N are as high as 35 mg/litre in some of the shallow wells. In general nitrate contamination is widespread at depths less than about 3 to 5 meters below ground surface. Deeper in the sand, nitrate is generally absent. At some locations the shallow nitrate values vary considerably with time in response to local rainfall. The nitrate-contaminated groundwater flows laterally from the upland toward Hillman Creek. Groundwater feeding Hillman Creek during low-flow and storm periods contains high nitrate concentrations.

Isotope data indicate that essentially all of the groundwater in the sand and gravel is less than about 5 years old. These data suggest that the absence of high nitrate values deeper in the sand is due to lateral flushing of non-nitrate water from sands located in nearby gravel pits. The clay layer that underlies the entire area prevents downward migration of nitrate-rich groundwater into deeper water-bearing zones. Preliminary calculations indicate that the amount of nitrate in storage in groundwater in the sand and gravel varies between 50 - 160 lbs/acre in the detailed study area. This nitrate in storage is gradually being discharged into Millman Creek as new nitrate is being added to the groundwater flow system in areas away from the stream.

Holiday Creek Subbasin:

A total of 9 observation wells have been installed in the detailed study area in the Holiday Creek basin. In comparison to Hillman Creek basin the stratigraphy of the geologic materials is much more complicated in this area. Preliminary results suggest that nitrate contamination of groundwater is not very widespread, and that it generally has not penetrated very far in the glacial till. There is insufficient data available so far to enable conclusions to be drawn with regard to the influence of groundwater contaminants on the chemistry of the small stream draining the subbasin.

Information collected to date suggests that the detailed study area in the Hillman Creek watershed is relatively well suited for use of two dimensional digital simulation models for integrated data analysis, sensitivity studies, and for development of predictions regarding sub-surface nitrate movement. Computer simulation studies have recently been initiated.

PHASE II - DETAILED STUDIES

PROJECT 15

HYDROLOGIC MODEL

Project Leader: H.R. Whitely,
School of Engineering
University of Guelph, Guelph, Ontario

Associate: S.R. Ghate

Objectives and Approach:

This project has as its aim the development of a hydrologic model which yields as output the rate of surface runoff generated by small (20 km^2) agricultural watersheds. The model is to be developed for individual storm events and is to be capable of attributing total watershed runoff to specific land use areas within the watershed. The watersheds for which the model is to be developed are Canagagigue (AG-4) and Holiday (AG-5) Creeks and the East Canagagigue watershed.

Progress:

- Watershed and subwatershed boundaries have been established for the Canagagigue and East Canagagigue watersheds. Stream channel lengths, cross-sections, slopes and roughnesses have been established.

- Some of the available streamflow and rain intensity information for the two Canagagigue watersheds for the period 1970 to 1974 has been assembled.

- An available hydrologic watershed model (HYMO) has been acquired and incorporated into the model-building process as a link between subwatershed hydrographs and the watershed outlet hydrograph.

- A computational algorithm has been established for subwatershed hydrograph computation based on the contributions to surface runoff of separate individual land use areas.

- Preliminary runs have been made to compute the watershed outlet stream-flow flowrate hydrograph for the Canagagigue watershed for one summer storm.

By March 31, 1976, model computations for surface runoff flow rates from rain storms occurring with different initial watershed wetness conditions should be available for the two Canagagigue watersheds.

PHASE II - DETAILED STUDIES

PROJECT 16

EROSIONAL LOSSES FROM AGRICULTURAL LAND

Project Leader: G.J. Wall, Ontario Soil Survey Unit
Agriculture Canada, Guelph, Ontario

Associate: L.J.P. Van Vliet

Objectives and Approach:

1) To physically define the seasonal variability in the sediment source areas in two agricultural watersheds;

2) To employ a mathematical soil erosion model in combination with knowledge of sediment source areas as a tool to predict sediment yields;

3) To compare predicted suspended sediment yields with measured suspended sediment outputs in two agricultural watersheds.

Progress:

Field work in both watersheds #4 Canagagigue Creek and #5 Holiday Creek started in early March 1975 in order to define and map sediment source areas by a detailed on-site evaluation during all annual snowmelt and rainfall events. In addition to event sampling of field runoffs, field observations and sampling of well defined stream channels, ditches, and all surface drainage ways other than field runoff was performed both on a routine basis (weekly) and storm oriented basis.

In order to obtain more detailed storm oriented observations on individual field erosion, a small subwatershed of about 1 square mile and representative for each watershed with respect to land use, soils and topography, was selected. Location of erosion sites as well as the percentage of each field and total percentage of the subwatershed contributing to sediment yield were recorded in these areas. Storm orientated sampling and observations will continue until freeze-up.

With all field observations and turbidity data combined, the seasonal variability of the sediment source areas of the agricultural watersheds can be defined. Turbidity data from all stream channels, other than field runoff, are used to locate the general areas contributing sediments in a watershed and to determine the relative importance of these areas for each event or combination of events (e.g. spring, summer, fall). In addition, from the observed flow levels at these sampling locations, flow regime maps, indicating high, medium, low or no flow, can be produced for each sampling event and compared for seasonal variability.

After the general contributing areas of the watersheds are determined, the detailed observations and turbidity data of individual fields (subwatershed and other fields) will give information about the number and location .of fields contributing sediments and about the contributing area of the individual fields. A demonstration for spring conditions has been completed.

The contributing area information will be utilized to develop a mathematical soil erosion model, based on hydrology and transport modifications of the Universal Soil Loss Equation, to facilitate the prediction of suspended sediment yields. Predicted suspended sediment yields will ultimately be compared with the measured suspended sediment output monitored at the mouth of both watersheds, in order to determine sediment delivery ratios.

PHASE II - DETAILED STUDIES

PROJECT 17

SEDIMENT DELIVERY RATIOS IN SMALL AGRICULTURAL WATERSHEDS

Project Leader: W.T. Dickinson, School of Engineering,
University of Guelph, Guelph, Ontario

Objectives and Approach:

The objective of this project is to determine the effect of drainage basin size on fluvial suspended sediment loads in selected agricultural watersheds.

In pursuit of the above objective, it was decided to construct seven stream monitoring stations. Five of these were to be on the Canagagigue Creek upstream of Floradale, and two were to be situated on Holiday Creek north-east of Embro. The purposes of these stations would be to (i) provide suspended sediment hydrograph data for this project, and (ii) provide stream-flow hydrograph data for both the project supervised by Dr. M. Miller (Project 18) and that undertaken by Drs. Kaushik and Robinson (Project 19).

It was the intent that the stream stations be situated to isolate contributions from tributary streams in the upland areas of the watersheds. Further, this data could be compared with potential erosion determinations (made for the same areas in another project) and data collected at downstream gauging locations run by either the Ontario Ministry of the Environment or the Water Survey of Canada.

Progress:

The seven sites were selected in May 1975, and plans for the construction and instrumentation phase began at that time.

The equipment at each site is similar, consisting of an 18 inch diameter galvanized corrugated stilling well, a Stevens Type F or Type A-35 water level recorder, a shelter for the recorder atop the stilling well, and a staff gauge. Prior to completion of the construction work during the summer months, streamflow in Holiday Creek and the west branch of Canagagigue Creek had ceased. Records of the spring runoff in both watersheds were not obtained for 1975.

One site had to be relocated due to a farmer's decision to deepen the stream channel. However, all sites are now installed and operative, and continuous records of water level are being monitored.

Regular field work, event orientated field work and laboratory analysis will be continued. Complete records of water level, streamflow, and suspended sediment data will be collected and stored in an orderly fashion. Determinations regarding streamflow rating curves, streamflow hydrographs, and suspended sediment hydrographs will be made for each site.

PHASE II - DETAILED STUDIES

PROJECT 18

CONTRIBUTION OF PHOSPHORUS FROM AGRICULTURAL LAND TO STREAMS BY SURFACE RUNOFF

Project Leader: M.H. Miller, Dept. Land Resource Science
University of Guelph, Guelph, Ontario

Associates: S.C. Sheppard, M. Thompson

Objectives and Approach:

The quantity of P lost from cropland on mineral soils to streams by surface runoff has been described by the equation (1).

amount of P lost in surface runoff	=	amount of eroded material in surface runoff	X	P content of the surface soil	X	P enrichment ratio	(1)

Models to predict the amount of eroded material in surface runoff are being developed by H. Whiteley and G. Wall of the University of Guelph group (Projects 15 and 16). The proposal of this project to use information that is available throughout Ontario to predict (A) the P content of surface soil, and (B) the P enrichment ratio. The information most likely to be useful is (1) the Ontario Soil Survey estimates of texture and drainage, (2) summaries of the Ontario Soil Test measures of pH and available ($NaHCO_3$ extractable) P, and (3) generalizations of agricultural land management.

Progress:

Problem A: In order to develop relationships to predict the P content of surface soil, the soils of the watersheds are being intensively sampled and three year histories of crop, fertilizer, manure and tillage of the sampled fields are being obtained. Each sample will be analyzed for available P by the Ontario Soil Test Service and each will be analyzed for total P.

Problem B: The first approach to prediction of the P enrichment ratio will involve correlating observed ratios with available soils information and calculated erosion intensity information. This approach is statistical and is not process oriented.

The second approach assumes that the P content of finer soil particles is different from the P content of coarser soil particles and that the P enrichment is caused by an erosional selection of the finer particles.

To test these approaches and to guide development of further approaches, grab samples of runoff from small, defined areas of farm fields throughout the study watersheds are being collected. The sediment loads of these samples are being separated into the sand, silt and clay fractions and the P content of these fractions and the filtered runoff solutions are being determined.

Duplicate soil samples are also collected from the contributing area corresponding to each runoff sample. These samples will be treated in a similar manner to the general soil samples with the addition of the following analyses. Subsamples of the soils will be dispersed (i) with calgon to provide a totally dispersed particle size analysis, and (ii) with an ultrasonic disintegrator to provide sand, silt and clay fractions for P analysis.

Further data being obtained: To provide data on the aggregation of eroded materials, the eroded materials collected during this study are first separated into coarse, medium, and fine fractions with minimal applied dispersion. The weight and P content of each of these fractions are being determined and may be useful in extended studies that attempt to predict P movement in stream systems.

This eroded material is then further dispersed to provide the sand, silt and clay fractions needed to test the second approach to the P enrichment ratio.

A table showing number of samples handled to date and samples that will be handled before spring 1976 is included in the complete report.

At this time about 80% of the soil samples have been collected. 42 runoff samples have also been collected at 30 sites. All of these suspended sediment samples have been analysed for aggregate size separation and total P. Sonic dispersion of soil and sediment samples has not yet been started, nor have the remaining P determinations.

PHASE II - DETAILED STUDIES

PROJECT 19A

NITROGEN TRANSPORT AND TRANSFORMATIONS IN TWO BRANCHES OF CANAGAGIGUE CREEK

Project Leader: J.B. Robinson, N.K. Kaushik
Dept. Environmental Biology
University of Guelph, Guelph, Ontario

Associate: P. Perk

Objectives and Approach:

The objective of this study is to determine the fate of nitrogen compounds in transport in streams. Such compounds are subject to a variety of transformations, some of which comprise temporary, and some permanent, sinks.

The study is being carried out in the upper basin of the Canagagigue Creek where two main branches can be identified. The "West Branch" is the PLUARG Watershed AG-4 and is characterized by its marked seasonal flow, its eroded banks and by the virtual absence of deciduous vegetation throughout its length. The "East Branch", on the other hand, is perennial, has a more clearly defined channel, and flows through areas of developed farm land interspersed with mixed deciduous and coniferous bush.

The study plan requires that reaches of each stream be selected and that an attempt be made to monitor inputs of nitrogen to the reach and compare these to the quantity of nitrogen in transport at the downstream end of the reach. It will also be necessary to monitor carbon inputs and outflow because nitrogen transformations such as immobilization and denitrification are dependent on the availability of carbon.

A further aspect of the study involves the laboratory determination of nitrogen process rates in water and sediment from the two streams.

Progress:

Two technicians, one for field work and one for laboratory work, have been engaged. Stream gauging stations have been installed at the upper and lower extremes of reaches in each of the two branches of the stream and in a major tributary of the East Branch. Gauging is just now commencing, however, the East Branch location has proven unsatisfactory and a new upstream gauging site is being prepared. Grab samples of stream water have been obtained weekly at a number of sites in the streams all summer and concentrations of nitrogen forms have been determined.

At the downstream station in the East Branch NO_3-N is quite constant at 3-4 mg/L with slightly higher concentration following events. Flow in the West Branch was extremely low or non-existent during most of the summer however concentrations of NO_3-N ranged between 1 and 2.5 mg/L with elevations to 5 mg/L following events. The East Branch reach under study receives inputs from drainage tiles which have continued to flow all summer with water at 10 - 20 mg/L NO_3-N.

Laboratory studies have commenced in which plexiglass columns are used to measure the rate of NO_3-N loss from aerated water overlying stream sediment. Typical results show that 90% of the NO_3-N is removed in 14 days from water with initial concentration of 10 mg/L NO_3-N.

With the commencement of gauging we intend to increase our sampling frequency, particularly during high flow periods. Nitrogen and carbon inputs and outflow will be determined and an assessment of the input from fallen leaves will be attempted. Laboratory studies will continue and we will examine the effects of temperature, NO_3-N concentration, and sediment characteristics on removal of NO_3-N from water. Drift material obtained from the Biology Department, University of Waterloo (Project 19B) will be analyzed.

PHASE II - DETAILED STUDIES

PROJECT 19B

SECONDARY PRODUCTION AND ORGANIC DRIFT OF NUTRIENTS IN TWO BRANCHES OF CANAGAGIGUE CREEK

Project Leader: H.B.N. Hynes, Dept. Biology,
University of Waterloo, Waterloo, Ontario

Associate: K.W. Dance

Objectives and Approach:

To provide information on movement of nutrients by drift of solid organic matter.

Progress:

The study is being carried out in the "West Branch" and the "East Branch" of the Canagagigue Creek described in Project 19A. Two sampling stations have been established in each branch.

All of the apparatus are permanent installations. Material is collected from the two vertical samplers at weekly intervals. The "vertical nylon monitor" collects fine and coarse organic material and sediment (i.e. - fluvial sediment, detritus, aquatic organisms and plant material). Coarse plant material is collected by the "vertical chicken wire sampler". Material is collected from the bedload (i.e. fluvial sediment) and leaf fall-blow in samplers at longer intervals.

All material is returned to the lab (in poly bags) on the day obtained. Material is divided into fractions, oven dried (until no further weight loss occurs) and weighed within a few days of the sample date. If samples are to be held for extended periods they are frozen. Weighed material is stored at room temperature in clean labelled poly bags. It will be transferred to Drs. Robinson and Kaushik (Project 19A) at Guelph for analysis of NO_3 and PO_4 and loss on ignition.

Stream velocity and depth at the vertical samplers is recorded on the sampling days so that later, when discharge data are available, the proportion of the total flow that was sampled may be calculated. Preliminary results from the vertical samplers have been obtained.

PHASE II - DETAILED STUDIES

PROJECT 20

EFFECTS OF LIVESTOCK ACTIVITIES ON SURFACE WATER QUALITY

Project Leader: S.L. Hodd, BEAK Consultants Ltd.
306 Rexdale Blvd., Toronto, Ontario

Associate: Paul R. Odom

Objectives and Approach:

The objective of this study is to evaluate the effect of livestock activities on the losses of nutrients and bacteria to surface waters. The Little Ausable River (Watershed AG-3) is well suited as the site to conduct this study. The clay soils in the watershed produce corn, hay, small grains and white beans. Livestock enterprises are beef, dairy cattle, swine and some poultry.

The approach to the study is to measure the flux of nutrients and bacteria on a regular and event-oriented basis over a period of at least two years. Surface water loadings from farm operations would be related to the intensity and type of agricultural practise.

Progress:

To accomplish this strategy, 26 sampling stations were established to monitor the loadings to surface waters from 17 farm operations, representing beef and dairy cattle, swine and non-livestock controls. The sampling stations have been located to determine the contribution of nutrients and bacteria from each of these operations on a seasonal and event basis.

The study has also been designed to provide water quality data every two weeks with more frequent sampling during spring runoff and heavy rainfall events. To date 8 surveys have been completed.

In some cases low summer flow conditions have dried up some stations, but most have continued to flow throughout the summer period.

Flows are measured at all stations at the time of sampling either directly by volume or through a stage discharge relationship with permanently established staff gauges. Water quality analysis for total Phosphorus, nitrate, nitrite, pH, conductivity, total alkalinity, total hardness, total and fecal coliforms are being performed in BEAK's mobile laboratory installed near the drainage basin. Samples are analysed with a minimum of delay after sampling. Other analyses such as total kjeldahl nitrogen, ammonia nitrogen and dissolved phosphorus are conducted at BEAK's Toronto laboratory.

With only the summer surveys completed, it is impossible to draw any meaningful preliminary conclusions. We have noted however, that many of the tile drains have excessive concentrations of nutrients and bacteria.

During the summer, nutrients in the upper reaches of the watershed were taken up producing considerable plant growth that dried up some of the head waters. The concentration of nutrients and bacteria found were well above the level of detection for the analytical method used.

Overall, we are optimistic that the objectives of the study will be met and that important observations will be made of the significance of both livestock operations and tile drainage to surface water quality in agricultural areas.

PHASE II - DETAILED STUDIES

PROJECT 21

FEEDLOT AND MANURE STORAGE RUNOFF

Project Leader: F.R. Hore, Engineering Research Service, Agriculture Canada, Ottawa, Ontario

Associate: D.R. Coote

Objectives and Approach:

1) To determine the quantity and quality of liquid runoff from cattle feedlots and cattle manure storage areas in southwestern Ontario.

2) To determine the detention storage capacity requirements to control contaminated runoff.

Progress:

To date this year, the study has been a continuation of one commenced in the fall of 1973. In February of 1975, a progress report on the 1st year was written. Rainfall and flow monitoring have continued to the present time, with an attempt at obtaining information on the presence of livestock enteroviruses included in the present water quality monitoring.

There are four sites: two feedlots - one on a paved surface, the other on an unpaved soil surface; and two manure storage areas - both paved, one holding solid manure, the other semi-solid slurry type manure.

Problems: The first problem is that of location - the sites originally selected are not readily accessible to us, and therefore we have relied heavily on the cooperation of the farmers in the servicing of rain gauges and flow recorders, and for the collection and shipping of samples. Though they are paid for this, interest on their part is waning noticeably, and they are becoming less reliable. For sampling for bacti and viruses, we must rely on visiting the farms ourselves, which means that a large element of luck exists as to whether we get there at the right time - runoff events are very brief.

The second problem is that of freezing - winter conditions are very hard to examine as the equipment is often inactive due to ice. This could be overcome by installing heaters at added expense and difficulty to ourselves and the farmers.

Results:

To date we may generalize some results as follows:

1. Runoff volumes from the paved sites are fairly predictable, with some reservation about snow-melt.

2. Runoff from the unpaved feedlot is much less than from the paved feedlot, however the quantity of nutrients washed off the feedlots, expressed per animal unit, were very similar in all cases except that there was a trend for B.O.D., and Kjeldahl and ammonia N to be lower on the unpaved site, while suspended solids were higher. This is probably a reflection of greater microbial activity on the unpaved surface where the manure remains for extended periods prior to a runoff event. However, it must be noted that the paved surface feedlot had manure regularly scraped off and removed between runoff events. Thus the unpaved feedlot is "holding back" a far larger proportion of the manure nutrients than the paved. This suggests accumulation of phosphorus, and either leaching or denitrification of N.

3. The concentrations of pollutants in runoff water from the feedlots and the manure storage areas are high, compared to usual stream quality, in terms of B.O.D., solids, organic and ammonia N, nitrite and phosphorus. Nitrate is comparable with commonly found stream levels. However, sampling and sample shipping delays may have influenced these values. The paved feedlot generally yields the most contaminated runoff (though all sites are fairly similar).

Our initial exploratory sampling for entero-viruses has yielded only one positive site. One entero-virus-like organism was isolated from the seepage water from the holding area for semi-solid manure. It is important to note, however, that at this site manure from calf pens has been used to hold back the dairy barn slurry. In past work by Dr. Derbyshire at Guelph, viruses have been isolated from fresh calf manure, but not from adult cow manure, so the calf manure stored in the area may well be the source of the one organism found. This discovery does, however, confirm the potential for livestock viruses to survive storage, and to be leached out in seepage water.

PHASE II - DETAILED STUDIES

PROJECT 22

POLLUTANT TRANSPORT TO SUBSURFACE AND SURFACE WATERS IN AN INTEGRATED FARM OPERATION

Project Leaders: N.K. Patni, Animal Research Institute, Agriculture Canada, Ottawa, Ontario

F.R. Hore, Engineering Research Service, Agriculture Canada, Ottawa, Ontario

Associates: A.D. Tennant, R. Toxopeus

Objectives and Approach:

1) To determine if subsurface pollutant transport in a small field can be extrapolated to a large field other conditions being the same;

2) To determine the difference in pollutant transport in tile drainage water under a largely coarse-textured soil, compared to a fine-textured soil under similar conditions of manuring and cropping;

3) To determine pollutant transport to surface waters in a 1400-acre watershed area under a closely controlled cropping operation.

Progress:

A special study was initiated at the Greenbelt Farm of the Animal Research Institute of Agriculture Canada in Ottawa to determine pollutant transport to subsurface and surface waters in an integrated farm operation.

Pollutant transport to subsurface waters due to use of livestock manures in cropping operations is being studied at three fields.

Pollutant transport to surface waters in a 1400-acre drainage area under known cropping operations is being studied by monitoring surface water entering the watershed at four locations and leaving at two locations.

At the end of the first six months of the project, the first year's cropping operation is nearing completion. Most field installations have been completed. A few are still in progress because of delayed delivery of equipment. Subsurface and surface water samples have been examined for chemical and microbiological quality. Because of an unusually dry summer and delayed field installations, the number of samples analysed is too small and the duration of sample collection is too short to derive meaningful conclusions at this time. By the end of the first year of study, preliminary data will be obtained on the chemical and microbiological changes in the quality of

subsurface water due to the use of livestock manure in cropping operations, and on the quality of surface waters due to a known integrated agricultural operation.