1974-02-01

# Detailed Study Plan

International Reference Group on Great Lakes Pollution From Land Use Activities

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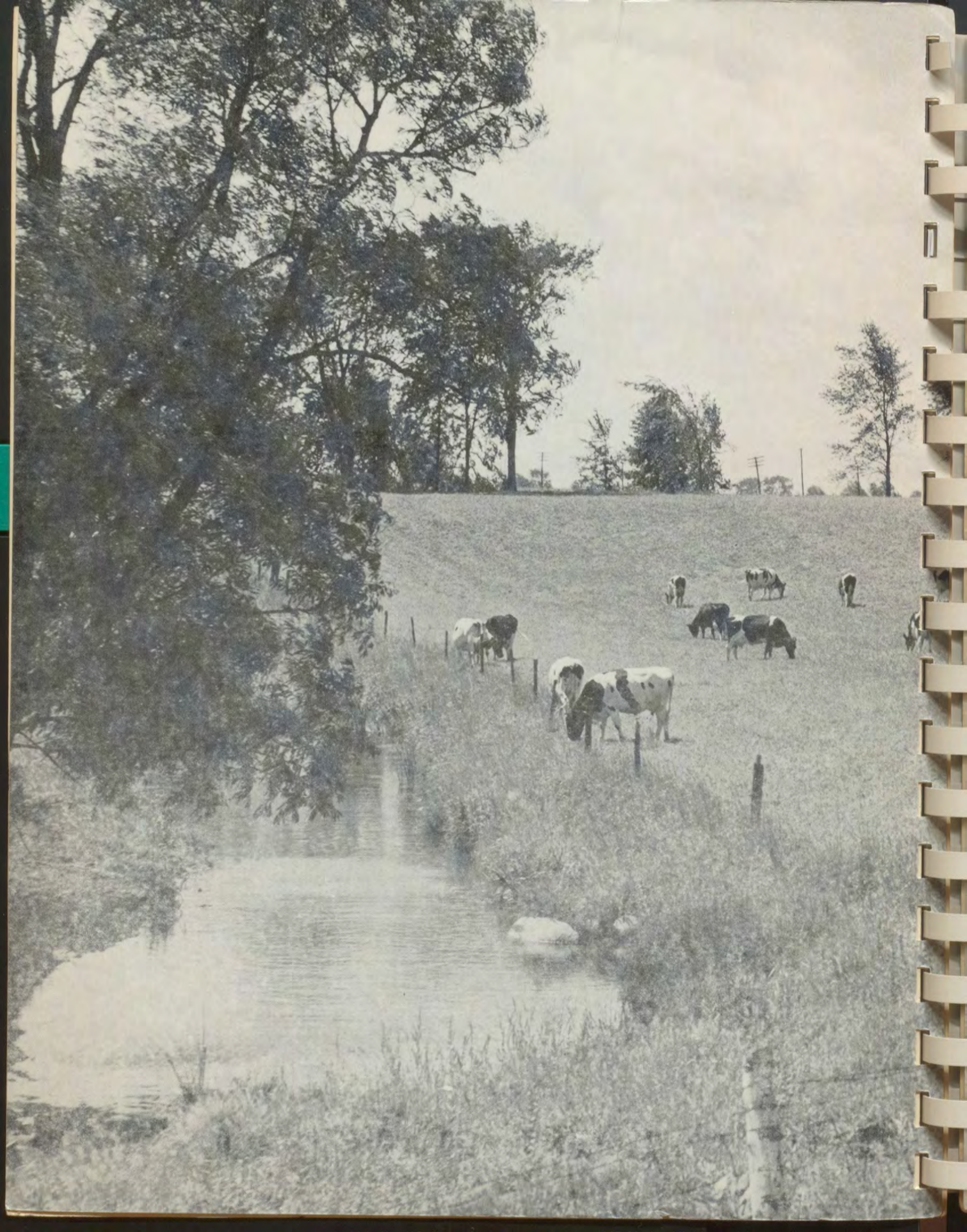
## Detailed Study Plan

## February, 1974



"Is the purpose of our civilization really to see how much the earth and the human spirit can sustain? The decision is still ours to make assuming we recognize that the goal of humanitarianism is not the quantity but the quality of life. If we evade the choice, the inevitable looms ahead of us — even sterner forces will make the decision for us. We cannot delay or evade. For now, as we look, we can see the limits of the earth."

Fairfield Osborn,
"The Limits of the Earth",
Little, Brown and Company, Boston.
1953.

INTERNATIONAL JOINT COMMISSION

INTERNATIONAL REFERENCE GROUP
ON GREAT LAKES POLLUTION FROM
LAND USE ACTIVITIES

February 1974

Great Lakes Water Quality Board
United States and Canada

Gentlemen:

The Reference Group on Great Lakes Pollution from Land Use Activities (Land Drainage Reference Group) takes pleasure in transmitting this Detailed Study Plan to the Board.

Respectfully submitted,

Canada

Murray G. Johnson
Chairman

United States

Norman A. Berg
Chairman

# DETAILED

# STUDY PLAN TO ASSESS

# GREAT LAKES POLLUTION FROM LAND USE ACTIVITIES

February 20, 1974

Submitted to the Great Lakes Water Quality Board by the
International Reference Group on Pollution of the
Great Lakes from Land Use Activities
(Land Drainage Reference Group)

# SUMMARY

## SUMMARY OF STUDY PLAN

The Study Plan emphasizes four main tasks:

Task A. *To assess problems, management programs and research and to attempt to set priorities in relation to the best information now available on the effects of land use activities on water quality in boundary waters of the Great Lakes.*

Task B. *Inventory of land use and land use practices, with emphasis on certain trends and projections to 1980 and, if possible, to 2020.* Present land use report to be completed in 1974, report on trends to be completed in 1975.

Task C. *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.* Preparation activities in 1974, intensive surveys in 1975 and 1976.

Task D. *Diagnosis of degree of impairment of water quality in the Great Lakes, including assessment of concentrations of contaminants of concern in sediments, fish and other aquatic resources.* Activities during 1974 - 1976.

The Study will require three years of intensive surveys, with much of the fourth year devoted largely to preparation of the final report, to be presented in 1977.

The estimated cost of the Study is $10,990,900. ($5,856,500 in the U.S. and $5,135,000 in Canada). In addition, available estimates of the cost of ongoing studies relevant to the task of the Reference Group through the study period (1973 to the end of 1977) total $8,209,000. Breakdown of direct study costs by country and Task is as follows.

| | CANADA | UNITED STATES |
|---|---|---|
| TASK A | $ 150,000 | $ 150,000 |
| TASK B | 185,000 | 209,500 |
| TASK C | 3,967,000 | 4,934,000 |
| TASK D | 733,000 | 463,000 |
| REPORT | 100,000 | 100,000 |

The general integration and scheduling of Reference Group Tasks and activities is shown in the accompanying diagram (Figure 1).

INTERRELATIONSHIPS OF TASKS AND ACTIVITIES IN THE STUDY PLAN

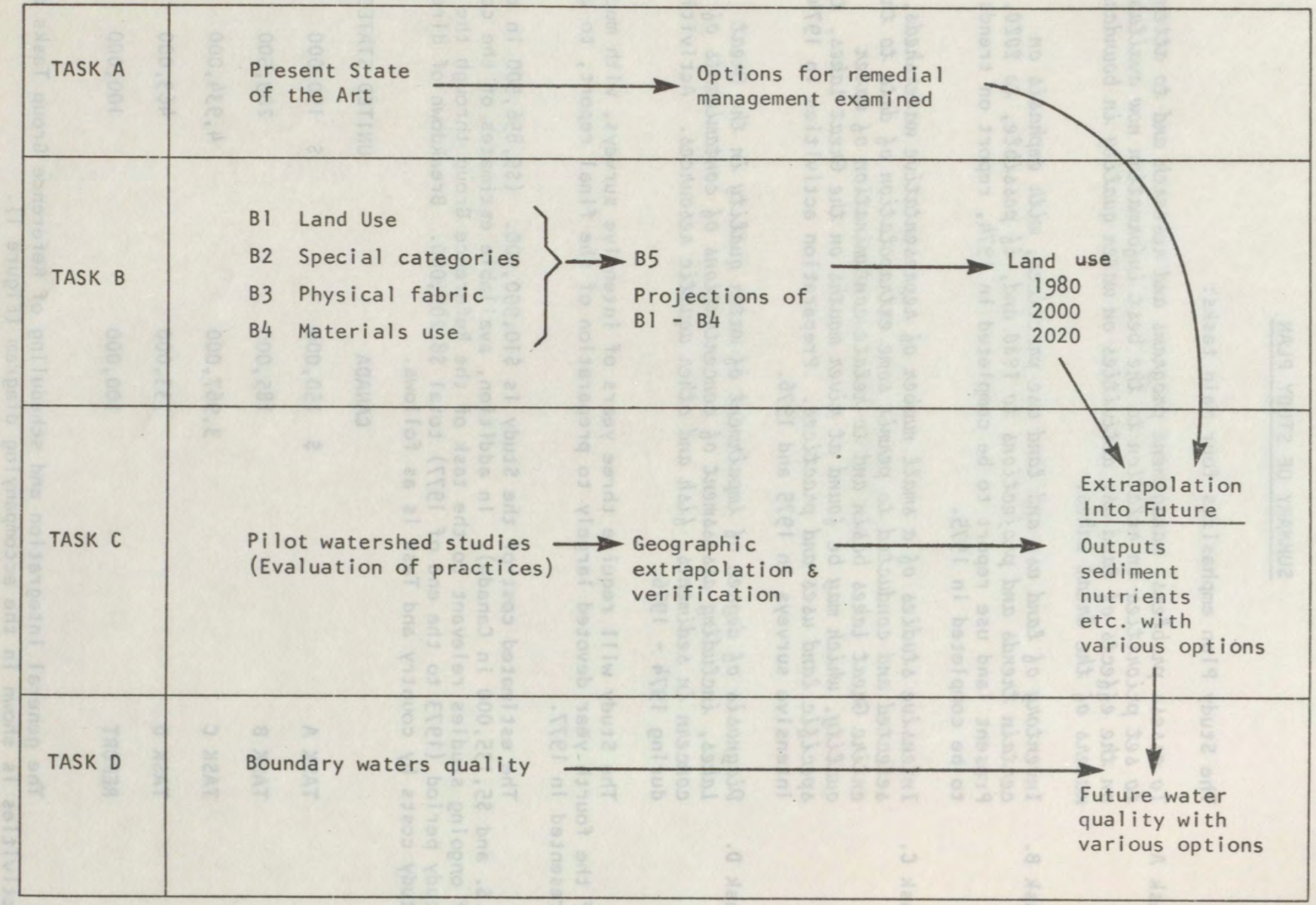
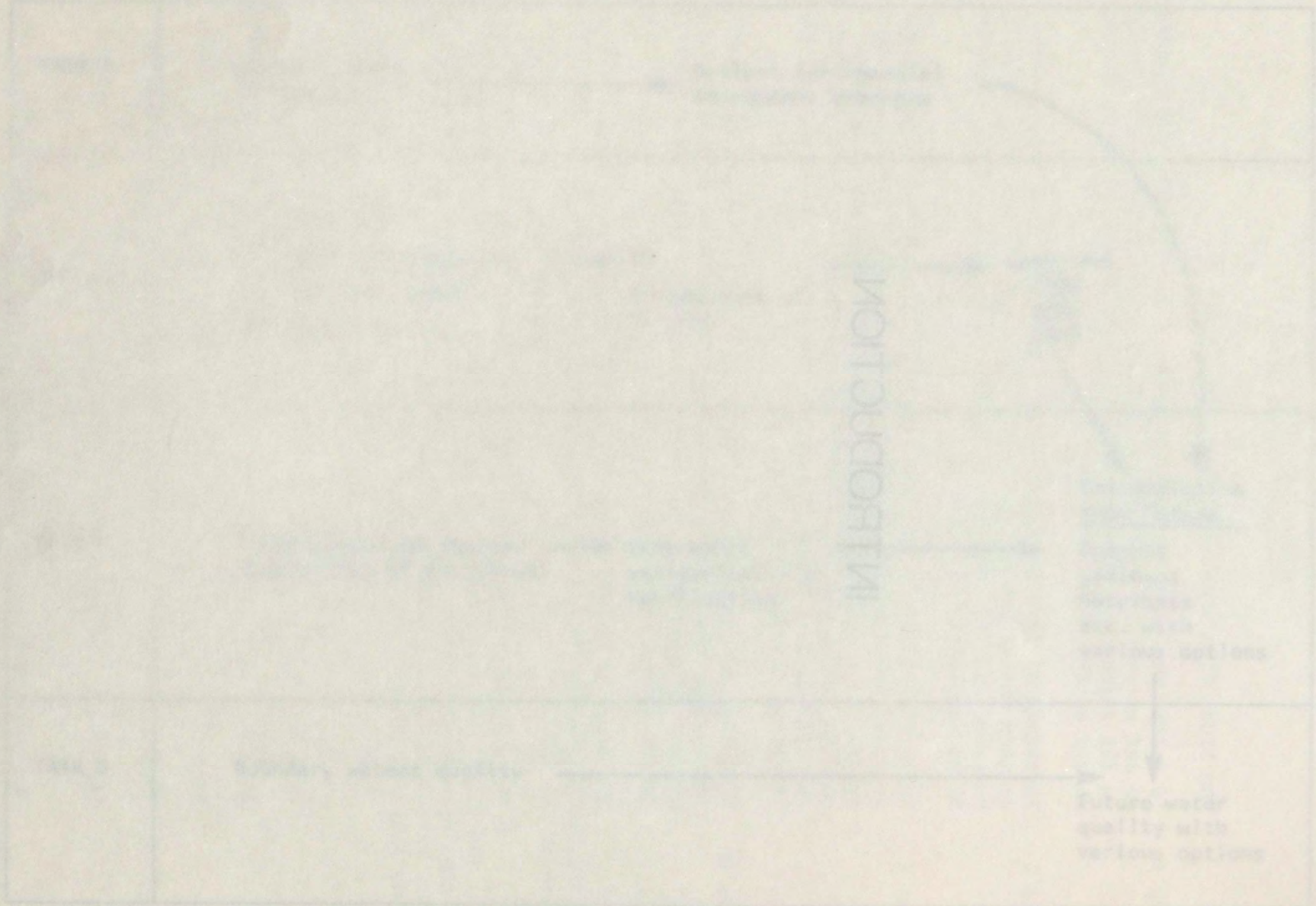



Figure 1

# INTRODUCTION



## INTRODUCTION

Studies requested by the International Joint Commission on water quality in the lower Great Lakes, completed and submitted in 1969, demonstrated that diffuse land drainage sources of pollutants were not only significant but also difficult to measure. The acceleration of tertiary treatment at point sources will magnify the relative importance of land drainage sources of many pollutants, and this calls for a much better definition of the impact of land use activities practices and programs on water quality in the Great Lakes.

It was for this reason that the Governments of Canada and the United States on signing the Great Lakes Water Quality Agreement of April 15, 1972 requested the International Joint Commission to investigate pollution of the boundary waters of the Great Lakes system from agricultural, forestry and other land use activities.

The Commission was requested to enquire into and report to the two Governments upon the following questions:

(1) Are the boundary waters of the Great Lakes System being polluted by land drainage (including ground and surface runoff and sediments) from agriculture, forestry, urban and industrial land development, recreational and park land development, utility and transportation systems, and natural sources?

(2) If the answer to the foregoing question is in the affirmative, to what extent, by what causes, and in what localities is the pollution taking place?

(3) If the Commission should find that pollution of the character just referred to is taking place, what remedial measures would in its judgment, be most practicable, and what would be the probable cost thereof?

The Commission was also requested to consider the adequacy of existing programs and control measures and the need for improvements thereto relating to:

(a) inputs of nutrients, pest control products, sediments and other pollutants.....

(b) land use

(c) land fills, land dumping, and deep well disposal practices

(d) confined livestock feeding operations and other animal husbandry practices

(e) pollution from other agricultural, forestry and land use sources

In carrying out its study, the Commission was requested to identify deficiencies in technology and recommend actions for their correction. The Commission was also asked to submit its report and recommendations as soon as possible and to submit reports from time to time on the progress of its investigations.

In November, 1972 the International Joint Commission appointed an International Group on Great Lakes Pollution from Land Use Activities composed of nine Canadian and nine United States' representatives to carry-out the study under the direction and supervision of the Great Lakes Water Quality Board. (See Appendix I-1 for Reference Group membership).

Subsequently, in Directive Number 1, the Water Quality Board requested the Reference Group to prepare and submit a study outline, schedule and cost estimate.

The Reference Group, in a series of meetings held during 1973, developed an approach to the solution of the problems and questions raised which culminated in a preliminary Study Plan submitted to and approved by the IJC in April of 1973. Since that time a more detailed program has been developed, and forms the basis of this submission.

In preparing the Study Plan, it was clear to the Reference Group, that, of the many and varied activities developing from the Canada-United States Agreement on Water Quality in the Great Lakes, the study on Great Lakes pollution from land use activities is but one component of an overall strategy. Therefore, the Study Plan was developed recognizing the other activities and following a general review of ongoing programs relevant to the charge of the Reference Group.

The Study will be successful in its technical aspects if the following criteria are satisfied:

(1) Detailed investigations on watersheds must indicate the relative significance of the specific sources and practices which yield pollutants of concern in boundary waters.

(2) The degree to which these pollutants are transmitted from sources along rivers to boundary waters must be determined.

(3) The extent of impact of transmitted pollutants on boundary waters must be determined, relative to point-source and atmospheric inputs now and in view of trends in point-source waste treatment.

These criteria, to be satisfied, require studies on watersheds, along rivers and in the boundary waters. Watershed surveys must yield information which goes beyond that provided by traditional "plot" experiments. River surveys should be more nearly complete quantitatively than most earlier studies in order to assess transmission of pollutants. Boundary water quality surveys will have to be supplemented to provide information on additional pollutants, usually through

examination for specific materials in specified locations. No signle aspect of this study is more important than any other. For example, information on inputs to boundary waters at river mouths alone may provide little information on land use practice of origin or on impact on boundary waters.

Because of the complexity of the problem and the necessity to understand behaviour of pollutants from upstream fields to boundary waters, much of the effort will have to be applied to selected watershed studies. Because of this need to extrapolate, as well as for basic needs, a land use inventory and ancillary data are required. Trends in land use patterns and practices will assist the Reference Group in recommending appropriate remedial measures over the long term with due regard to future developments.

This rationale has led to the preparation of a Study Plan composed of four Tasks. Task A is devoted to the collection and assessment of management and research information and, in its later stages to the critical analysis of implications of potential recommendations. Task B is first the preparation of a land use inventory, largely from existing data, and, second, the analysis of trends in land use patterns and practices. Task C is the detailed survey of selected watersheds to determine the sources of pollutants, their relative significance and the assessment of the degree of transmission of pollutants to boundary waters. Task D is devoted to obtaining supplementary information on the imputs of materials to the boundary waters, their effect on water quality and their significance in these waters in the future and under alternative management schemes. The proposed Schedule of Activities for the Land Drainage Reference Study, dependent, of course, on funding, is included in this submission, (Figure 2) together with descriptions of these activities, participating agencies and costs. Activity costs are "supplementary" unless otherwise indicated. A summary of the budgetary requirements is included in Appendix I-2.

PROPOSED SCHEDULE OF ACTIVITIES - LAND DRAINAGE REFERENCE STUDY
(Calender Years)

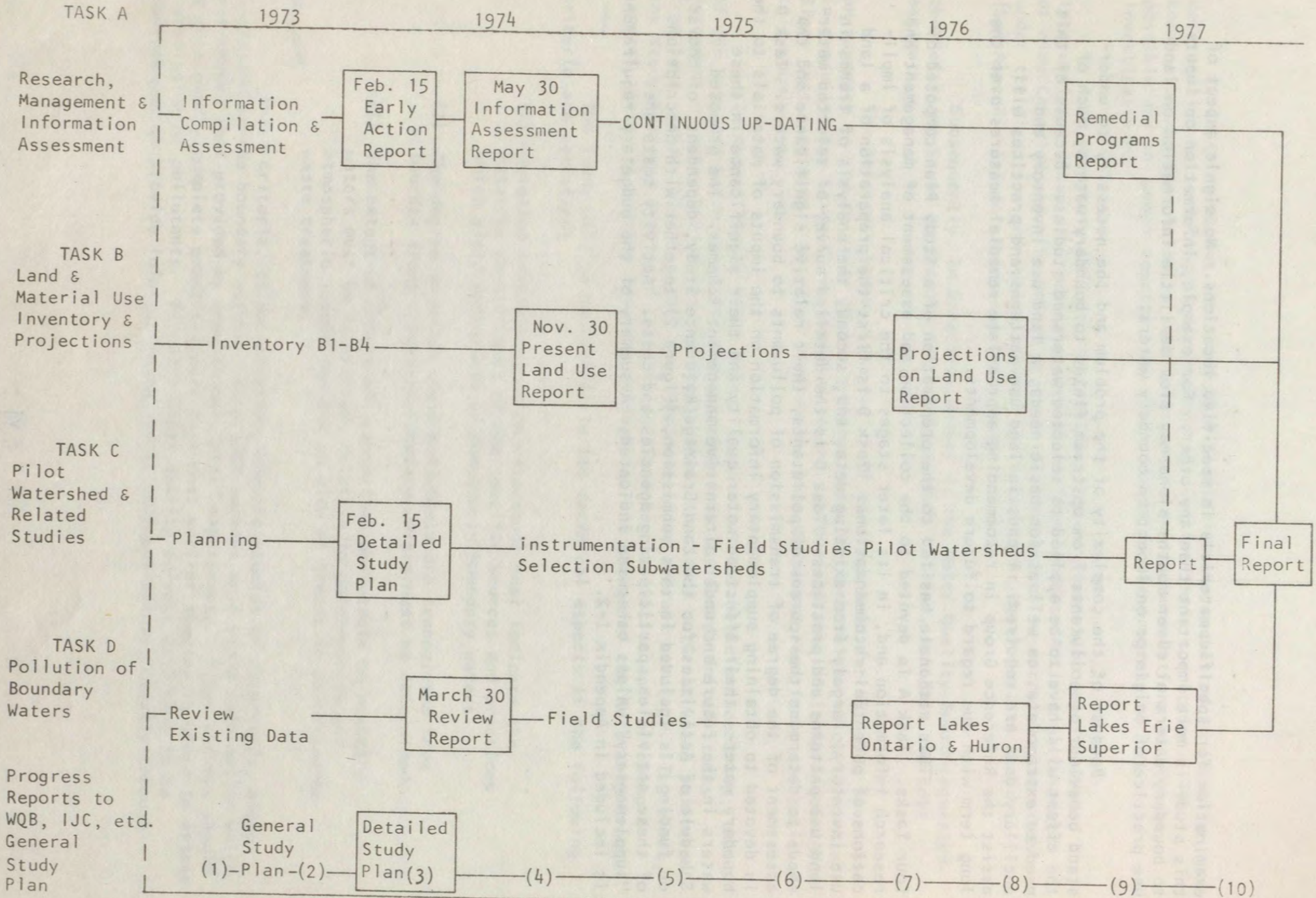



Figure 2

Responsibility for the four Tasks identified and outlined in the Summary has been divided among Reference Group members in the following manner:

TASK A

United States - R. R. Parizek, Penn. State University
- R. L. Herbst, Minnesota, (J. Dooley, Michigan protem)

Canada - G. M. Wood, Ontario Ministry of the Environment
- K. Shikaze, Environment Canada (EPS)

TASK B

United States - L. R. Carter, Indiana
- W. D. Marks, (J. Dooley), Michigan

Canada - L. H. Eckel, Ontario Ministry of Natural Resources
- J. E. Brubaker, Ontario Ministry of Agriculture and Food

TASK C

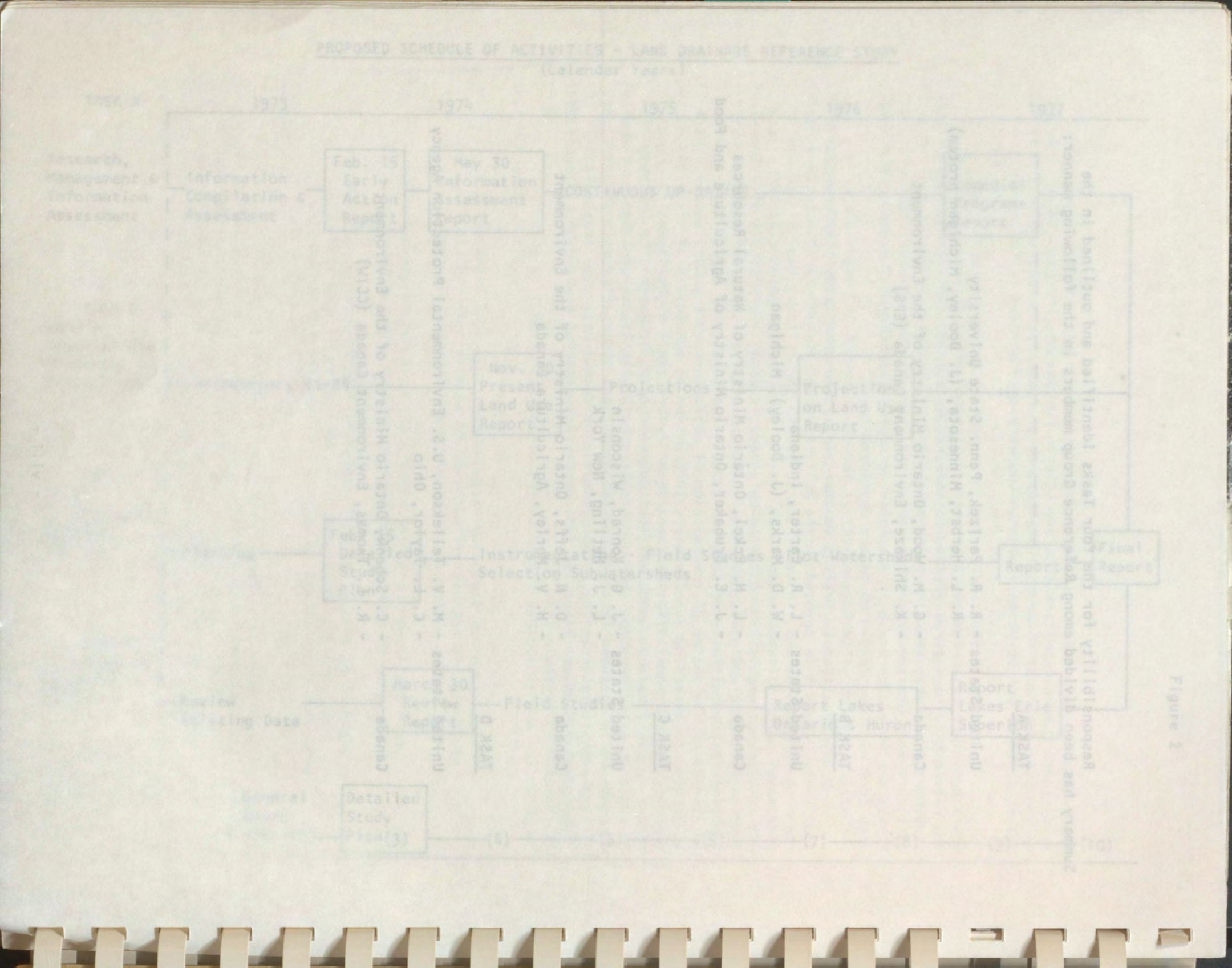
United States - J. G. Konrad, Wisconsin
- L. J. Hetling, New York

Canada - D. N. Jeffs, Ontario Ministry of the Environment
- H. V. Morley, Agriculture Canada

TASK D

United States - M. V. Tellekson, U.S. Environmental Protection Agency
- C. L. Taylor, Ohio

Canada - C. Schenk, Ontario Ministry of the Environment
- R. L. Thomas, Environment Canada (CCIW)



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# TASK A

# TASK A

*To assess problems, management programs and research and to attempt to set priorities in relation to the best information now available on the effects of land use activities on the water quality of the boundary waters in the Great Lakes.*

## INTRODUCTION

In order that subsequent Tasks may derive the full benefit of past and present programs and activities pertinent to the goals of the Reference Group, it is essential that an assessment of the current state of the art be carried out, and that the Reference Group be kept informed of current developments. A detailed review of existing and potential control and remedial measures is required to consider their adequacy, practicability and probable cost.

This activity will answer those questions put to the Reference Group concerning the adequacy of existing control measures and will provide the data base upon which the Reference will draw in order to recommend management and control programs relevant to the problem areas defined by its studies.

## ACTIVITIES (CANADA AND U.S.)

(1) to assess the current state of knowledge regarding the pollution potential of various land uses.

(2) to assess and document the practicability and probable cost of available remedial or control measures.

## ACTIVITY 1 -

To assess the current state of knowledge relating to, and define problems associated with possible pollution of the Great Lakes arising from agriculture, forestry and other land use activities.

## METHODOLOGY

### Canada

Phase 1 -

The preparation of background documents on the current state of knowledge regarding management practices, regulations and

compliance, present and potential degree of pollution, public attitudes and socio-economic conditions related to pollution of the Great Lakes arising from land use practices in Canada as defined in Appendix II-1.

Phase 2 -

A continuous updating of this information, taking into account the many existing and proposed programs will assure the Reference Group is kept up to date on developments in this area. This activity is to be carried out by the Canadian members of the Reference Group and their staffs with some supplementary funding. Completion of a questionnaire and data matrix (Appendix II-2) by industrial, academic and government sources will support this activity.

United States

The Great Lakes Basin Commission (GLBC) will coordinate the execution of seventeen contracts relating to the provision of background data for Activity 1. The proposed categories and the type of information required for these background papers on land use/water quality relationships are listed in Appendix II-3.

These contracts will call for the contractor to indicate in quantitative terms, the present and potential degree of problems of the defined land use affecting surface and/or groundwater quality, with emphasis on the qualitative aspects which may impact upon the boundary waters of the Great Lakes system, the state of the art in assessing and quantifying problems, the range and general effectiveness of management technology, gaps in information for identifying problems and an assessment of the problems, state of research by classifying important projects as to pragmatic importance for reducing pollution and general priorities for management technology and applied research.

PARTICIPATING AGENCIES

Canada
- Environment Canada (EPS, EMS, FMS)
- Agriculture Canada
- Ontario Ministry of the Environment
- Ontario Ministry of Natural Resources
- Ontario Ministry of Agriculture and Food

United States
- Great Lakes Basin Commission
- Soil Conservation Service (USDA)
- Environmental Protection Agency

TIME SCHEDULE

Canada
- Phase 1 - estimated completion date March 30, 1974
- Phase 2 - continuing to 1977.

United States
- 6 months from initiation of contract
- estimated completion date May 1974.

ACTIVITY COST

Canada

| | |
|---|---|
| Environment Canada | $ 20,000 |
| Ontario Ministry of the Environment | 34,000 |
| | $ 54,000 |

United States

| | |
|---|---|
| Environmental Protection Agency | $ 50,000 |

ACTIVITY 2 -

A review of legislation pertinent to the land use activities under investigation. Documentation of all available remedial measures pertinent to problem areas defined by Tasks C and D. An evaluation of the efficiency and merit of the options available for remedial measures in general, as well as for the specific problems documented. Assessment of the probable cost of the remedial measures to be recommended by the Reference Group to the IJC. This activity will subsequently be integrated with Activity 5 of Task B.

PARTICIPATING AGENCIES

Canada
- Environment Canada (EPS)
- Ontario Ministry of the Environment

United States - Environmental Protection Agency

## TIME SCHEDULE

Canada - 3 years (74/75, 75/76, 76/77)

United States - 2 years (FY 75/76 and 76/77)

## ACTIVITY COST

Canada

| | |
|---|---|
| Environment Canada ..... | $ 75,000 |
| Ontario Ministry of the Environment ..... | 21,000 |
| | 96,000 |

United States

| | |
|---|---|
| Environmental Protection Agency ..... | $ 100,000 |

(Note - to date there has been no budgetary allocation for Activity A2 on the U.S. side).

# TASK B

## TASK B

*Inventory of land use and land use practices with emphasis on certain trends and projections to 1980 and 2020.*

### INTRODUCTION

Background information on characteristic basin properties such as land use and related material usage, physical fabric, climate, population and other socio-economic data is required for: (1) selection of study areas, (2) extrapolation of results from watersheds to larger regions (3) the foundation for assessment of trends in land use patterns and practices. Much of this information is available from a variety of sources.

The overall relative importance of many land uses and practices will change substantially in future years. In order that the management of land to minimize loss of pollutants in drainage waters can be planned in the light of these future trends, projections of land use, land use practices, population and other socio-economic characteristics are to be made to the years 1980 and 2020.

### ACTIVITIES (CANADA AND U.S.)

(1) To provide a general land use inventory of the Great Lakes Basin. (See Appendix III-1 for classification).

(2) To provide specific information concerning the nature and location of defined specialized land use categories in the Great Lakes Basin. (See Appendix III-2 for categories).

(3) To provide information on the physical fabric of the Great Lakes Basin including soils and their capability, hydrology, geomorphology, climate, mineral and gas resources, broad vegetation zones.

(4) To provide an inventory of various materials applied to land which may influence the quality of drainage waters.

(5) To provide a consistent and comprehensive set of forecasts for 1980 and 2020 relating to land uses and land use activities based upon socio-economic, technological and political developments.

## ACTIVITY 1 - General Land Use Inventory

This activity will inventory existing land uses for the total U.S.-Canada Great Lakes Basin according to the land use classification developed by the Reference Group. (See Appendix III-1). Output will be in the form of maps and tables delineating countys and watersheds or planning subareas. It is anticipated maps will be of the scale 1:250,000 or 1:500,000.

### METHODOLOGY

### Canada

### Data Collection

Much of the Great Lakes Basin has been mapped for the Canada Land Inventory at a scale of 1:50,000. This land use information has been generalized and the scale reduced to 1:250,000 for input to the data base of the Canadian Geographic Information System.

Due to the differences in classification between CLI and the LDRG, and due to the extent and date of CLI information, the following additional land use data is to be obtained.

(1) Urban (residential - commercial - industrial).
The Canada Centre for Remote Sensing (CCRS) will provide data in map form showing the present extent of the urban land use for major urban centres in the Canadian portion of the Great Lakes Basin. The urban land use will be separated into residential, commercial and industrial land uses. High altitude photography will be used.

(2) Within the Golden Horseshoe area (Oshawa to Niagara Falls) the CCRS will also indicate changes in other classes of land use.

(3) The CCRS will also provide land use information for the northern part of the Canadian portion of the Great Lakes Basin, outside of the area mapped by the CLI. CCRS will derive this information from ERTS imagery.

(4) The cropland - improved pasture ratio on the original CLI maps was based on the 1961 census of agriculture. This will be updated using the 1971 census of agriculture.

## Data Processing

The CLI and CCRS land use information will be put into the data base of the Canadian Geographic Information System. In addition the boundaries of the watersheds and political units will be put into the data base.

The Geographic Information System will then provide the land use composition of each watershed, county and district in acres, hectares and percent in a tabular form.

## Data Presentation

### Maps

(1) 1:250,000 Minor Watershed Maps

Approximately 33 1:250,000 maps will be produced indicating the land use composition of each of the minor watersheds within the Canadian portion of the Great Lakes Basin. On each map will be shown the boundaries of minor watersheds in the Basin. Within each basin will be a graph indicating the percentage land use composition of the watershed. These maps will be produced in black and white to enable easy reproduction.

(2) 1:500,000 Major Watershed Maps

Two maps will be produced, one for the northern part of the Canadian portion of the Great Lakes Basin and one for the southern part. The maps will be printed in two colours: black and red. The land use information by percent composition will be indicated by a graph inside or near each watershed.

(3) 1:500,000 County Maps

Two maps will be produced, one for the northern part of the Canadian portion of the Great Lakes Basin and one for the southern part. The land use information will be shown by graphs indicating percentage located in or near each of the counties and districts in the Basin.

### Tables

Accompanying the printed maps will be tables indicating the land use composition of each of the minor and major watersheds, lake basins, counties, districts and regional municipalities in the Canadian portion of the Great Lakes Basin. The tables will show the land use composition in hectares, acres and percent.

United States

Data Collection

Land use will be determined from computer analysis of imagery from the Earth Resources Technology Satellite (ERTS) by the Laboratory for Applications of Remote Sensing (LARS) of Purdue University in West Lafayette, Indiana, under contract to the U.S. Environmental Protection Agency.

The detailed work items for accomplishing activity B1 by LARS are:

(a) Proposal preparation (LARS)

(b) Ground-truth aircraft overflights of selected ground sites to secure detailed data for ground-truth background information. (LARS and SCS).

(c) Contract negotiations with LARS. (EPA)

(d) Negotiate with NASA and/or U.S. Geological Survey to obtain satellite imagery of the U.S. portion of the Great Lakes Basin (LARS and LDRG).

(e) Execute contract with LARS. (EPA)

(f) Implementation of contract.

Phase 1 -

(1) Refinement of land use classes (LARS and Task Group B).

(2) Initiate dialogue with printer (SCS, LARS and Task Group B). The LARS output must be compatible with printing and reproduction requirements and capability.

Phase 2 -

(1) Conduct land use inventory (LARS).

(2) Verification of results with local agents (LARS, SCS, Task Group B).

Phase 3 -

(1) Refinement of inventory (LARS).

Phase 4 -

Preparation of final report with maps, tables, and narrative including procedures used and evaluation of results (LARS).

Data Presentation

Maps

(1) County maps. Major land uses will be shown in colour for all U.S. counties in the Great Lakes Basin as defined by the mapping system developed by the Great Lakes Basin Commission.

(2) Subarea maps. Coloured maps of land use by counties will be aggregated to form land uses in each of the 15 planning subareas defined by the mapping system developed by the Great Lakes Basin Commission.

Tables

(1) Land uses will be tabulated by county, 1) as percent of total land in the county, and 2) as total area of each land use in the county in both metric and English units of measurement.

(2) Land uses will be aggregated in the tabular format specified in (a) for each of the 15 planning subareas in the Great Lakes Basin.

(3) Land uses will be aggregated in the tabular format specified in (a) for each of the 5 lakes in the Great Lakes Basin.

PARTICIPATING AGENCIES

Canada
- Environment Canada (Canada Land Inventory)
- Energy, Mines & Resources Canada. (Canada Centre for Remote Sensing)
- Ontario Ministry of Natural Resources

United States
- Environmental Protection Agency
- Soil Conservation Service

## TIME SCHEDULE

Canada - 11 months from initiation of activity
estimated completion date November 1974.

United States - 9 months from contract execution
estimated completion date January 1975.

## ACTIVITY COST

Canada

| | |
|---|---|
| Environment Canada (EMS) ..... | $ 59,500 |

United States

| | |
|---|---|
| Environmental Protection Agency ..... | 151,500 |
| Soil Conservation Service (USDA) ..... | 8,000 |

## ACTIVITY 2 - Specialized Land Uses

The objective of this activity is to provide specific information concerning the nature and location of the specialized land use categories in the Great Lakes Basin indicated in Appendix III-2. Also included in this category in the U.S. portion of the Basin is Recreational land which cannot be inventoried using satellite imagery.

### METHODOLOGY

#### Canada

This activity to be carried out by Chrysler-Latham Associates under contract to Environment Canada.

#### Data Collection

(1) Liquid Waste Disposal Sites
Review system certificates issued by Ontario Ministry of the Environment to operators of liquid waste disposal systems as well as the Soil Conditioning Site Certificates which approve disposal at individual sites. This data collection will have to be carried out at the MOE regional offices to insure accuracy.

(2) Solid Waste Disposal Sites
Information will be collected on the location and design of disposal sites which have been operating from 1971 to the present. Similar information will also be collected for those sites which had ceased to operate by 1971. The data on those systems that were in a non-operating condition in 1971 will be included because most of these sites will continue to produce leachates beyond the closing of the site. The inventory will include sites used for both industrial and municipal solid waste disposal. Data will be derived from the records of the Waste Management Branch, MOE, and from a survey of Municipal governments in the Great Lakes Basin.

(3) Land Fill Sites
Information on land fill applications will have to be extracted from the records in each of 37 Regional Conservation Authorities. Information may not be consistent across the Basin since each Conservation Authority acts independently on land fill applications.

(4) Deep Well Disposal Sites

Personnel in the Waste Management Branch, MOE have recently completed a report on the location of all deep well disposal sites. Therefore, only changes in format will be necessary for the compatible presentation of this data with other specialized land use information.

(5) Lakeshore and Riverbank Erosion

(a) Lakeshore -

Detailed information on the extent and rate of erosion affecting the Great Lakes shoreline will be available by June 30, 1974. This information, which is the subject of a joint Canada/Ontario Shore Damage Survey, will provide information on the historical changes in shoreline geometry as well as quantitative measurements of material eroded. Most of this information will only require changes in the scale of cartographic presentation to be compatible with other specialized land use information.

(b) Riverbank Erosion -

A number of studies have been undertaken by the Conservation Authorities Branch, Ministry of Natural Resources, pinpointing stream bank erosion problems in the following areas:

i) Nottawasaga River Basin
ii) Saugeen River Basin
iii) Niagara Peninsula
iv) Lower Trent River Basin
v) Metropolitan Toronto and Region Basins

Data supplied by MNR and that gathered by Task Group C will be utilized wherever possible.

(6) Intensive Animal Feedlots

For the purposes of the project, this land use class will include all livestock and poultry operations where confinement feeding is practised.

Wherever possible, information collected on livestock operations by personnel of Task C will be utilized, after some adjustment, to meet the requirements of Task B. In addition, a search of livestock marketing board records and a survey of county agricultural representatives will provide the remainder of the required information.

(7) High Density Non-Sewered Residential Areas
This specialized land use class will include year-round or full-time residential areas, as well as seasonal or part-time residential areas where possible. At this time, no government agency has collected comprehensive information on sewered versus non-sewered residential areas; therefore, information must be obtained from a variety of sources. This data must be reduced to a common denominator before final presentation.

(8) Past and Present Mining Activities Including Tailings and Slag Deposit Areas
It is believed that data on these areas will be available from the Ministry of Natural Resources and possibly from the Regional Offices of the Ministry of the Environment.

Data Presentation

Data to be presented in tabular and cartographic form with data aggregated on political (county) and drainage basin (watershed) basis. All cartographic presentations will be on black and white line maps of scale 1:250,000.

United States

This activity will be undertaken by the Great Lakes Basin Commission (GLBC) through a contract with the U.S. Environmental Protection Agency.

Data Collection

The GLBC will send a questionnaire to the State and local areas through the State members of the Reference Group on Pollution of the Great Lakes from land use activities. The questionnaire will require that data in this category be spotted on GLBC maps, that data will be supplied in tabular form, and that relative descriptive narrative be supplied. GLBC will also make use of data collected for its Great Lakes Basin Framework Study.

Data Presentation

The GLBC will organize the information collected in report form. The report will include a narrative and data presentation by county, planning subarea, lake drainage, and Great Lakes Basin drainage both in graphical and tabular form. For detailed output see Appendix III-3.

PARTICIPATING AGENCIES

Canada
- Environment Canada (EMS)
  (Chrysler-Latham Engineering Associates)
- Ontario Ministry of the Environment
- Ontario Ministry of Natural Resources

United States
- Environmental Protection Agency
  (Great Lakes Basin Commission)
- Soil Conservation Service USDA
- Economic Research Service USDA
- Great Lakes States

TIME SCHEDULE

Canada - 6 months from initiation of contract
estimated completion date August 1974.

United States - 1 year from execution of contract
estimated completion date January 1975.

ACTIVITY COST

Canada

Environment Canada (EMS) ..... $ 14,000

United States

Environmental Protection Agency .....

(Note: in U.S. Activities B2 - B5 have
a total supplementary cost of $50,000).

## ACTIVITY 3 - Physical Fabric

The objective of this activity is to provide background information and data on the physical fabric of the Great Lakes Basin with a specific slant toward land drainage/water quality relationship and to provide a detailed description of the Basin in terms of climate, population and socio-economic conditions, etc.

### METHODOLOGY (Canada and United States)

In the U.S. this activity will be undertaken by the GLBC through a contract with EPA. Assistance will be required from the SCS. In Canada the Ontario Ministry of Natural Resources will take prime responsibility for this activity.

### Data Collection

Data on the following parameters will be collected from various agencies, collated and synthesized to produce descriptive narrative maps and tables.

- soils (in Canada - includes soil capability)
- geology
- geomorphology (topography)
- hydrology (Canada - includes watersheds and man made impoundments)
- climate (includes rainfall-runoff)
- tributary stream description (Canada - includes major migration routes of sports fish)
- geography (broad vegetation zones, wildlife)
- mineral, oil and gas resources
- population (Canada - includes land ownership)
- economic activity

### Data Presentation

The report will include a summary narrative and statistical data presentation by county and watersheds or drainage area. (Also planning subarea for U.S. data).

### PARTICIPATING AGENCIES

Canada - Ontario Ministry of Natural Resources

United States - Environmental Protection Agency
- Soil Conservation Service

TIME SCHEDULE

Canada - 4 months from initiation
estimated completion date August 1974.

United States - 1 year from initiation
estimated completion date January 1975.

ACTIVITY COST

Canada

Ontario Ministry of Natural Resources ..... $ 60,000

United States

Environmental Protection Agency
(See Activity B2).

## ACTIVITY 4 - Material Usage

This activity will provide an up-to-date inventory of production and/or usage within the Great Lakes Basin of certain materials applicable to land with the potential of reaching the Great Lakes System through land drainage.

## METHODOLOGY (Canada and U.S.)

Data will be gathered, collated and synthesized so as to provide narrative, graphic and tabular information on the production and/or usage of the selected materials by county, planning subarea, lake drainage and Great Lakes Basin drainage on the U.S. side and on a major watershed basis (as defined by Activity B1) on the Canadian side. See Appendix III-4 for data collection guidelines.

Materials to be inventoried include:

(1) Pesticides (includes insecticides, herbicides, fungicides, etc.)

(2) Fertilizers

(3) Road Salts (deicing compounds)

(4) Agricultural Manures (applied to land)

(5) Agricultural lime and liming materials (U.S. only)

## PARTICIPATING AGENCIES

See Appendix for data collection guidelines.

Canada - Ontario Ministry of Agriculture and Food

United States - Soil Conservation Service
- Environmental Protection Agency (Great Lakes Basin Commission)

## TIME SCHEDULE

Canada - 6 months from initiation
estimated completion date September 1974.

United States - 1 year from initiation
estimated completion date January 1975.

ACTIVITY COST

Canada - Ontario Ministry of Agriculture and Food ..... $ 5,000

United States - Environmental Protection Agency
(See Activity B-2)

## ACTIVITY 5 - Future Trends

To identify and assess future trends in major land uses, specialized uses, material usage, and related information which directly or indirectly may affect the drainage of pollutants into the Great Lakes, for the target years 1980, 2000, 2020. The forecasts should take into consideration various assumptions that could be made regarding technological developments, changes in attitude of the Basin population, and consequent policy and legal adaptations. This Task will integrate with Activity 2 of Task A and portions of Working Group A of the Upper Lakes Reference Group.

### METHODOLOGY

#### Canada

This activity will produce projections of major land uses, specialized land use, and material usage for the target years indicated, by analyzing the following sectors, insofar as these conditions affect the land or material usage and/or directly or indirectly affect the transfer of pollutants to the Great Lakes system.

(1) Population Trends

- (a) national and regional projections
- (b) migration patterns
- (c) urbanization
- (d) Basin projections

(2) Economic Activity Trends

- (a) primary industries
  - agriculture
  - mining
  - forestry
  - power generation
- (b) secondary industry by major class
- (c) tertiary industry by major class
- (d) investment trends
- (e) industrial location

(3) Institutional and Legal Structures

- (a) jurisdictions
- (b) legislative framework (e.g. land use control)
- (c) public participation

(4) Alternative Assumptions

Alternative assumptions regarding population attitudes with regard to resources management and consequent changes in institutional and legal arrangements will be listed. Changes in technological development will be considered at various rates of change.

Application of alternative assumptions to the conventional projections will result in the production of a number of scenarios for future land uses.

United States

Activity B-5 will be completed under the general direction of the Great Lakes Basin Commission under contract with the U.S. Environmental Protection Agency. The Basin Commission will coordinate and provide for publication of inputs from the other parties. Negotiations are underway to secure data on trends in population, economic activity and general land use; the Task B technical committee will formulate a statement concerning future trends in specialized land uses and it is proposed that the Soil Conservation Service assess trends in certain material usage. It is anticipated that much of the data required will be available from the Great Lakes Basin Commission's Great Lakes Framework Study.

The report will consist of four sections:-

(1) Population and Economic Activity

- population changes and characteristics
- economic activity, particularly areas such as agricultural and forest production, etc.

(2) Major Land Use Classes

(3) Special Land Use Classes

(4) Material Usage

PARTICIPATING AGENCIES

Canada
- Environment Canada (EMS, EPS)
- Statistics Canada
- Agriculture Canada
- Ontario Ministry of the Treasury, Economic and Intergovernmental Affairs

United States - Environmental Protection Agency
(Great Lakes Basin Commission)
- Soil Conservation Service USDA
- Economic Research Service USDA
- Great Lakes States

TIME SCHEDULE

Canada - 1 year from initiation
- estimated completion date April 1975

United States - 1 year from initiation
- estimated completion date April 1975

ACTIVITY COST

Canada - Environment Canada ..... $ 95,000

United States - Environmental Protection Agency
(See Activity B-2)

# TASK C

## TASK C

*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.*

### INTRODUCTION

Watersheds have been selected for intensive studies in Canada and the United States of America to cover a wide variety of potential sources of pollution to the waters of the Great Lakes. The selection criteria included climate, geology, soil characteristics, land uses, and information available from completed or on-going studies.

Major watersheds selected for study in Canada are:

Grand River draining to Lake Erie

Saugeen River draining to Lake Huron

Wilton Creek draining to Lake Ontario (Hay Bay)

(See Appendix IV-1 for map and descriptions).

Major watersheds selected for study in the United States are:

Genesee River, New York and Pennsylvania, draining to Lake Ontario

Menomonee River, Wisconsin, draining into Lake Michigan

Felton-Herron Creek and Mill Creek, portions of the Grand River, Michigan, draining to Lake Michigan

Black Creek portion of the Maumee River, Indiana, draining to Lake Erie, supplemented by a study in the Ohio portion of the basin

(See Appendix V-1 for map and descriptions).

Agricultural and other land uses not adequately represented in the major basins will be incorporated into the study by including additional sub-watersheds. Information on the effect of boreal forestry operations will be derived in large part from on-going studies of the Canadian Forestry Service in the Winnipeg River system, to the west of the Great Lakes basin. Other on-going studies that will contribute needed information are to be utilized, and promoted if necessary and feasible, to help meet the needs of the Land Drainage study.

The characteristics of the major Canadian and U.S. watersheds are summarized in Appendices IV+V. The selection of sites for detailed studies of various sources of pollution and land-use practices is to be made on the basis of continuing evaluation of monitoring results, physical characteristics, land uses and literature and state-of-the-art reviews. The studies to be carried out in the major basins and in selected sub-basins are described for the Canadian studies under activity headings, and with individual basin write-ups for the U.S. studies. Laboratory support costs have been assigned to the major activities.

The extrapolation of results from the selected watersheds to other parts of the Great Lakes basin will be investigated through the use of quality and quantity modelling techniques. For example, the Ontario Ministry of the Environment is currently developing a model in the Thames River basin which deals with a number of water quality and quantity parameters. This model will undergo further testing and development as one of the methods for extrapolating information. Another method available for extrapolation of results, will be to proportion the quality parameters measured at quality monitoring stations on the basis of the land uses within those basins and the results of the detailed watershed studies and the literature and state-of-the-art reviews and work carried out under Tasks A, B, C and D.

Duration of Study

The main period of field activities will extend from the spring of 1974 to the spring of 1977. The data collected during this period are to be analysed and presented in the main report on Task C activities, scheduled for completion in November 1977.

Many of the monitoring facilities will be installed, calibrated and tested during 1974. The initial results will provide information needed to aid in selecting sites and developing plans for subsequent, detailed monitoring and survey programs. Most detailed studies of specific sources of pollution will commence in 1975/76 and continue through 1976/77.

It is anticipated that the results obtained during the field programs will indicate that several studies should be continued through 1977 and into subsequent years, and provision is made in the cost estimates to continue selected monitoring programs to March 31, 1978.

ACTIVITIES - CANADA

ACTIVITY 1 - Agricultural Watershed Surveys

The object of the study outlined in the following pages is 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.

The approach is intended to allow measurements to be made of the quality and quantity of water which is known to have flowed from agricultural land and/or facilities. It is also intended that different types of agriculture, in different parts of the Great Lakes basin, will be identified in relation to the water quality measurements made. In this way, it is hoped that "agriculture" imputs can be quantified and incorporated into the overall analysis of the contribution of pollutants by land drainage to the Great Lakes.

SCHEDULE OF ACTIVITIES

Sub-Activity 1 -

Identification of factors to be utilized in the selection of agricultural regions and watersheds within these regions (Factors A) and those to be utilized in the selection of watersheds for detailed studies (Factors B). Factors A and B are listed in Appendix IV- 2a. Estimated completion date September 30, 1973 - Completed.

Sub-Activity 2 -

Compile and prepare existing data for the Canadian Great Lakes Basin in a form suitable for watershed selection. See Appendix IV-2b for details of data collection. Estimated completion date: Factors A - November 30, 1973; Factors B - September 15, 1974.

Sub-Activity 3 -

Utilize prepared data for identification of major agricultural regions in terms of the factors determined above. Estimated completion date December 31, 1973.

Sub-Activity 4 -

Select required number of sub-watersheds to represent each major agricultural region. Estimated completion date January 31, 1974.

Sub-Activity 5 -

Determine number of monitoring sites, frequency of sampling and type of analyses required to evaluate the impact on water quanlity of the agriculture of each region. Re-examine estimates of costs. Estimated completion date February 15, 1974.

Sub-Activity 6 -

Determine responsibility for sample collection laboratory analyses and evaluation of results. Estimated completion date Fabruary 15, 1974.

Sub-Activity 7 -

Preliminary Instrumentation. Estimated completion date March 15, 1974.

Sub-Activity 8 -

Carry out preliminary phase of the study until sufficient data has been collected to assess the relative significance of each agricultural region in terms of water quality and to determine watershed priorities for the detailed phase of the study. Estimated completion date September 15, 1974, (end of Phase I).

Sub-Activity 9 -

Utilize prepared data (Factors B) for identification of sub-watersheds to be included in the detailed study. Estimated completion date October 15, 1974.

Sub-Activity 10 -

Install continuous monitoring equipment on outlets of watersheds selected for the detailed phase of the study. Estimated completion date November 30, 1974.

Sub-Activity 11 -

Determine monitoring needs for implementation of the detailed phase of the study, so that individual agricultural activities and associated management practices may be investigated in the selected watersheds. Re-examine cost estimates. Estimated completion date December 31, 1974.

Sub-Activity 12 -

Distribute responsibility for the components of the detailed study. Estimated completion date February 28, 1975.

Sub-Activity 13 -

Instrumentation within selected watersheds. Estimated completion date May 30, 1975.

Sub-Activity 14 -

Conduct study until sufficient data has been collected to assess relative significance of individual agricultural activities in the selected watersheds and assess effects of various management techniques. Estimated completion date May 30, 1977. (End of Phase II).

Sub-Activity 15 -

Final Report and Recommendations. Estimated completion date November 30, 1977.

## METHODOLOGY

### Agricultural Region Selection

Existing information has permitted the identification of five distinct agricultural areas at the present time. The boundaries of these areas remain to be determined upon completion of the mapping phase described below. It is anticipated that between 10 and 20 distinct agricultural regions will be identified from inspection of the soils, livestock and crop distribution maps, and consideration of the two major climatic zones of the basin. Regions close to the boundary of the two climatic zones will be given special consideration to ensure that duplication of regions does not occur.

### Sub-Watershed Selection

Airphotos* on a scale of 4 in. (or more):1m. are being used to determine the precise land use for small (1-10 sq. miles) watersheds within the major agricultural regions. Comparisons between a number of small watersheds are being made with the airphotos, and the small watershed which has the least amount of non-agricultural land use, and which also includes the typical agricultural activities of the region, is being selected for inclusion in the study. Prior to the final selection of any small watershed, contact is being made with research personnel - Federal, Provincial and University - to ensure that areas of particular interest, or those included in present or proposed related studies, are given adequate consideration.

*Airphotos are from both Ontario Ministry of Natural Resources and Department of Energy, Mines and Resources, Canada.

### Sample Collection

The preliminary phase of the study will rely heavily on measurements made at the outlets from the small watersheds. If the small watersheds fall on a section of a stream, measurements will also have to be made upstream of the section. It is possible that use could be made of batch type sampling (grab samples) in this phase of the study. The sampling interval would need to be frequent, especially on the smallest watersheds where samples may need to be taken in relation to the runoff pattern. Continuous proportional sampling may be necessary on some of these watersheds.

Approximation of flow rates may be acceptable, or recording water level gauges with or without controlled cross sections may be necessary. Rain gauges may be needed in regions where there are no permanent weather stations. Rain water sampling will be necessary on at least an intermittant basis. It is anticipated, however, that instrumentation for the preliminary phase of this study will not be extensive.

## Determinations and Analyses

The following is the list of microbiological, physical, in situ, inorganic and organic measurements to be included in the preliminary phase of the study:

Microbiological: faecal coliform
total coliform
faecal streptococci
enteroviruses

Physical: Total solids, suspended solids, turbidity, alkalinity, $BOD_5$, COD.

In situ: Flow, temperature, pH, conductivity, D.O.

Inorganic

nitrogen - (Kjeldahl, ammonium, ammonia, nitrate, nitrite)
phosphorus - (total, organic, soluble ortho, particulate)
potassium
chloride

sodium, calcium, magnesium - perhaps only intermittantly

sulphur - (sulphate, mercaptans where pesticide usage known)
arsenic - (in apple orchards and if found in fertilizers)

selenium, copper - where known to be used as a livestock feed additive

mercury - if pesticide or other usage known

lead, zinc - perhaps intermittantly

boron, chromium, fluorine - if found in fertilizers

Organic

Pesticides - as indicated by usage in the watershed.
N.T.A. - if used in detergents on farms in watershed.

## IMPLEMENTATION OF THE STUDY

### PHASE I

Implementation of the preliminary phase of the study should proceed until enough data has been collected to evaluate the relative contribution of each agricultural watershed to water quality downstream or in a receiving lake. In some cases, it is anticipated that a relatively short period of monitoring may reveal the presence of some contaminant in fairly high concentrations. If this is the case, plans can be made immediately for more detailed studies with the object of determining the sources and characteristics of the contaminant. Where other chemicals and/or water quality parameters do not appear to vary significantly from the mean values found for all the agricultural watershed outflows, the monitoring should be continued, at least in some form, for the entire duration of the study so that confidence limits may be placed on the values obtained. If, however, it is subsequently evident that a seasonal or other change in water quality occurs which was not detected in the initial phase of the study, and which results in contaminant levels which are of concern, then detailed studies should be conducted to determine the nature and cause of the variability.

### PHASE II

It is anticipated that the detailed studies, to be the main feature of the second phase of the study, will not be required on all of the small watersheds. The results of the preliminary phase of the study should allow the watersheds to be ranked in order of priority for the detailed phase. Consultation with involved and other interested specialists will help determine priorities and plan proposals for the detailed phase of the study.

Monitoring equipment suitable for Phase II of the studies will be installed as the watersheds for detailed study are identified.

## ACTIVITY COST

| | |
|---|---|
| Agriculture Canada ..... | } $ 1,606,000 |
| Ontario Ministry of the Environment ..... | |
| Ontario Ministry of Agriculture and Food ..... | |

## ACTIVITY 2 - Forested Watershed Surveys

On-going studies by the Great Lakes Forest Research Centre, carried out in northwestern Ontario, will adequately serve the needs of the study with respect to the impact of forestry activities on water quality in Precambrian watersheds with boreal forests.

### OBJECTIVES

(1) To determine the effect that various forest management practices may have on water quality and quantity.

(2) To describe the relationship between topography, soil, vegetation and road locations, and the incidence and severity of soil erosion.

### PARTICIPATING AGENCIES

- Environment Canada, Great Lakes Forest Research Centre

### TIME SCHEDULE

This on-going program will be continued through the period of the Land Drainage Reference Study.

### ACTIVITY COST

This on-going project is being financed by the Environmental Management Service, Environment Canada at the rate of $160,000 per year. No supplementary financing is required at this time.

ACTIVITY 3 - Study of Pollution and the Adequacy of Controls Related to Urban Land Development and Use, Transportation and Utility Systems, Sanitary Landfills, Processed Organic Waste Disposal, Waste Water Lagoons and Irrigation Systems, Land Fill, Extractive Industries, Private Waste Disposal, and Recreational Land Use.

General Objectives

1. To determine the levels and quantities of major and trace constituents, including nutrients, pesticides and sediments, reaching the Great Lakes or moving in flow systems likely to reach the Great Lakes in the future by studying selected operations of the land use activities outlined above in representative basins or areas and extrapolating the results to provide estimates for other areas of the Great Lakes Basin.

2. To determine the adequacy of existing control measures related to the above sources of pollution and develop recommendations for improvements as needed.

METHODOLOGY

Parameters of Pollution

The study of land use practices outlined in Activity 3 will include analysis for some or all of the following physical, chemical, biochemical and bacteriological parameters. The selection of pollutants to be measured in any of the individual studies will be dictated by materials expected to be found associated with the land use activity.

Microbiological

Total and fecal coliform, fecal streptococcus.

Physical

Total, suspended and dissolved solids, turbidity, conductivity, temperature, streamflow and pH.

Chemical

(a) $BOD_5$, COD, dissolved oxygen, nitrogen fractions, total and soluble phosphorous, chloride, alkalinity, sodium, potassium, calcium, magnesium, sulphur, arsenic, iron, copper, lead, zinc, chromium, mercury, cadmium, selenium, boron, fluorine.

(b) Pesticides, NTA, PCB.

Specific Land Use Study Plans

Urban Land Development and Use

This study will determine the significance and magnitude of material inputs from municipal land drainage. Among the potential sources of pollution within this land use category are storm drainage, sewage by-pass, deicing salt operations, construction, and runoff from industrial areas and parking lots.

Field Activities:

1974-1975

No major studies are planned for this year but events which may occur within the pilot basins and could provide useful information will be investigated.

Municipalities to be studied in subsequent years will be selected during this period.

1975-1976

(i) Six municipalities ranging from cities with full sanitary and storm sewer systems through smaller towns and villages with varying forms of sewerage systems to small communities with no organized collection systems will be studied.

Emphasis will be placed on seasonal variations in material loadings caused by such factors as major rain storms, winter road salting, subdivision construction, etc.

Parameter (pollutant) selection will be dictated by the particular land use activity under investigation.

(ii) Intensive investigations of urban land drainage in several municipalities in a pilot basin will be conducted this year. These in-depth studies will provide data for meaningful extrapolation of the magnitude of material inputs from other municipalities in the Great Lakes Basin.

1976-1977

A similar program to that outlined in Item (i) for 1975-1976 will be undertaken this year. Several other municipalities, again ranging from cities to villages will be studied, and two studies initiated in municipalities in 1975-1976 will be continued.

1977-1978

No field work is anticipated for this year. All efforts will be devoted to data interpretation and report writing.

The agency primarily responsible for this study is the Ontario Ministry of the Environment.

Transportation and Utility Systems

The purpose of this study is to measure the magnitude and significance of material inputs from transportation and utility corridors (i.e. highways and roads, railways, hydro lines, pipeline crossings, etc.) under the two categories (i) maintenance and (ii) construction. Surveillance of the maintenance programs will include winter deicing and sanding operations and summer dust control on highways and roads, the use of herbicides for weed control along roadways and hydro corridors, etc. Construction programs are for the most part short-term events (e.g. pipeline crossings, bridge construction, etc.) which may cause some water quality impairment during and shortly after the construction operations. Their effects will be studied at selected construction sites.

Field Activities:

1974-1975

No major studies are planned for this year but events which may occur within the pilot basins and could provide useful information will be investigated.

The selection of sites for investigations during 1975-76 and 1976-77 will be made during this year.

1975-1976

(i) Highway and roads a) construction - one major crossing
- one smaller (routine) crossing

b) maintenance - one highway (summer & winter)
- one unpaved roadway (summer & winter)

(ii) One railway crossing (maintenance)
(iii) One hydro corridor (maintenance)
(iv) One pipeline crossing (construction)

1976-1977

A similar series of projects to 1975-76 will be conducted during this year at different sites. (Note: A major construction program initiated in 1975-76 may require further field work during this year).

1977-1978

No field work is anticipated during this year. Efforts will be devoted to data interpretation and reporting.

The Ontario Ministry of the Environment will be primarily responsible for this study.

Sanitary Landfill Sites Study

Two major sanitary landfill sites are proposed for detailed study to determine the levels and quantities of major and trace constituents moving in flow systems likely to reach the Great Lakes. Two possible sites are:

(1) a site in the vicinity of Waterloo in the Grand River basin.

(2) a site in the vicinity of Kingston.

These sites will represent typical site conditions from two different soil type areas, an area of thin soils over limestone bedrock and an area of thick overburden. The study will provide information on leachate composition, migration, soil attenuation and the ultimate fate of constituents from a sanitary landfill.

Field Activities:

1974-1975

Ground-water monitoring and soil-testing facilities will be installed and operated at one site and monitoring will be carried out at another site where suitable conditions and facilities are available.

1975-1976 and 1976-1977

Monitoring programs will be continued.

1977-1978

Results will be analyzed and incorporated in the Task C report. The principal participating agency is the Ontario Ministry of the Environment.

Processed Organic Waste Sites Study

The study will investigate the possible contributions of processed organic wastes disposed on land to the pollution of the Great Lakes through detailed surveys at two locations. In the Grand River Basin, two possible sites are the City of Brantford site (70 acres) and the City of Guelph site (approximately 20 acres). These sites are suggested as they have been used continuously over a number of years. The soils are typical for much of Southern Ontario. Nutrients and heavy metals will be investigated since many of the heavy metals represent a serious pollution hazard and since many are ubiquitous in leachate.

At each site surface and ground-water samples will be taken and analyzed. In addition soil and vegetation samples will be taken at each site before the start of the study and thereafter at intervals and analyzed for nutrients and heavy metals.

Field Activities:

1974-1975

Ground- and surface-water monitoring and soil-testing facilities will be installed and operated at one site.

1975-1976

Ground- and surface-water monitoring and soil-testing facilities will be installed at a second site and monitoring programs will be carried out at both sites.

1976-1977

Monitoring programs will be continued at both sites and additional tests of soil or water characteristics will be made as needed.

1977-1978

Results will be evaluated and incorporated in the Task C report. The Ontario Ministry of the Environment is the principal participating agency.

Wastewater Lagoons and Irrigation Systems

Selected waste-water lagoons and irrigation systems will be studied as needed to augment information available from inventories and on-going studies to determine the significance of pollution loads from municipal and/or industrial disposal systems.

Field Activities:

1976-1977

Ground-water and surface-water monitoring facilities will be installed and detailed monitoring programs commenced to assess the movement of pollutants from waste-water lagoons and irrigation sites.

1977-1978

Monitoring programs will be continued and additional monitoring stations installed at existing or new study sites. The first year's results will be assessed and incorporated in the main Task C report.

The Ontario Ministry of the Environment will be responsible for this study.

Land Fill

The purpose of this investigation is to determine the effects of land fill activities (i.e. reclamation) on water quality within river basins.

Field Activities:

1974-1975

No field activities are planned for this year.

1975-1976 and 1976-1977

One land fill or reclamation operation will be studied within an Ontario river basin during each of the two study years. If possible, two entirely different types of reclamation operation will be studied (i.e. rubble vs. sand, silt, or clay fill).

The Ontario Ministry of the Environment will be principally responsible for this study.

Extractive Industries

This study will be undertaken to determine the effects of land-based extractive operations (quarries, pits, mines, etc.) on water quality.
Note: Dredging of river beds is not included but this activity is being adequately assessed by other investigators.

Field Activities:

1974-1975

No field activities are planned for this year but areas for study during 1975-1976 and 1976-1977 will be selected.

1975-1976 and 1976-1977

Two extractive operations will be studied in each of the two years. If possible, one study each year will be from an operation with a treated discharge and one from an extractive operation with uncontrolled discharge.

1977-1978

No field activities are planned for this year. Efforts will be devoted to interpretation of data and report preparation.

The Ontario Ministry of the Environment will be responsible for this study.

Private Waste Disposal

The purpose of this study is to determine the significance and magnitude of material inputs to river basins from private sewage treatment systems (septic tanks) in various areas of the Province. It is planned that studies will proceed in

municipalities or densely developed recreational areas in the Precambrian Shield and other areas of shallow overburden. Other studies are planned in municipalities with no organized collection systems in south-western Ontario. Radioactive tracers and other methods will be employed to determine the movement of contaminating materials from private waste disposal systems.

Field Activities:

1974-1975

Studies in some of the areas outlined above will be initiated this year probably in the Precambrian area.

1975-1976, 1976-1977 and 1977-1978

Studies will continue at a reasonably constant rate throughout these years with the areas of study expanded to other typical areas of Southern Ontario.

While it is not expected that all field studies will be completed in time for the final report, it is expected that many of the investigations will be completed and included in the report.

The principal investigating agency involved with this study is the Ontario Ministry of the Environment.

Recreational Lands

The purpose of this study is to measure the effects of recreational land use (day parks, camp sites, trailer parks, etc.) on water quality.

Field Activities:

1974-1975

No field activities are planned for this year but site selections for 1975-1976 and 1976-1977 field activities will be made.

1975-1976 and 1976-1977

Each year one of each of the two following types recreational areas will be studied.

(i) Densely populated camp ground or trailer park.

(ii) Day park with facilities for picnicing, etc.

1977-1978

No field work is planned for this year. Effort will be devoted to interpretation of data and report preparation.

The Ontario Ministry of the Environment and the Ontario Ministry of Natural Resources will be primarily responsible for this study.

ACTIVITY COST

Ontario Agencies ..... $ 1,346,000

ACTIVITY 4 - Water Quantity and Quality Monitoring Framework

The objective of this activity is to determine the levels and quantities of major and trace constituents, including nutrients, pesticides and sediments reaching the Great Lakes or moving in flow systems likely to reach the Great Lakes in the future by sampling surface and ground waters and operating streamflow gauging networks. The monitoring program will be intensified in the three pilot basins and other areas of the Province where land use activities are being studied. This program will provide the framework for studies of pollution attributable to various specific land use practices.

The monitoring program will be devided into two principal functions. The larger program which is being identified as the "Extensive Surveillance Network" will comprise a number of semi-permanent ground-water and surface-water quality and quantity measuring stations. The exact number of stations and their locations will be dictated by the various individual land use studies. Sampling frequencies and water quality analysis will also be governed by the individual land use activities (seasonal changes due to management practices, weather, etc.).

The second function called the "Intensive Studies Program" is basically a series of short-term (24-96 hour) investigations in river basins to complement individual land use studies underway at the same time or to provide detailed information where on-site investigations are not practical or possible. The length of each study, sampling frequency, sampling locations, parameter selection, etc. will be dictated by the land use under study. It is intended that at least two such studies be carried out at each site under different climatological conditions or at times when management practices or other influencing factors may cause major changes in land drainage patterns.

Field Activities:

1974-1975

Extensive Surveillance Network - A number of key surface and ground-water monitoring stations will be established to assist in the identification of significant agricultural and other land use activities.

As the exact areas for land use studies are identified, monitoring locations will be assessed and all pre-operational activities will be undertaken to make the stations functional by early 1975.

Intensive Studies Program - A number of intensive studies dealing primarily with ground-water will be undertaken this year to assess individual land use practices. These are generally long-term studies which must be initiated this year for inclusion in the final report.

1975-1976 and 1976-1977

Extensive Surveillance Network - All stations in the network will be in operation for the 1975 spring runoff and will continue through the spring of 1977. Although there may be some changes at some locations, it is expected that the number of stations and sampling frequency will remain fairly constant through this period.

Intensive Studies Program - This program will be in full operation in 1975 and it is expected that 20 to 30 individual intensive studies will be conducted in each of the two years.

1977-1978

Extensive Surveillance Network - It is expected that activities in this program will be reduced to about 50% of the 1975-77 monitoring program. Sampling will concentrate on "hot-spots" or areas where insufficient information was accumulated, for various reasons, during the 1975-77 study period.

Intensive Studies Program - Studies in this program will be reduced to about 33% of the 1975-77 activities. As in the Extensive Program, studies will centre in "hot-spots" or areas requiring further study.

The Ontario Ministry of the Environment is principally responsible for the maintenance of this activity-

ACTIVITY COST

Ontario Ministry of the Environment ..... $ 901,000

ACTIVITY 5 - Laboratory Support for Water Quality Monitoring, and Pollution-Source Studies

Laboratory support is to be increased significantly to meet the requirements of the water quality monitoring program and surveys of pollution sources. Several Ontario and Canadian laboratories will carry out the analyses. Analytical methods and results are to be reviewed by a Methodology Task Force representing laboratories in Canada and the United States to ensure that the results from the various laboratories are comparable.

PARTICIPATING AGENCIES

Agriculture Canada, Ontario Ministry of Agriculture and Food, Ontario Ministry of the Environment. Laboratory facilities of other agencies may be utilized.

ACTIVITY COST

The costs of laboratory services have been distributed to the various monitoring and survey programs.

## ACTIVITY 6 - Riverbank Erosion Surveys

Riverbank erosion may represent a significant contribution of sediment to the Great Lakes. It is intended to measure the quantity and quality of eroded streambank material. The erodibility will be identified in different parts of the Great Lakes basin in relation to soil groups, climate, and river morphology. It is expected that streambank erosion inputs can be determined and incorporated into the overall analysis of Great Lakes pollution.

### METHODOLOGY

#### (a) Preliminary phase of study

In the preliminary phase, extensive, typical and/or unique streambank erosion regions should be identified in the Great Lakes region. It is expected that about 20 streambank erosion regions can be identified from inspection of soils and river morphology.

A streambank erosion region is defined as an area of similar streambank soils in the same river morphology and climatic zone.

(1) Soils - Grouping of streambank conditions considering soil profiles, grain size distribution, ground water conditions and other parameters which will reflect the erodibility of streambanks.

(2) River morphology - The morphology of rivers has been grouped where possible with respect to flow, slope, meander pattern and channel cross-section to determine the effect on streambank erosion.

(3) Climate - The lower degree-days, higher snowfall, rainfall and runoff in the central uplands is considered in contrast with the climate at lower elevations, and more influence from the Great Lakes.

Data collection should proceed until sufficient data are available to evaluate the relative contribution of each streambank erosion site to the water quality of the stream.

#### (b) Detailed phase of study

The data from the preliminary phase of the study should be evaluated.

The data should indicate those streambank erosion regions from which significant quantities of pollutants are discharged into the Great Lakes. The Primary objective of the detailed phase of the study will be the measuring of quantities of pollutants.

The streambank erosion study will rely on measurements made at the erosion sites, and the physical and chemical analyses of the streambank by means of boreholes. The sampling intervals would be frequent during high flows and heavy rains. Approximate flow rates should be determined by means of level gauges. Rain gauges may be needed in regions where there are no permanent weather stations.

PARTICIPATING AGENCIES

Ontario Ministry of Natural Resources

| SCHEDULE OF ACTIVITIES | Target Date |
|---|---|
| Identification of factors required in the selection of streambank erosion sites. | February 15, 1973 - completed |
| Compile and review existing data, select representative streambank erosion sites, and determine monitoring program and cost estimates for preliminary phase of study. | September 30, 1974 |
| Install instrumentation, monitor, assess relative significance of each erosion area and determine monitoring needs for detailed phase of study. | December 15, 1975 |
| Install instrumentation at new monitoring sites. | January 15, 1976 |
| Conduct study until sufficient data have been collected to assess relative significance of each streambank erosion area and assess effects of streambank protection techniques. | May 31, 1977 |
| Prepare final report and recommendations | November 30, 1977 |

ACTIVITY COST

Ontario Ministry of Natural Resources ..... $ 120,000

## GENESEE RIVER WATERSHED STUDY

Because of previous experience, a great variety of land uses, and an extensive existing base of data in the Genesee River Basin, it has been selected as one watershed to be studied as part of the IJC Program.

Facilitating studies on the Genesee, New York State has maintained water sampling stations in the area and has collected historical water quality data; and the U.S. Geological Survey has maintained stream gages on the river since at least 1935 and on its tributaries since 1945.

The Genesee River possesses a wide variety of industrial and agricultural enterprises which discharge hazardous substances. The possibility of transport spills is also great and could be profitable exploited. Records of stream flow and some historical water quality data are available. The State district health and environmental conservation offices are located nearby and have personnel familiar with the area. An EPA sampling station for the materials balance aspect of IFYGL was located at the mouth of this watershed.

### OBJECTIVES

(1) To measure the ambient concentration and loading rates for various pollutants that occur with given land use types.

(2) To determine the effects of the geophysical and geochemical nature of land on ambient concentrations and loading rate.

(3) To derive information on the mechanics of transport and storage of pollutants in a large stream system.

(4) To develop a model for the above relationships so that the information derived can be utilized in a predictive sense and extrapolate to other watersheds.

### METHODOLOGY

The overall plan of the study is as follows:

(1) Develop a conceptual model of occurrence and transport of pollutants* in the Basin.

(2) Quantify the model to the extent possible utilizing existing data not only from the Genesee River Basin, but from studies and research done elsewhere.

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* The specific pollutants to be considered will be those developed by the Land Drainage Group Task C Committee.

(3) Develop and implement a sampling network to provide data for final model verification.

(4) Develop and carry out intensive detailed studies in those areas where insufficient data is available and mechanisms are insufficiently understood.

(5) Verify the model.

All planning, study methodology, field sampling, analytical methods and data analyses will be coordinated with other IJC study programs. Data and information from other programs will be integrated into the study as they are developed.

## POTENTIAL STUDY PARTICIPANTS

As presently envisioned, the following groups would participate in the study:

| Group | Major Functions |
|---|---|
| (1) IJC Land Drainage Reference Group Task C Technical Committee | Overall study direction and coordination with other IJC watershed studies, standardization of field and laboratory methods. Selection of parameters to be studied. |
| (2) Environmental Quality Research Unit, New York State Department of Environmental Conservation | Coordination with other IJC studies, development of sampling station network program, overall project management, detailed project direction, model development, coordination of special studies, field sampling, overall data analyses, development of field instrumentation, development of point source and other pertinent field data, special studies as appropriate, preparation of final report. |
| (3) Cornell University | Detailed project development, model development, data evaluation, project evaluation, sediment studies, special studies as appropriate. |
| (4) Division of Laboratories and Research, New York State | Development of field instrumentation, development of laboratory methods, laboratory analysis, studies on biological interaction and the effects of weeds, other special studies as appropriate. |

| Group | Major Functions |
|---|---|
| (5) New York State Department of Education, Geological Survey | Sediment studies, geochemical analysis, geological and geochemical data interpretation. |
| (6) U.S. Department of the Interior, Geological Survey, Albany District | Hydrology of basin, flow measurements, precipitation measurements, time of travel studies. |

Intended Use of Output

The primary use of the outputs of the study will be to answer the questions given to the Land Drainage Reference Group by the International Joint Commission concerning the effect of land use activities on the international waters of the Great Lakes.

The study will also provide valuable data and information for use by the State in implementing Sections 201, 208, 303, 305 and 314 of the Federal Water Quality Act. In order to properly implement these sections, the following questions regarding non-point source pollution must be answered.

What is the impact of non-point source pollution on in-stream water quality?

How does non-point source pollution originate?

When and in what quantity does it reach the stream?

How is it transported in the stream?

How does it affect the assimilative capacity of the stream in relation to non-point sources?

TIME SCHEDULE

It is estimated the project will take 4 years to complete with an estimated completion date of December 1977.

ACTIVITY COST

Supplementary requirements are $1,326,500

| | |
|---|---|
| Federal Agencies | $1,326,500 |
| State Agencies | $ 397,600 |
| TOTAL | $1,724,100 |

(see Appendix V-2 for a detailed cost summary).

## MENOMONEE RIVER WATERSHED STUDY

Several key factors entered into selection of the Menomonee River watershed for intensive study under the IJC project. Not only is the watershed highly urbanized--approximately three-fourths of the land is in some type of urban use--but the watershed and contiguous lands contain a full range of urban uses including low to high density residential areas, extensive commercial and industrial tracts, and a considerable amount of land devoted to transportation facilities. The high degree of diversity of urban land uses in this watershed is reflected by the existance of combined and separate sewer systems. A dynamic dimension is added by the rapid development occurring in the upper quarter of the basin where agricultural land is being converted to urban land uses. An unique facet of the Menomonee watershed stems from the proposed plan to remove all municipal point sources of pollution by 1976, at which time, the effects of land use on water quality will arise almost entirely from non-point sources. Thus, of the six major watersheds chosen for intensive study, the Monomonee watershed will serve as the focus of investigations on the impact of urban land uses on water quality. Data obtained in the Menomonee watershed will be used to extrapolate the effects of urban land use on the water quality of the entire Great Lakes Basin.

The Menomonee River watershed contains a diversity of urban land uses confined within the relatively small area of 136 square miles, making feasible the detailed monitoring of basin-wide spatial and temporal changes in water quality and quantity. A number of water quality studies have been conducted in the Menomonee Basin since 1953 (see Appendix V-3a ) which serve to provide the necessary background information for planning and conduct of the proposed IJC land drainage study.

Rapid urbanization has resulted in the emergence of a number of serious water resource and water resource related problems within the watershed, including water pollution, flooding, water supply deficiencies and need for protection of park and open space areas. As a result of these environmental problems, the Southeastern Wisconsin Regional Planning Commission (SEWRPC)--the official planning agency for the seven county Southeastern Wisconsin Region--is conducting currently an inventory and analysis of the developmental and environmental problems of the area and is preparing a comprehensive land and water resource plan for the watershed. Information obtained or developed during the inventory, analysis and forecast phases of this SEWRPC study will be available to and provide a substantial information base for the IJC sponsored Menomonee River watershed. The SEWRPC staff's participation in the Menomonee watershed study will complement the extensive manpower resources being brought to bear on this project by the Wisconsin Department of Natural Resources, the University of Wisconsin System, and other public and private institutions and agencies.

A proposal for a Research and Demonstration Project under Section 108 of Public Law 92-500 has been submitted to EPA by the Wisconsin Board of Soil and Water Conservation Districts. This proposal is to develop the institutional mechanisms necessary to enact and enforce sediment control ordinances in urban and urbanizing areas which encompass incorporated as well as unincorporated areas. The field demonstration aspects of the project will be centered in the upper portion (Washington

County) of the Menomonee River watershed. This project will be coordinated with the IJC-LDRG program to obtain maximum results with a minimum of overlap. A substantial savings in the monitoring costs of both projects will be realized by using the same watershed for both programs.

OBJECTIVES

(1) To determine the levels and quantities of major and trace constituents, including, but not limited to nutrients, pesticides and sediments reaching or moving in flow systems likely to reach Lake Michigan.

(2) To define the sources and evaluate the behavior of pollutants from a metropolitan complex with particular emphasis on the impact of residential and industrial, including utility facilities, transportational, recreational, agricultural and constructional activities associated with rapid urbanization.

(3) To develop the predictive capability necessary to facilitate extension of the findings from the Menomonee watershed study to other urban settings, leading to an eventual goal of integrating pollution imputs from urban sources to the entire Great Lakes Basin.

METHODOLOGY

(1) Select critical water quality constituents that could affect Lake Michigan or other lakes.

(2) Select catchment areas that are representative of the forms of land use activities of particular interest to the study.

(3) Design a land use/water quality model that permits utilization of study findings for determination of pollution loads from selected and generalized land use practices.

(4) Develop and conduct an integrated water quality monitoring program utilizing standardized procedures (Task C Technical Committee) for the collection, storage and analysis of samples.

(5) Analyze field information on a continuous basis to determine the suitability of the data toward describing the impact of the individual land use activities. Intensive, short-duration studies will be employed to refine and extend the basic information collected in the continuous monitoring activities.

(6) Refine and test the applicability of the land use/water quality model for determining water quality impacts.

(7) Prepare interim and final reports in cooperation with other studies sponsored by the IJC under Task C.

## PARTICIPATING AGENCIES

The Wisconsin Department of Natural Resources, the University of Wisconsin and the Southeastern Wisconsin Regional Planning Commission constitute the three lead agencies or organizations responsible for participating with the Task C Technical Committee for the planning and conduct of the intensive study of water quality land use relations in the Menomonee River watershed. Other governmental units and agencies including, but not limited to, State of Wisconsin agencies such as the Wisconsin Geological and Natural History Survey and U.S. federal agencies such as the Soil Conservation Service, the Geological Survey, and the National Oceanic and Atmospheric Administration, will be involved as direct participants recognizing that their special capabilities are required to achieve the study objectives.

The role and function of each of the three lead agencies and of some of the anticipated participating agencies are as follows:

### Lead Organizations

Wisconsin Department of Natural Resources (WDNR)

The University of Wisconsin System Administered Through the Water Resources Center (UW-WRC)

Southeastern Wisconsin Regional Planning Commission (SEWRPC)

#### Principal Functions

Organization and management of the project study plan

Provide background inventories on land use activities and forecase information (principally SEWRPC)

Water quality monitoring activities (principally WDNR)

Identify and select research projects

Coordination of selected research (principally UW-WRC)

Conduct of specific research

Development of the land use water quality model

Preparation and processing of reports

Special Service Organizations

Soil Conservation Service

Provide background soils data

Participate in the selection of monitoring stations and analysis of sediment data

Wisconsin Geological and Natural History Survey

U.S. Geological Survey

Jointly participate in selection and operation of stream flow and sediment yield monitoring stations, determine variations in surface and groundwater flow and assist in the analysis of geologic and soils data relative to water quality

National Oceanic and Atmospheric Administration

Participate in the selection, installation and operation of precipitation monitoring stations and assist in the preliminary analysis of precipitation data

Others

Because of the deversity of talent required in this major effort, several more units will be actively involved in the study

Intended Use of Output

The primary use of the outputs from this study are related back to the objectives and the questions put forth in the Great Lakes Water Quality Agreement.

In addition to providing answers to the Land Drainage Reference, the study will also aid the State of Wisconsin in implementing portions of Section 303 and 305 dealing with non-point sources and related water quality and will provide valuable background for evaluation of pollution abatment programs in the Menomonee River watershed.

TIME SCHEDULE

It is anticipated that program will take four years to complete. The estimated completion date is December 31, 1977.

ACTIVITY COST

The total supplementary request in this program is $2,129,744. The proposed budget and schedule of activities is attached as Appendix V-3b. It is proposed that the Wisconsin Department of Natural Resources be designated as the principal agency for purposes of administration of the project. The Wisconsin Department of Natural Resources will subcontract to the other agencies as per the attached budget. A more detailed budget will be developed for purposes of the final project study plan and associated contracts which will be let.

## FELTON-HERRON CREEK AND MILL CREEK SUBWATERSHED STUDY

Two Michigan subwatersheds are proposed for inclusion as representative U.S. watersheds for land drainage studies on the input of polluting materials to the Great Lakes. One, Felton-Herron Creek is a subwatershed of the Grand River with features unusually well suited for investigating land drainage from a liquid waste disposal area. The other, Mill Creek, represents a basin typical of the large fruit growing area of southwestern lower Michigan. Both of these subwatersheds are the subject of current investigation and constitute two important land uses in the Great Lakes basin. The study plan of this proposal has been designed to furnish practical land management recommendations needed for pollution abatement of the Great Lakes and is structured to provide a sound scientific basis for meeting water quality objectives.

The Great Lakes serve as a depository for all materials brought in from the land mass via stream systems. These inputs include the vast array of complex chemicals, and elements such as mercury which have, in the past, proven to be a serious threat to aquatic life and a threat of unknown dimension to human well being. Chlorinated hydrocarbon pesticides have proven to be a serious threat to both recreational and food resources of the Great Lakes and more recently the polychlorinated byphenyls have added their burden. Adding to and compounding these stresses are the inputs of nutrients (nitrogen, carbon, and phosphorus) that have far-reaching effects on the entire Great Lakes sytem and pose a serious and perhaps irreversible threat to all of them.

Understanding the effects of toxic inputs, nutrients, and other inflowing materials that cause biological stress will come from research directly on the Great Lakes themselves. Thus, research and monitoring on the Great Lakes can be arbitrarily divided into two categories or approaches. (1) It is important to understand the chemical, biological, and physical dynamics of the lakes and to document and interpret the reactions of these bodies of water to externally induced stresses. These stresses, with minor exceptions, originate from land masses which drain into the Great Lakes. This research and monitoring must be done on platforms on the surfaces of the Great Lakes themselves. This requires the facilities of large ships capable of all-weather operations and far-ranging movement. (2) A quantitative and qualitative evaluation of the inputs from the land masses to the Great Lakes. It is the chemical input that actively controls the chemical and biological dynamics of the lakes. It is also the only factor in the ecology of large lakes that is subject to dimunition and management. It thus warrants immediate and strong attention. There is an urgency to understand the complexities of retention, transformation, and transport through and across land surfaces of those materials constituting a threat to the receiving water bodies. Management of these is a true necessity if we are to maintain the present quality of the Great Lakes waters. This second approach forms the focus for the proposed investigation.

OBJECTIVES

The general purpose of the special subwatershed studies proposed for the State of Michigan is to evaluate land drainage from agricultural or other land uses not adequately represented in the other U.S. Watershed Studies. The two selected for inclusion will significantly extend the resolution of the impact of unique land uses to streams tributary to the Great Lakes.

The Michigan subwatershed studies have been subdivided into six (6) basic tasks. The purpose and output of each task is as follows.

TASK 1. *Water Balance Studies for the Felton-Herron Creek Watershed*

The purpose and output of this task is to measure those elements of the hydrological cycle on a well defined watershed receiving land application of municipal wastewater so that runoff hydrographs can be predicted by knowing such input variables as hydraulic loading rates, frequency of irrigation, soil and vegetative covertype, slope, wastewater quality and climate. The purpose of this activity is to:

(1) provide investigators of the other tasks with baseline water balance data in order that they may accurately assess the effectiveness of alternative irrigation strategies and accurately characterize the movement of those materials that move from land with water; and

(2) provide predictive information on water runoff from hydraulically stressed watersheds to permit extrapolation of these data to other wastewater irrigation sites in the Great Lakes Basin.

Currently, a variety of hydrological models exist to simulate runoff from watersheds, but none have been altered, calibrated or verified to account for watersheds experiencing the stresses imposed by long-term wastewater irrigation activities. The output of this task will satisfy these important information gaps and, from a hydrological standpoint, identify the best land management practices to use in other liquid waste irrigation sites in the Great Lakes basin.

TASK 2. *Soil, Nutrient and Vegetation Monitoring for the Felton-Herron Creek Watershed*

The general purpose of this task is to establish design and management criteria for the operation of liquid waste disposal areas taking into consideration the quality of the out-flowing water and longevity of the soil-vegetation system.

In this activity, the dominant materials of concern will be (1) organic carbon compounds, (2) compounds of phosphorus, (3) compounds of nitrogen, (4) heavy metals and their compounds, and (5) mobile sediments. Information obtained on the diverse soils of the Felton-Herron Creek Watershed, coupled with the land management-irrigation demonstration activities now underway and proposed for this site, will provide an opportunity to develop a list of management recommendations that will relate directly to the quality of water draining the majority of land wastewater irrigation sites in the Great Lakes basin. The specific objectives of this task have been developed in light of state agency needs to formulate site selection criteria and design and management manuals for wastewater irrigation programs. This task is tightly coupled and coordinated with the hydrological studies proposed for Task 1.

TASK 3. *Microbiological Monitoring for the Felton-Herron Creek Watershed*

The purpose is to measure the extent of bacterial and viral transmission into and through a controlled wastewater irrigation system. The general goal assigned to this task is to determine the relevant variables governing the movement and attenuation of pathogenic micro-organisms in soil-water systems. This task will be part of an ongoing program evaluating the more important enteric pathogenic bacteria, including Salmonella, Shigella, Escherichia and Leptospira and certain enteric viruses including Polioviruses, Coxsachieviruses, and Echoviruses. The total scope of these studies now underway at Michigan State University include microbiological monitoring in the secondary waste treatment plant and artificial lake system that were constructed to accompany the Felton-Herron Creek irrigation system. Movement of pathogens into the groundwater and attenuation of pathogens at downstream points in the receiving stream will constitute a major aspect of the monitoring activities.

TASK 4. *In-Stream Process Studies for the Felton-Herron Creek Watershed*

The purpose of this task is to monitor the movement, deposition and translocation of pollutants that drain the land irrigation site. Of particular importance will be studies focused on the movement of toxic materials into and out of stream sediments and their ultimate movement downstream as dissolved or particulate material in the water column. The general goal of this task is to precisely determine how much of a particular pollutant will ultimately reach a receiving lake after its initial introduction into a stream. Information on concentrations of the critical pollutants at points downstream from the liquid irrigation system coupled with information on the dynamics of these materials on the land under various management practices will provide the analytical basis for extrapolating pollutional runoff for similar land uses in the Great Lakes basin.

TASK 5. *Water Balance Studies for the Mill Creek Watershed*

The purpose of this task is the same as that for Task 1 with the exception that data will apply to fruit orchard practices rather than land irrigation practices.

TASK 6. *Water Quality and Soil Monitoring Studies for the Mill Creek Watershed*

The purpose of this task is to characterize the dynamics of pesticides, herbicides and nutrients in a typical fruit orchard watershed and establish management criteria to minimize the runoff of polluting materials. Sampling will be scheduled to show the lateral and/or vertical movement of pesticides, herbicides and nutrients in the soil and the transport rate to the receiving stream. Since previous studies on similar watersheds demonstrate a tight coupling of pesticide movement with soil movement this aspect will be given high priority. The soil, climatic, and cultural similarities of the Mill Creek watershed to other orchard areas in the Great Lakes basin will provide for good extrapolation of data to other areas.

METHODOLOGY

*Felton-Herron Creek Subwatershed Studies (Tasks 1 through 4)*

As part of the study plan for the Felton-Herron Creek Program, Michigan State University investigators will look in detail at the entire cycle of water reaching the land, its modifications while on the land, and the quality of the water and associated materials as they leave the land and enter the receiving watercourse. The physical facilities now available for this study are uniquely suited for an in-depth evaluation of liquid irrigation sites.

The facility, covering approximately one square mile, constitutes the majority of a well defined watershed and includes a diverse array of soils quite typical of the Great Lakes states. Conceptually and from an analytical viewpoint this area represents a microcosm for most land irrigation sites in the Great Lakes basin.

Available will be flexibility in stressing the spray irrigation site with an array of water application regimes and water qualities, ranging from almost continuous application to no application above that of natural rainfall. Quality can be varied from that of a poor quality secondary effluent to application of water treated to high purity and low solids concentration. Under this system, nearly all of the recognized types of application of water to land can be evaluated with concurrent measurement of stress effects. Included would be the response of a

broad array of vegetative types, rate and quality of runoff from these vegetative types, effectiveness of different soils, and effects on macro and microclimate. The transport of water through underground systems can be measured on both tiled and untiled areas. Through a series of 64 monitoring wells (now installed) it will be possible to thoroughly characterize vertical and lateral water dispersion. In addition, the chemical constituents of the applied water can be traced through the soil mantle and on into the entrance to the potable water aquifer or as it may be discharged in the form of springs to the nearest watercourse.

The public health aspects of runoff and groundwater will be examined in detail. Programs now underway have already perfected a variety of virus isolation techniques and these are now being applied to surface and groundwater in the area for necessary background information.

Within the Felton-Herron Creek watershed are two well defined micro-watersheds of size and design to enable the partitioning of runoff due to independent treatments. Tested here will be variables that in a larger system would be impossible to characterize due to confounding interactions. It will be possible to conduct detailed analyses of the effects of ground vegetation on water quality and effect of cropping procedures on the ground vegetation itself or to the quality of the water leaving the watershed. Within the microwatersheds and throughout the entire area will be an extensive network of climatic and water quality monitoring instrumentation. Weighing and non-weighing lysimeters will be installed to provide invaluable information on evapotranspiration, a little understood but extremely important variable in water balance studies.

### *Mill Creek Subwatershed Studies (Tasks 5 and 6)*

Activities for this phase of the subwatershed program will focus on drainage from a fruit orchard area in southwestern lower Michigan. This area has been the subject of intensive research activity in recent years and with supplemental funding for hydrological studies and increased sampling activity the output of results applicable to IJC objectives will be greatly accelerated.

This area is extremely important because of its heavy pesticide use pattern and the subsequent implications of the translocation of the pesticides into the Great Lakes via runoff and/or evaporation and subsequent precipitation. Of special importance is the persistance of the newer pesticides that are replacing the chlorinated hydrocarbons and how far they move in a watershed system.

## TIME SCHEDULE

The timing of activities for the various tasks is illustrated in Figure 3.

SCHEDULE OF ACTIVITIES FOR SPECIAL SUBWATERSHED STUDIES

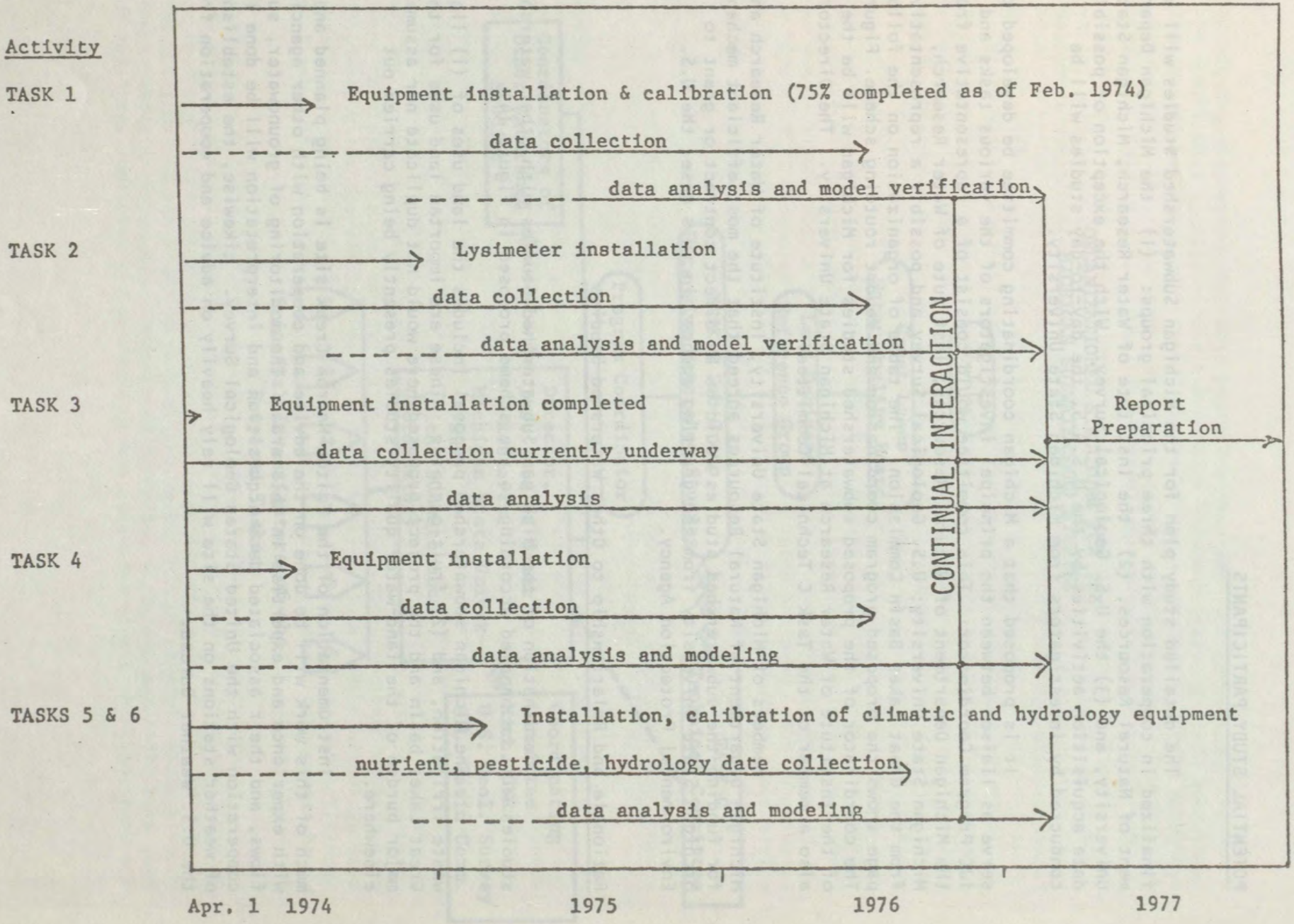



Figure 3

## POTENTIAL STUDY PARTICIPANTS

The detailed study plan for the Michigan Subwatershed Studies will be finalized in cooperation with three principal groups: (1) the Michigan Department of Natural Resources, (2) the Institute of Water Research, Michigan State University, and (3) the U.S. Geological Survey. With the exception of possible data acquisition activities by the U.S.G.S. the day-to-day studies will be conducted by investigators from Michigan State University.

It is proposed that a Michigan coordinating committee be developed to serve as liaison between the principal investigators of the various tasks and the IJC Program Coordinator. This committee would consist of a representative from the Michigan Department of Natural Resources; Institute of Water Research, Michigan State University; U.S. Geological Survey and possibly a representative from the Great Lakes Basin Commission. The table of organization on the following page shows the proposed program coordination and report routeing scheme. Figure (4). The coordinator of the proposed subwatershed studies for Michigan will be the Director of the Institute of Water Research at Michigan State University. The Director is also a member of the Task C Technical Committee.

Members of Michigan State University, Institute of Water Research and the Michigan Department of Natural Resources agreed that the most efficient mechanism for funding the subwatershed studies would be by direct contract or grant to Michigan State University from the granting agency, in this case, the U.S. Environmental Protection Agency.

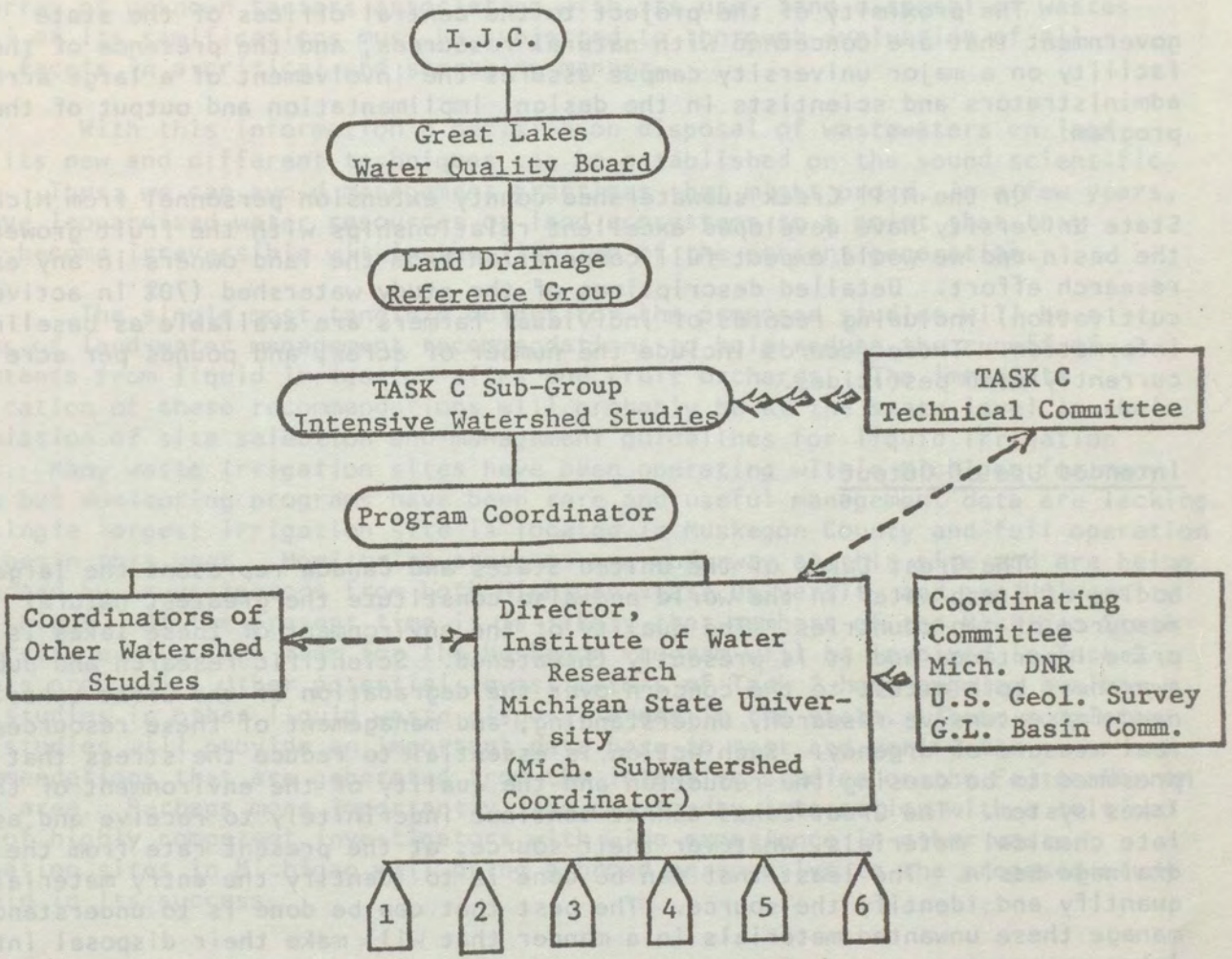
### Rationale and Relationship to Other Watershed Studies

Coordination of the Michigan Subwatershed Studies with other watershed studies will be handled according to the scheme proposed in Figure (4).

The Michigan subwatershed proposal includes the land uses of (1) liquid waste irrigation, and (2) fruit orchards. These are importan land uses for the Great Lakes basin and the project proposed here would not duplicate nor assume the major burden of the land-water quality studies presently being carried out elsewhere.

Instrumentation of the Felton-Herron Creek site is being planned and much of this work will be done on the advise and cooperation with other agencies with experience and expertise in this area. The monitoring of groundwater, surface flows, and their associated data acquisition and interpretation will be done in cooperation with the United States Geological Survey. Likewise, the establishment of weather stations on the site will rely heavily on advice and cooperation from the U.S. Weather Bureau.

ORGANIZATIONAL STRUCTURE FOR THE
MICHIGAN SUBWATERSHED STUDIES




Principal Investigators of the Proposed Tasks

Informal support has been solicited from the Ingham County Drain Commission where a strong computer program has been developed around the Hydrocomp Model. The Grand River Watershed Council has been actively assembling water chemistry data and physical data for the larger watershed which receives the drainage of the Felton-Herron Creek watershed. Michigan State University investigators are making use of their facilities and data input. The adjunct chemical analyses are being developed within Michigan State University laboratories to take all possible advantages of autoanalyzers and automatic processing chemical analyses.

The proximity of the project to the central offices of the state government that are concerned with natural resources, and the presence of the facility on a major university campus assures the involvement of a large array of administrators and scientists in the design, implimentation and output of the program.

On the Mill Creek subwatershed county extension personnel from Michigan State University have developed excellent relationships with the fruit growers in the basin and we would expect full cooperation from the land owners in any expanded research effort. Detailed descriptions of the study watershed (70% in active cultivation) including records of individual farmers are available as baseline information. These records include the number of acres, and pounds per acre for 34 currently used pesticides.

Intended Use of Output

The Great Lakes of the United States and Canada represent the largest bodies of fresh water in the world and also constitute the greatest natural resource of two countries. The quality of the environment of these lakes is of prime importance and it is presently threatened. Scientific research and public awareness both attest to the concern over the degradation of the Great Lakes. The need for extensive research, understanding, and management of these resources has a real measure of urgency. Such action is essential to reduce the stress that is presumed to be causing the reduction and the quality of the environment of the total lakes system. The Great Lakes cannot continue indefinitely to receive and assimilate chemical materials, whatever their source, at the present rate from the drainage basin. The least that can be done is to identify the entry material and quantify and identify the source. The best that can be done is to understand and manage these unwanted materials in a manner that will make their disposal into the lakes unnecessary.

Developing at an accellerating rate in the Great Lakes drainage basin are alternatives to the traditional waste treatment plants in the form of land disposal of wastes. These offer the potential of producing an end product that does not contain those elements recognized as detrimental to the eventual receiving waters. They also offer the important option of converting those nutrient elements which are becoming increasingly expensive and in short supply into food and fiber for

reuse. There are numerous examples of wastewater systems based on land disposal and the uptake of nutrient materials by plants and animal associations. In this way they can be converted into useful products, or in the case of heavy metals they can be converted into forms that can be stored in such a way as to prevent them from eventually reaching our lakes and contributing to their degradation.

It is believed that the use of land and natural ecosystems to recycle and reclaim the elements of our wastewaters will find widespread acceptance to the point of becoming an important adjunct in the treatment of domestic wastes in the Great Lakes basin. Because of the potential of this method, as well as the array of unknown factors associating with its use, land disposal of wastes in all of its ramifications must be subjected to thorough evaluation of all known facets in a critical and searching manner.

With this information a decision on disposal of wastewaters on land with its new and different techniques can be established on the sound scientific basis. Thus, we can avoid management practices that might prove, in a few years, to have jeopardized water resources or land ecosystems to a point that they might become irreversible within the lifetime of the present generation.

The single most tangible output for the proposed studies will be a series of land-water management recommendations to help reduce the runoff of pollutants from liquid irrigation sites and fruit orchards. The immediate application of these recommendations will probably be at the state level in their formulation of site selection and management guidelines for liquid irrigation sites. Many waste irrigation sites have been operating within Michigan for many years but monitoring programs have been rare and useful management data are lacking. The single largest irrigation site is located in Muskegon County and full operation will begin this year. Monitoring programs are underway at this site and are being conducted by investigators from both Michigan State University and the University of Michigan. At the present time it is likely that members of the Michigan State University evaluation team for the Muskegon Program will be involved in Task 2 of this proposal. Other potential investigators of Task 2 have ongoing evaluation studies in other liquid waste disposal areas in the state. These complementary studies will provide an important data base to test and verify the recommendations that are generated from the intensive studies on the Felton-Herron Creek area. Perhaps more importantly, the day-to-day interaction with a critical mass of highly competent investigators with wide experience in other waste irrigation sites in Michigan will bring a broad perspective to the proposed study and aid in its success.

ACTIVITY COST

*Ongoing Funding*

The requested funding for the Felton-Herron Creek studies will be supplemental funding to accelerate the output of information from an existing research-demonstration facility in order to meet the reporting deadlines for the IJC. The facility consists of a secondary sewage treatment plant located next to the Michigan State University campus, a four and a half mile asbestos-concrete pipeline with a 6 MGD capacity leading to the project site, four artificial lakes (40 acres total area), and a land disposal site covering 314 acres. Water from the lakes, either singly or in combination, can be piped to the irrigation site equipped with 17 miles of irrigation pipe and 100 individual experimental spray sites. The construction of the facility is now complete and a number of research and monitoring activities are now underway.

Expenditures for facility construction totalled $2,381,181 and were obtained from the following sources:

| | |
|---|---|
| EPA - Section 5 | $ 170,000 |
| EPA - Section 15 | 570,000 |
| EPA - Section 8 | 438,900 |
| State of Michigan | 535,000 |
| Michigan State University | 667,281 |
| *Ford Foundation | |
| *Rockefeller Foundation | |
| *Kresge Foundation | |

In addition to the above, approximately $273,000 for operations and maintenance and research and monitoring activities is contributed by Michigan State University.

A research and demonstration grant from the Rockefeller Foundation was awarded to the Institute of Water Research of Michigan State University early in 1973 in the amount of $326,000 for a 4 year period. The project entitled "Wastewater Reclamation: Hydrological, Chemical and Public Health Aspects" will serve as a significant contribution to the objectives of the IJC Land Drainage Studies. Approximately 75% of this project can be considered congruent with the aims of the special subwatershed study proposed for the Felton-Herron Creek area. In addition, Michigan State University has contributed $324,000 to this project.

The Mill Creek study area is also the subject of current investigation. The ongoing activities are being supported by Michigan State University at an approximate level of $10,000 per year.

Thus, during the tenure of the tasks proposed for the Michigan Subwatershed Studies there will be a contribution of approximately $658,700 fron non-federal sources to support the same program. The approximate distribution of these dollars is indicated in Appendix V-4.

*Supplemental Funds Required*

Total supplemental funds in the amount of $1,002,500 over the duration of the proposed study period will be required. Breakdown of these funds by task are shown in Appendix V-4.

*Budget Justification*

There is a high congruence between the objectives of the two ongoing subwatershed projects in Michigan and objectives set forth in the IJC agreement as detailed in the Land Drainage Reference Group Study Plan. The primary difference between ongoing programs and the IJC Study Plan is that of completion date. In order for the ongoing programs to complete the objectives before the 1977 target date it will be necessary to significantly increase the intensity of current studies. Since the success or failure of field studies are highly dependent on uncontrollable phenomena, especially the stochastic nature of climate, it is difficult to achieve statistical significance of conclusion based on data taken over a two year period, when the initial sampling design called for at least five years of observation. Thus, to achieve an acceptable degree of confidence in data obtained within the limited time span of the proposed study it will be necessary to markedly increase sampling frequency, increase the number of sampling stations, enlarge the support staff, and increase the amount of analytical hardware. In addition, certain field equipment items not currently installed will have to be provided.

The largest single budget item in the proposed study will be for salaries of Research Associates (4), Technicians (5), Research Assistants (10), and hourly labor (5). This will amount to approximately $500,000 over the budgeted period, plus approximately $300,000 in indirect costs. Cost sharing by Michigan State University, however, will contribute about $470,000 in the form of faculty time. Additional equipment items include three wiers (or flumes) for unguaged reaches of stream, an additional weather station, automatic water samplers and field lysimeters. The cost of these totals approximately $80,000 and will be purchased during the first quarter of the study period.

*Budget Breakdown by Participating Group*

With the exception of time contribution by the U.S. Geological Survey and their possible involvement in the installation of guaging stations the expenditure of supplemental funds will be undertaken by Michigan State University in cooperation and consultation with the Bureau of Water Management of the Michigan Department of Natural Resources.

## MAUMEE RIVER WATERSHED STUDY - OHIO SUPPLEMENT

With the increasing public concern over water pollution, many questions are being asked as to the relative contribution of agricultural land as a source of chemical nutrients, particularly nitrogen and phosphorus, and sediments as possible pollutants into the Great Lakes Basin including Lake Erie. This is of particular concern in the Maumee River Basin in northwestern Ohio because of the high concentration of intensive continuous cultivation on agricultural land in that area. According to the 1968 Lake Erie report by the Federal Water Quality Administration, agricultural production in the Lake Erie Basin is expected to double by the year 2020. The report states, "Agriculture produces wastes, the bulk of which are nutrients, and these alone could over the long run ruin Lake Erie if the rate of erosion loss continues unchecked. This is demonstrated by the fact that, in the past two years, the amount of fertilizer phosphorus used in the basin has increased by more than 15 percent". This report includes the statement that agricultural runoff is a major source of nutrient and sediment pollution to Lake Erie, contributing an estimated 250 pounds of total phosphorus per square mile, and eight million tons of sediment. Nitrogen and phosphorus are particularly critical because they act as nutrients causing excessive multiplication of organisms, such as blue-green algae.

Suspended solids are another serious class of pollutants entering Lake Erie, amounting to 24 million tons annually. The Lake Erie Report states that sediment from land runoff is the primary constituent of the discharge from the Maumee River. In its recommendations, the report states that agricultural runoff control is probably as necessary as any recommendations to municipalities or industries because of runoff containing large amounts of nutrients and possibly toxic materials. According to the "Water Inventory of the Maumee River" by the Ohio Department of Natural Resources, deposition of sediment in the Maumee River Basin exceeds $2 million in damages annually, exclusive of the Toledo harbor. The main cause, according to this report, is sheet erosion from farm fields, followed by stream bank and gully erosion, and flood plain scour.

The role of sediments in water pollution, however, is not clear. These particles are extremely good adsorbants of compounds such as herbicides and pesticides which find their way into the natural waterways and of almost all metals which are frequently present in industrial wastes. Therefore, sediments may alleviate pollution by adsorbing these wastes, removing them from solution. But, they retain these wastes over long time periods and thus may aggravate the overall pollution problem and delay efforts for water purification. A more accurate assessment of the source of the various pollutants and their interactions in the water system is needed before measures for pollution control can be formulated and pollution abated.

The Northwest Ohio Water Development Plan, developed by the Ohio Water Commission, also recommends "that a study of the pollutional aspects of agriculture be conducted with special reference to the transport of soils, nutrients, herbicides, and their long-term, accumulative effects on Lake Erie".

However, little reliable quantitative data are available on the actual losses of fertilizer nutrients and sediment by surface runoff from agricultural cropland in the Maumee Basin. This is partially due to the lack of concern in the past on erosion or runoff losses on these soils due to the relatively level topography. Data of this type are greatly needed to assist planning of investments in practical control measures as recommended.

Sediment control regulations in Ohio will use the Universal Soil Loss Equation to determine maximum permissible sediment losses from agricultural land. However, the equation cannot be applied to the nearly level and level heavy-textured soils in northwestern Ohio. Therefore, it is imperative that reliable estimates of soil loss under prevailing management practices be made so that reasonable guidelines can be formulated.

The Maumee River Basin has been selected as one of three representative watersheds on the U.S. side of the Basin. The Allen County study of Black Creek in Indiana has been selected as the primary study group for the Maumee Basin. However, this section of the Basin represents a small percentage of the total land area and excludes a number of the important soil types of the Basin. For example, about 74% of the entire Basin lies in Ohio; 17% of this area is occupied by lacustrine clay soils which do not extend into Indiana. Furthermore, 72% of the total population of the Basin occur in Ohio and thus a disproportionate percentage of the land use activities pertinent to the water quality of the Basin are governed by the Ohio sector. A supplemental study in Ohio will provide critical additional information on these important soils; this information is essential for a complete analysis of land use activities on water quality of the entire Basin.

A number of studies have already been completed on chemical and sediment losses from Ohio soils in the Maumee River Basin. It is apparent from this work that: (a) significant sediment losses occur from nearly level cultivated agricultural tablelands in the Basin, particularily the finer-textured clay soils; (b) sediment losses closely reflect climatic and cropping practices; (c) significant sediment losses can arise from tile drainage of nearly level tablelands as well as from surface runoff; (d) clay mineralogy may be used as a reliable index to differentiate surficial sources of sediments from stream bank scour (geologic sources); (e) suspended clay sediments in the Maumee River and tributaries reflect clay minerals of terrestrial surface source materials in the Basin and do not change strikingly in composition by season or discharge rate from upstream to downstream sites; (f) suspended silt sediments in the Maumee River and tributaries have strikingly different mineralogical compositions seasonally reflecting different stream discharge rates (surface runoff). There is evidence that secondary precipitation of calcite occurs to the extent that it is the major suspended $> 2\ \mu$ sediment during low flow conditions while quartz and feldspars are the predominant mineral components during high flow periods. This aspect could be a very important factor in the equilibrium dynamics of soluble phosphates found in stream waters.

Particle-size, sorbtive capacity, and mineralogy of sediments are closely interrelated and, thus, it is essential to characterize these parameters to fully understand the role of sediments in water chemistry dynamics. Likewise, to better

define mechanisms involved in fluvial transport-sedimentation processes it is necessary to characterize bottom sediments in quasi-equilibrium with stream water and suspended sediments. Quantity of sediments carried by a stream represents only one parameter of water quality and depending on particle-size-mineralogy interactions may not be the most important consideration. Therefore, it is proposed that the Ohio Supplement to the Black Creek Study will provide information of this nature to make sediment quantity data collected under the major project more meaningful in understanding the impact of land-use on stream water quality.

Several heavy metal studies of the Maumee River Basin have been conducted in recent years. These include the analysis of five metals (Pb, Ni, Cu, Cr and Cd) in limestone and dolomite, an examination of seven elements (in addition to above Ca and Sr) in 46 streamside and acquatic plants, the determination of the concentration and distribution of four elements (Cu, Pb, Mg and Zn) in water and stream sediment in the vicinity of Lima and in the vicinity of Findley.

Areas characterized by anomalous trace element concentrations have not been re-examined. Selected sites where industrial plating wastes, metallic wastes, and phenolic compounds have been discharged into water courses have not been adequately sampled or examined. The apparent high concentration of mercury in agricultural areas is not well understood. Studies along these lines should be initiated.

## OBJECTIVES

The overall objective of this study is to supplement the work of the Allen County, Indiana project. This project including the Ohio supplement will investigate the effects of land use in the Maumee River Basin on water quality of the Great Lakes Basin. The specific objectives of the Ohio study are designed to provide information that will not be available from the Indiana study. These objectives include:

(1) To determine the effects of land use practices on the loss of sediment and nutrients from representative soils in the Basin and to determine the contribution of losses from these soils to the total discharge of sediment and nutrients into Lake Erie.

(2) To determine the effects of soil management, environmental and topographical factors on sediment and nutrient losses from representative soils in the Basin.

(3) To study and determine the physical, chemical and mineralogical properties of soil colloids which determine their susceptibility to erosion and fluvial transport.

(4) To determine the physical, chemical, and mineralogical properties of suspended sediments and compare them to bottom sediments to identify fluvial transport mechanisms and evaluate equilibrium stabilities of suspended and bottom sediments.

(5) To determine the effects of sediment type and concentration on the levels of selected chemicals in water which subsequently enter Lake Erie.

(6) To determine heavy metal concentrations as point sources in the Basin and determine uptake of selected heavy metals by aquatic plants in stream and drainage ditch courses.

(7) To supplement data collected in the Black Creek Study in development and refinement of conceptual models to predict the effects of land use by soil type on the load of sediments and chemicals entering Lake Erie. The Black Creek Study will have primary responsibility for development of the model and data collected in this Supplement to the Black Creek Study will be used to refine and test the model.

METHODOLOGY

(1) A new research facility which is being installed at NW branch OARDC on Hoytville clay loam will be available in Spring 1974. Eight plots 50' x 100' will be continuously monitored for both surface runoff and tile drainage. Tillage practices (fall-plowing, spring-plowing, fall chisel plow and no-tillage) and time of application of fertilizer will be studied. Sediment and nutrient losses will be measured. Sediment properties will be characterized.

(2) Up to five agricultural watersheds will be selected on Roselms, Paulding, Latty, Fulton and Blount soils and instrumented to measure and sample runoff. Prevailing soil plus crop management practices in the area will be used. The soils selected are representative of the Basin and except for Blount, do not occur in the Black Creek, Indiana drainage area. Surface runoff will be sampled throughout the year and analyzed for sediment parameters and nutrient loss. On one of the watersheds, runoff will be measured on four different segments of the landscape to determine the effect of the landscape parameters on soil and nutrient loss.

(3) Soil samples from the surface horizons of the selected watersheds and other important soil types will be taken for laboratory studies. The effect of water quality (municipal wastewater, septic tank effluent, distilled water) on the flocculation of soil colloids will be studied. Relative dispersibility of soil materials subjected to simulated freezing and thawing will be determined and these results will be correlated with the mineralogy of the soil. Laboratory studies will also investigate the adsorption and desorption of phosphate to suspended sediment and the possible precipitation of phosphates during fluvial transport in streams. Equilibrium dynamics of phosphate-carbonate systems will be studied in the laboratory and related to field conditions.

(4) Suspended sediment, bottom sediment, and solution parameters will be obtained at or just upstream from the USGS Waterville, Ohio gauging station seasonally

to determine the integrated effect of prevailing land use activities on sediment and solution losses from the Basin. These data will be used to test and refine the model developed to predict nutrient and sediment loads entering Lake Erie. All data collected in the Ohio Supplement to the Maumee River Watershed Study will be available to personnel of the Black Creek Study developing and testing the transport model.

(5) Suspended sediments, bottom sediments, and solution parameters will be obtained seasonally at the juncture of the Maumee River with Lake Erie. These data will be compared to similar parameters collected at the Waterville gauging station to determine the impact of Toledo, the largest urban center in the Basin, on stream water quality. These data will permit further modification in the transport model for the entire Basin.

(6) Suspended sediments, bottom sediments, and stream water collected under (5) and (6), at sites previously characterized by anomalous trace element levels, and at selected point sources of industrial plating wastes, metallic wastes, and phenolic compounds will be characterized for Ag, As, Cd, Co, Cr, Cu, Hg, Ni, Pb, Sn, Sr, and Zn. At these same sites aquatic plants will be assayed for above heavy metals as an integrated index of biological availability of these metallic species. Agricultural sediments will be monitored for Hg levels.

PARTICIPATING AGENCIES

The research work will be conducted by the Departments of Agronomy, Agricultural Engineering, Civil Engineering and Geology of The Ohio State University and the project will be administered by the Water Resources Center, Ohio State University. Cooperating agencies include: Ohio Agricultural Research and Development Center, Ohio EPA, ARS-USDA (Coshocton), USDA-SCS.

Intended Use of Data

The end-product of this study will be a comprehensive report on sediment and nutrient losses from Ohio soils in the Maumee River Basin as affected by land use activity. Means of predicting future activities in the Basin will be proposed. This information will supplement the data collected from the Black Creek study in Indiana, and, together will represent a comprehensive study of water quality in the entire Maumee River Basin as affected by land use activities.

This proposed Ohio Supplement Study (to the Black Creek Study) for the Maumee River Watershed will provide valuable data for use by the State in implementing Sections 303, 208, 201, and other pertinent sections of the Federal Water Pollution Control Act Amendments of 1972 (PL 92-500). The State is not funded to perform a study such as the one proposed herein. Proper implementation of those sections of PL 92-500 will require answers to several questions concerning non-point

source pollution:

(1) How and from what sources does non-point pollution originate?

(2) What is the periodicity and correlated quantity of loss of sediment and nutrients from the soils?

(3) How is sediment (and its associated nutrients) transported, where is it deposited, and what is its affects?

(4) What is the relationship of the non-point source contribution to the point sources?

TASK D

## TIME SCHEDULE

An estimated 3 years are required for completion. Estimated completion date June 30, 1977.

## ACTIVITY COST

Supplementary funding of $369,450 is anticipated for this program. (See Appendix IV-5 for detailed budget summary).

# TASK D

## TASK D

*Diagnosis of the degree of impairment of water quality in the Great Lakes, including an assessment of contaminants of concern in sediments and fish and other aquatic resources.*

### ACTIVITIES (CANADA AND U.S.)

1. Assessment of shoreline erosion
2. Survey of river sediments and associated water quality
3. Assessment of the effects of river inputs on Boundary waters

### ACTIVITY 1 - Shoreline Erosion

Shoreline erosion constitutes a major source of sediment input to the boundary waters of the Great Lakes. The magnitude of the input has been very apparent during the recent high lake levels with severe land loss, due to the recession of erodible shorelines.

In Canadian shoreline regions, in particular in the lower Great Lakes, there has been a considerable acceleration in the compilation of detailed assessment inventories of coastal recession. These include annual rates of recession from aerial photography, assessment of land use and shoreline structures, and property evaluation. Coverage includes Lakes Ontario, Erie, St. Clair, south-east Huron and southern Georgian Bay. These inventories form the base data from which the annual tonnage of eroded material can be calculated. In addition, bluff profiles have been established extending to a water depth of 20 metres, below active wave base, to survey the short-term changes in the bluff profiles due to shoreline erosion. One hundred and sixty-two profiles have been established as follows:

| | |
|---|---|
| Lake Ontario | 72 |
| Lake Erie | 50 |
| Lake St.Clair | 2 |
| Lake Huron-Georgian Bay | 38 |

The studies proposed in this study plan take advantage of these profiles as a basis for calculating total tonnages of material input and as a control network for sampling.

On the United States side, the United States Corps of Engineers has classified shorelines of the Great Lakes, according to 10 categories of upland shore types and the amount of shoreline erosion. On the basis of this classification, and

with the use of elevations and land surface contours from topographic maps and aerial photography, the total quantity of eroded shoreline sediment will be estimated.

## OBJECTIVES

1. To calculate the total quantity of sediment entering into the Great Lakes as a direct product of shoreline erosion.

2. To determine levels of nutrients, trace elements in erosive materials and to calculate their contribution to the lakes.

## METHODOLOGY

### Canada

The programme will comprise the following integrated sub-activities:

Sub-Activity 1 -

The compilation of all available information on historical erosion, in order to compute a mean annual tonnage of sediment input.

Sub-Activity 2 -

The evaluation of the stratigraphy of individual profiles to calculate the mean annual tonnage of individual stratigraphic horizons lost to the lake by shoreline erosion.

Sub-Activity 3 -

To sample the profiles on a stratigraphic basis to conduct the following analyses:

(a) Particle size analysis to quantify inputs for 1 and 2 above, in terms of sand and gravel, silt and clay.

(b) Geochemical analyses of major, minor and trace elements, carbon and nitrogen, to determine the total geochemical input from shoreline erosion.

(c) The determination of the forms of phosphorus in order to estimate the availability of phosphorus derived from shoreline erosion in the boundary waters.

Sub-Activity 4 -

To determine the engineering properties of the erodible bluffs relative to dispersion of wave energy in order to elucidate the major mechanisms of shoreline erosion and the efficiency of present day protective structures.

Sub-Activity 5 -

To investigate the mineralogy of bluff materials to observe stratigraphic variation, and to relate such variation to the engineering properties in 4 above.

Sub-Activity 6 -

By observation of variations in the sub-aqueous profiles 0-20 meters to calculate wave-induced sub-aqueous erosion and to determine onshore/offshore movement of sediment.

It can be seen that the study objectives can be met by satisfactory completion of Sub-Activities 1 to 3 inclusive. However, these data alone are insufficient and Sub-Activities 4 to 6 are required in order to understand the process mechanisms involving bluff erosion, sediment transport and deposition as they may relate to present day protective structures, beach nourishment and depletion etc. Further, the Land Use Activities Reference Group is required to submit suggestions with costing on remedial measures. Such measures cannot be suggested without knowledge of the process involved and costing by qualified civil engineers will require the data base also generated under Sub-Activities 4 to 6.

United States

Sub-Activities 1, 2

On the basis of the Corps of Engineers classification, and with the use of elevations and land surface contours from topographic maps and aerial photography, the total quantity of shoreline sediment eroded will be calculated. The work will be contracted by the U.S. EPA, and will use the Lakeshore and Riverbank Erosion portion of Task A.

Sub-Activity 3

The consultant will also be requested to formulate a study plan for achieving the necessary data to develop Objective 2. This study plan would involve the locating and sampling of representative sites in the 10 categories of upland shore area as well as defining the program necessary to calculate the effect on lake water quality. The field work required by this study plan will also be done by contract between the U.S. EPA and a consultant.

NOTE

Sub-Activities #4, 5, & 6 of the Canadian Section, Task D, Activity 1, in part, reflect ongoing work of the Canadians. It is felt that much of this work is applicable to the U.S. shorelines and duplication by the U.S. Section would be redundant. If it is determined during the course of the preceding studies that work of this nature is needed on the U.S. side, it will be done by contract. No estimated costs are available and supplemental funds would probably be required.

PARTICIPATING AGENCIES

Canada - Environment Canada - (MSD) Marine Sciences Directorate
- (LRD) Lakes Research Division, CCIW

United States - Environmental Protection Agency
- Corps of Engineers (U.S. Army)
- Consultants

TIME SCHEDULE

Canada - 2 years from initiation
- estimated completion date March 1976

United States -

Sub-Activities 1 & 2 - 6 months
- estimated completion date June 1974

Sub-Activity 3 - 2 years
- estimated completion date June 1976

ACTIVITY COST

Canada - Environment Canada (EMS) ..... $ 40,000

United States - Environmental Protection Agency ..... $ 60,000

## ACTIVITY 2 - Survey of River Sediments and Associated Water Quality

In order to assess the contribution of compounds associated with land use activities such as pesticides, nutrients, and heavy metals commonly associated with particulate or suspended matter, both the quantity and quality of such particulate materials must be determined. Previous studies on river inputs to the Great Lakes have resulted in the accumulation of substantial quantities of primary data. These data are predominantly composed of water quality parameters and flow rates, with some information on particulate inputs. The interpretation of these past data, when related to new information derived from a specific river mouth sampling program to recover and analyze solids, will provide a quantification of materials and compounds entering the boundary waters. The statistical evaluation of these parameters against land use practice for individual watersheds provided by Task B and the pilot watershed studies of Task C of the study plan, will enable an initial assessment of the contributions of such practices both on the quantity and quality of particulate compounds introduced by river input to the Great Lakes.

### OBJECTIVES

(1) To determine through sedimentation surveys, the extent of transport of nutrients, selected metals, and pesticides into the lake system based on total sediment loadings.

(2) To determine the effect of land use practices on incoming sediment quality.

(3) To assess the exchangeability of these pollutants on sediments and their present and potential impact on water quality.

### METHODOLOGY

#### Canada

Sub-Activity 1 - Evaluation of Existing Data

All available data on discharges, and water quality parameters for all river inputs selected for river mouth sampling will be compiled. Data parameters will be machine processed for all years for which records are available to provide the following information on individual river inputs:

(a) Monthly, seasonal and annual mean discharge rates and associated mean turbidity values to enable the selection of optimum sampling periods and to form a basis for the computation of total input loadings and total sediment yield.

(b) To calculate the total input of those soluble materials determined during the monitoring programmes.

(c) By multi-variate and cluster analysis to determine significant groupings of parameters and controlling factors.

Sub-Activity 2 - River Mouth Survey

To recover suspended particulate material from all streams draining into the boundary waters of the Great Lakes whose annual discharge represents greater than 0.5% of the total river discharge to the recipient lake, excluding interconnecting channels. Sampling will be conducted during spring run-off and will be carried out over a two-year period. Year one to sample Lake Ontario and Lake Huron, and year two to sample Lake Erie and Lake Superior. During the time of collection a filtered water sample will be recovered in addition to the solids sample.

At each river mouth, an integrated water sample will be pumped and fed through a continuous flow centrifuge to recover particles in excess of 0.05 microns. The total solids will be freeze-dried and subjected to the following analyses:

- major elements: Si, Al, Fe, Mn, K, Ca, Mg, P and S to provide a chemical assessment of the gross mineralogical composition of the inorganic fraction of the sediment and as an indicator of the form of phosphorus in the sediment. The statistical evaluation of the trace metals and pesticides relative to the major elements will further provide an insight into the bonding and form of transportation of these components to the Great Lakes. Such interpretations will be confirmed by selective extraction techniques.
- carbon (organic and inorganic), nitrogen.
- trace metals - Hg, Pb, Cu, Zn, Ni, Co, Cr, Cd, Be, V, Sr, As, and Se.
- particle size and mineralogy. Mineralogy on selected watersheds only.
- pesticides. Ontario Pesticide Laboratories will run scans on Organo-Phosphates on all samples. Depending on the results of this survey and the Task B inventory, more detailed quantitative pesticide analyses will be undertaken on selected watershed inputs for specific compounds.
- other analyses, as needed.

United States

(1) Objective 1 will be accomplished through the use of contracts between the States and the U.S. EPA to perform the necessary river mouth sampling. Presently, under the Upper Lakes Study, the mouths of all tributaries entering Lakes Superior and Huron are being sampled. This program will run for 24 months from August 1973.

This sampling program will be extended to include Lakes Michigan and Erie. Data obtained during the International Field Year on the Great Lakes (IFYGL) will be utilized for Lake Ontario and expanded if difficulties exist.

(2) Objective 2 will be carried out by contract with a consultant during the third year of the Study when data become available.

(3) The assessment called for by objective 3 will be made by a consultant. In his assessment, he will make use of work done by the Canadians and at the Duluth Water Quality Lab.

PARTICIPATING AGENCIES

Canada - Environment Canada - (LRD) Lakes Research Division, CCIW
- (SOD) Scientific Operations Division, CCIW,
- (MSD) Marine Sciences Directorate.

Ontario Ministry of Agriculture and Food - (OPL) Ontario Pesticide Residue Testing Laboratory.

United States - Environmental Protection Agency (Consultants)

TIME SCHEDULE

Canada
- 3 years, 1974/75, 75/76, 76/77
- Sub-Activity 1 estimated completion date August 1974
- Sub-Activity 2 estimated completion date March 1977

United States - 2 years FY 75, 76

ACTIVITY COST

| | | |
|---|---|---|
| Canada | - Environment Canada ..... | $ 275,000 |
| | - Ontario Ministry of Agriculture and Food ..... | 24,000 |
| | | $ 299,000 |
| United States | - Environmental Protection Agency ..... | $ 320,000 |

## ACTIVITY 3 - Effects of River Inputs

Information on use patterns within watersheds for contaminants such as metals, pesticides and stable organic compounds will be examined in relation to river inputs to boundary waters for the Task C pilot watersheds and other watersheds examined under Activity 2 of Task D. Such an analysis should determine the dispersion of contaminants and indicate areas which merit further examination. However, generalized assessment of the levels of these contaminants in water and aquatic life forms would be of limited value. This is because of the lack of definitive information relating concentrations of contaminants in water, sediments and tissues with the well-being of the biota. Consequently, this study plan purposely avoids collection of more data of the monitoring type.

## OBJECTIVES

(1) To assess the significance of specific contaminants gaining access to boundary waters as a result of land use activities.

(2) To establish areas which may be adversely affected as a result of such inputs including a determination of the extent of dispersion of sediments offshore and the extent of impairment of water quality in boundary waters.

(3) To determine degree of contamination of fish and other aquatic resources in areas exposed to higher-than-average loadings of specific contaminants.

## METHODOLOGY

### Canada

Sub-Activity 1 -

Review input data from (Activity 2, Task D) and select contaminants attributable to land drainage which appear to represent hazards to aquatic life, municipal water use, etc.

Sub-Activity 2 -

Simulate comparable input rates of contaminants in laboratory ecosystem (which will be available for use at the CCIW Great Lakes Biolimnology Laboratory) and measure the impact of these systems in terms of:

(a) effects on performance of algae, invertebrate fish-food organisms and fish

(b) biomagnification of contaminants in food chains, relating these levels in fish to both health of fish and marketability of fish.

Existing information attesting to the significance of selected contaminants will guide the development of this activity.

Sub-Activity 3 -

Carry out field surveys of selected areas of boundary waters which 1 and 2 above indicate as being potentially adversely affected. The field surveys should determine the extent and degree of impairment of water quality and damage to ecosystems. Assessments of residues of pesticides and other persistant contaminants in fish will be made where warranted, based on the results of Sub-Activity 2 and Tasks A and B. Portions of these surveys will be aimed at determining the residues of contaminants in sediments and bench tests will be performed to determine the availability of these materials to further invade biological systems and to continue to lead to water quality impairment. This information must be interpreted in the light of future trends in inputs of contaminants which appear to have a significant impact on boundary water ecosystems. It is important to stress that many new materials may be posing less of a hazard at the present time than the hazard which may develop with expanded use in the next few decades.

Sub-Activity 4 -

The synthesis of all available information from these limited studies and the many on-going programmes to relate lakewide water quality impairment to the relative inputs from all sources of contaminants, nutrients, etc. This calls for a careful examination of land drainage inputs in relation to atmospheric and point-source inputs at present and when projected into the future based on detectable trends in water and land resources management (incorporating results from Task B).

Sub-Activity 5 -

To assess the spatial extent of high turbidity water, and associated areas of localized high planctonic productivity ascribable to sediment input from shoreline erosion and river input, by the interpretation of ERTS imagery and multispectral photography of the Great Lakes. To further utilize this technique to elucidate suspended sediment transportation pathways with water mass movement as a response to climatic conditions in order to define the zone of effect.

Sub-Activity 6 -

Selected surface sediment samples from the Great Lakes collected by CCIW will be analysed for organochlorine insecticides to determine regional residual levels and dispersion pathways in the boundary waters, as they relate to past and present agricultural practices in the watershed.

United States

Sub-Activity 1 -

Sufficient data should be generated by studies proposed by the Canadian section under Objective 1 of Activity 3 (see Canadian Sub-Activities 1-4), the Dredging Criteria work group, Upper Lakes Fisheries Study, and Task C of the Land Drainage Reference Group to allow a critical assessment of Objective 1 for the American side. Data from representative watersheds surveyed in Task C will be analyzed to provide the data on specific contaminants present at river mouths. A combination of the analytical data provided by the river sampling and sediment transport studies carried out under Activities D1 and D2 and the above mentioned data will be analyzed and assessed by a consultant.

Sub-Activity 2 -

Methods of achieving Objective 2 are still being considered. Presently NASA's work with multi-spectral photography and ERTS data is being considered.

PARTICIPATING AGENCIES

Canada - Environment Canada - Fisheries and Marine Service (GLBL)
- Environmental Management Service
(Water Quality Laboratory - CCIW)
(Scientific Operations Division - CCIW)

- Ontario Ministry of the Environment - Water Quality Branch
- Ontario Ministry of Agriculture and Food (OPL)
- Ontario Ministry of Natural Resources

United States - Environmental Protection Agency

TIME SCHEDULE

Canada - 3 years FY 74/75, 75/76, 76/77

United States - 2 years 1975, 1976

ACTIVITY COST

| | | |
|---|---|---|
| Canada | - Environment Canada | $ 265,000 |
| | - Ontario Ministry of the Environment | 66,000 |
| | - Ontario Ministry of Agriculture and Food | 63,000 |
| | | 394,000 |
| United States | - Environmental Protection Agency | 83,000 |

# APPENDIX

# APPENDIX 1

# INTERNATIONAL REFERENCE GROUP ON GREAT LAKES POLLUTION FROM LAND USE ACTIVITIES

## Canada

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# INTERNATIONAL REFERENCE GROUP ON GREAT LAKES POLLUTION FROM LAND USE ACTIVITIES

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BUDGET SUMMARY

LAND DRAINAGE REFERENCE GROUP

| Task | Description of Activity | Agency | FY 74 1973-74 '000$ | | FY 75 1974-75 '000$ | | FY 76 1975-76 '000$ | | FY 77 1976-77 '000$ | | FY 78 1977-78 '000$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Ongoing | Suppl. | Ongoing | Suppl. | Ongoing | Suppl. | Ongoing | Suppl. | Ongoing | Suppl. |
| A | CANADA | | | | | | | | | | | |
| | 1. Compilation and | OME | 16 | 10 | - | 8 | - | 8 | - | 8 | | |
| | Assessment of | OMAF | 4 | - | - | - | - | - | - | - | | |
| | Management and | OMNR | 4 | - | - | - | - | - | - | - | | |
| | Research Information | DOE | 5 | - | - | - | - | 10 | - | 10 | | |
| | | CDA | 5 | - | - | - | - | - | - | - | | |
| | 2. Assessment and review | OME | | | - | | - | 50 | - | 25 | | |
| | of remedial measures. | DOE | | | - | 7 | - | 7 | - | 7 | | |
| | SUB TOTAL | | 34 | 10 | - | 15 | - | 75 | - | 50 | | |
| | UNITED STATES | | | | | | | | | | | |
| | 1. as A1 above | EPA | - | 50 | | | | | | | | |
| | 2. as A2 above | EPA | | | | | - | 50 | - | 50 | | |
| | SUB TOTAL | | - | 50 | - | - | - | 50 | - | 50 | | |
| | TOTAL | | 34 | 60 | - | 15 | - | 125 | - | 100 | | |

## BUDGET SUMMARY

## LAND DRAINAGE REFERENCE GROUP

| Task | Description of Activity | Agency | FY 74 1973-74 '000$ | | FY 75 1974-75 '000$ | | FY 76 1975-76 '000$ | | FY 77 1976-77 '000$ | | FY 78 1977-78 '000$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Ongoing | Suppl. | Ongoing | Suppl. | Ongoing | Suppl. | Ongoing | Suppl. | Ongoing | Suppl. |
| B | CANADA | | | | | | | | | | | |
| | 1. General Land Use Inventory | DOE | 34.5 | - | ND | 25 | | | | | | |
| | 2. Specialized Categories | DOE | 14 | - | - | - | | | | | | |
| | | OME | - | - | - | - | | | | | | |
| | 3. Physical Fabric | OMNR | - | - | ND | 60 | | | | | | |
| | 4. Material Usage | OMAF | - | - | - | 5 | | | | | | |
| | | CDA | - | - | 5 | - | | | | | | |
| | 5. Forecasts | DOE | - | - | - | 25 | - | 50 | - | 20 | | |
| | SUB TOTAL | | 48.5 | - | 5 | 115 | - | 50 | - | 20 | | |
| | UNITED STATES | | | | | | | | | | | |
| | 1. General Land Use Inventory | EPA | - | 151.5 | | | | | | | | |
| | | SCS | - | 8 | | | | | | | | |
| | Items B2-B5 above | EPA | | | | | | | | | | |
| | | SCS | - | - | - | 50 | | | | | | |
| | | ERS | | | | | | | | | | |
| | SUB TOTAL | | | 159.5 | | 50 | | | | | | |
| | TOTAL | | 48.5 | 159.5 | 5 | 165 | - | 50 | - | 20 | | |

BUDGET SUMMARY

LAND DRAINAGE REFERENCE GROUP

| Task | Description of Activity | Agency | FY 74 1973-74 '000$ | | FY 75 1974-75 '000$ | | FY 76 1975-76 '000$ | | FY 77 1976-77 '000$ | | FY 78 1977-78 '000$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Ongoing | Suppl. | Ongoing | Suppl. | Ongoing | Suppl. | Ongoing | Suppl. | Ongoing | Suppl. |
| C | CANADA | | | | | | | | | | | |
| | 1. Agricultural Watershed Surveys | CDA | | | 400 | 160 | 400 | 640 | 400 | 544 | ND | 128 |
| | | OMAF | | | 180 | 15 | 180 | | 180 | | ND | |
| | | OME | | | ND | 119 | ND | | ND | | ND | |
| | SUB TOTAL | | | | 580 | 294 | 580 | 640 | 580 | 544 | ND | 128 |
| | 2. Forested Watershed Surveys | DOE | | | 160 | - | 160 | - | ND | - | ND | - |
| | 3. Development and Waste Disposal Uses | | | | | | | | | | | |
| | a. Urban Land Development and Use | OME | | | | - | | 116 | | 45 | | 7 |
| | b. Transportation and Utility Systems | OME | | | *** | *** | *** | *** | *** | *** | *** | *** |
| | c. Sanitary Landfills | OME | | | | 81 | | 52 | | 52 | | 62 |
| | d. Processed Organic Waste Disposal | OME | | | | 109 | | 125 | | 125 | | 71 |
| | e. Wastewater Lagoons and Irrigation Systems | OME | | | | - | | - | | 41 | | 57 |

BUDGET SUMMARY

LAND DRAINAGE REFERENCE GROUP

| Task | Description of Activity | Agency | FY 74 1973-74 '000$ | | FY 75 1974-75 '000$ | | FY 76 1975-76 '000$ | | FY 77 1976-77 '000$ | | FY 78 1977-78 '000$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Ongoing | Suppl. | Ongoing | Suppl. | Ongoing | Suppl. | Ongoing | Suppl. | Ongoing | Suppl. |
| C | 3f. Land Fill (reclamation) | OME | | | | *** | | *** | | *** | | *** |
| | g. Extractive Industries | OME | | | | *** | | *** | | *** | | *** |
| | h. Private Waste Disposal | OME | | | | 116 | | 96 | | 101 | | 90 |
| | i. Recreational Lands | OME OMNR | | | | *** | | *** | | *** | | *** |
| | SUB TOTAL | | | | 615 | 306 | 503 | 389 | 503 | 364 | ND | 287 |
| | 4. Water Quantity and Quality Monitoring Network. | | | | | | | | | | | |
| | a. Extensive Surveillance Network | OME | | | | 228 | | 197 | | 182 | | 143 |
| | b. Intensive Studies Program | OME | | | | 16 | | 54 | | 61 | | 20 |
| | SUB TOTAL | | | | 113 | 244 | 113 | 251 | 113 | 243 | 113 | 163 |
| | 5. Laboratory Support | | | | | **** | | **** | | **** | | **** |

BUDGET SUMMARY

LAND DRAINAGE REFERENCE GROUP

| Task | Description of Activity | Agency | FY 74 1973-74 '000$ | | FY 75 1974-75 '000$ | | FY 76 1975-76 '000$ | | FY 77 1976-77 '000$ | | FY 78 1977-78 '000$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Ongoing | Suppl. | Ongoing | Suppl. | Ongoing | Suppl. | Ongoing | Suppl. | Ongoing | Suppl. |
| C | 6. Riverbank Erosion Surveys | OMNR | | | ND | 5 | ND | 60 | ND | 40 | ND | 15 |
| | TOTAL CANADA C | | | | 1468 | 819 | 1356 | 1340 | 1196 | 1191 | 113 | 593 |
| | Footnotes | | | | | | | | | | | |
| | *** to be covered as part of the surveillance programs. | | | | | | | | | | | |
| | **** cost distributed among specific activities. | | | | | | | | | | | |
| | UNITED STATES | | | | | | | | | | | |
| | Genesee River Basin | Federal | | 274 | | 360.5 | | 334 | | 334 | | 34 |
| | | New York State | 60 | | 100 | | 100 | | 100 | | 25 | |
| | Menomonee River Basin | All Sources | ND | 191 | 100 | 619.5 | 100 | 621.2 | 100 | 541.3 | ND | 156.7 |

## BUDGET SUMMARY

## LAND DRAINAGE REFERENCE GROUP

| Task | Description of Activity | Agency | FY 74 1973-74 '000$ | | FY 75 1974-75 '000$ | | FY 76 1975-76 '000$ | | FY 77 1976-77 '000$ | | FY 78 1977-78 '000$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Ongoing | Suppl. | Ongoing | Suppl. | Ongoing | Suppl. | Ongoing | Suppl. | Ongoing | Suppl. |
| C | UNITED STATES (cont'd) | | | | | | | | | | | |
| | Michigan Subwatersheds | Federal | | 109.8 | | 285.9 | | 276.8 | | 280 | | 50 |
| | | NF* | 68.5 | | 192.2 | | 198 | | 200 | | ND | |
| | Maumee River (Ohio Supp.) | All Sources | 500** | 40.7 | 500** | 110.8 | 500** | 106.3 | 500** | 116.6 | ND | 25 |
| | River Bank Erosion Studies | EPS | | 60 | | 11 | | | | | | |
| | | SCS | | | | | | | | | | |
| | TOTAL UNITED STATES C | | 628.5 | 675.5 | 892.2 | 1387.7 | 898 | 1338.3 | 900 | 1266.9 | 25 | 265.7 |

* Non federal funds

** Estimates of yearly expenditures of funded Black Creek project.

| Task | Description of Activity | Agency | FY 74 | | FY 75 | | FY 76 | | FY 77 | | FY 78 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Ongoing | Suppl. | Ongoing | Suppl. | Ongoing | Suppl. | Ongoing | Suppl. | Ongoing | Suppl. |
| C | UNITED STATES (cont'd) | | | | | | | | | | | |
| | Mishigan Subwatersheds | Federal | | 109.8 | | 285.9 | | 276.8 | | 280 | | 50 |
| | | NR* | 68.5 | | 192.2 | | 190 | | 200 | | ND | |
| | Mamee River (Ohio Supp.) | All Sources | 500** | 40.7 | 500** | 110.8 | 500** | 106.3 | 500** | 116.6 | ND | 25 |
| | River Bank Erosion Studies | EPS<br>SCS | | 60 | | 11 | | | | | | |
| | TOTAL UNITED STATES C | | 638.5 | 675.5 | 892.2 | 1397.7 | 898 | 1339.3 | 900 | 1266.9 | 25 | 265.7 |

* Non Federal Funds

** Estimates of yearly expenditures of Tundee Block Creek project.

BUDGET SUMMARY

LAND DRAINAGE REFERENCE GROUP

| Task | Description of Activity | Agency | FY 74 1973-74 '000$ | | FY 75 1974-75 '000$ | | FY 76 1975-76 '000$ | | FY 77 1976-77 '000$ | | FY 78 1977-78 '000$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Ongoing | Suppl. | Ongoing | Suppl. | Ongoing | Suppl. | Ongoing | Suppl. | Ongoing | Suppl. |
| D | CANADA | | | | | | | | | | | |
| | 1. Shoreline Erosion | DOE | 100 | - | 100 | 20 | 100 | 20 | - | - | | |
| | 2. River Inputs | DOE | - | - | - | 110 | - | 110 | - | 55 | | |
| | | OME | 50 | - | 50 | - | 50 | - | 50 | - | | |
| | | OMAF | - | - | - | 12 | - | 12 | - | - | | |
| | 3. Effects of River Inputs | DOE | - | - | 50 | 95 | 50 | 105 | 50 | 65 | | |
| | | OME | ND | - | ND | 20 | ND | 23 | ND | 23 | | |
| | | OMAF | - | - | - | 21 | - | 21 | - | 21 | | |
| | SUB TOTAL | | 150 | - | 200 | 278 | 200 | 291 | 100 | 164 | | |
| | UNITED STATES | | | | | | | | | | | |
| | Same as D1 above | EPA | ND | 20 | ND | 20 | ND | 20 | | | | |
| | Same as D2 above | EPA | ND | - | ND | 165 | ND | 155 | | | | |
| | Same as D3 above | EPA | ND | - | ND | 40 | ND | 43 | | | | |
| | SUB TOTAL | | ND | 20 | ND | 225 | ND | 218 | | | | |
| | TOTAL | | 150 | 20 | 200 | 503 | 200 | 509 | 100 | 164 | | |

BUDGET SUMMARY

LAND DRAINAGE REFERENCE GROUP

| Task | Description of Activity | Agency | FY 74 1973-74 '000$ | | FY 75 1974-75 '000$ | | FY 76 1975-76 '000$ | | FY 77 1976-77 '000$ | | FY 78 1977-78 '000$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Ongoing | Suppl. | Ongoing | Suppl. | Ongoing | Suppl. | Ongoing | Suppl. | Ongoing | Suppl. |
| Final Report | 1. Preparation of charts, graphs, maps, photos & text, plus reduction | | | | | | | | | | | |
| | Canadian Section | DOE | | | | | | | | | | 100 |
| | U.S. Section | EPA, SCS | | | | | | | | | | 100 |
| | Total Funding - Canada | | 232.5 | 10 | 1673 | 1257 | 1556 | 1756 | 1296 | 1425 | 113 | 693 |
| | Total Funding - U.S. | | 628.5 | 905 | 892.2 | 1662.7 | 898 | 1606.3 | 900 | 1316.9 | 25 | 365.7 |
| | Grand Total | | 861 | 915 | 2565.2 | 2919.7 | 2454 | 3362.3 | 2196 | 2741.9 | 138 | 1058.7 |

## BUDGET SUMMARY

### LAND DRAINAGE REFERENCE GROUP

| Task | Description of Activity | Agency | FY 74 1973-74 '000$ Ongoing | FY 74 1973-74 '000$ Suppl. | FY 75 1974-75 '000$ Ongoing | FY 75 1974-75 '000$ Suppl. | FY 76 1975-76 '000$ Ongoing | FY 76 1975-76 '000$ Suppl. | FY 77 1976-77 '000$ Ongoing | FY 77 1976-77 '000$ Suppl. | FY 78 1977-78 '000$ Ongoing | FY 78 1977-78 '000$ Suppl. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Final Report | 1. Preparation of charts, graphs, maps, photos & text, plus reduction | | | | | | | | | | | |
| | Canadian Section | DOE | | | | | | | | | | 100 |
| | U.S. Section | EPA, SCS | | | | | | | | | | 100 |
| | Total Funding - Canada | | 232.5 | 10 | 1673 | 1257 | 1555 | 1756 | 1296 | 1425 | 113 | 693 |
| | Total Funding - U.S. | | 628.5 | 905 | 892.2 | 1662.7 | 898 | 1606.3 | 900 | 1316.9 | 25 | 365.7 |
| | Grand Total | | 861 | 915 | 2565.2 | 2919.7 | 2454 | 3362.3 | 2196 | 2741.9 | 138 | 1058.7 |

# APPENDIX 2

CANADA - CATEGORIES ON LAND USE/WATER QUALITY RELATIONSHIPS

1. Urban, Industrial and Commercial
2. Agricultural
3. Forest
4. Recreation
5. Unused, vacant or unallocated
6. Liquid waste disposal areas
7. Solid waste disposal areas
8. Land fills
9. Deep well disposal sites
10. Lakeshore and river bank erosion
11. Intensive livestock feeding operations
12. Private waste disposal areas

# INTERNATIONAL REFERENCE GROUP ON GREAT LAKES POLLUTION FROM LAND USE ACTIVITIES

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U.S. Department of Agriculture
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B. Lake Sink Areas (within specific lakes).

| Magnitude of problem | Unknown 1973 | Suspected 1973 | Known 1973 | Suspected 1980 | Inevitable 1980 | Suspected 2020 | Inevitable 2020 |
|---|---|---|---|---|---|---|---|
| Serious | | | | | | | |
| Moderate | | | | | | | |
| Low | | | | | | | |
| Not Detectable | | | | | | | |

Remarks.

V. Institutional arrangements to regulate landuse, enforcement against pollution etc.

(A) Regulation and enforcement programs.

| | YES | NO |
|---|---|---|
| Landuse | | |
| Pollution | | |

Present annual budget _____

(B) Are regulations and enforcement programs adequate to cope with existing or future problems?

| | YES | NO | Nature of deficiency; manpower, money etc. |
|---|---|---|---|
| Landuse | | | |
| Pollution | | | |

Estimated budget required to upgrade the regulatory program.

1973 _____ 1975 _____

Are these funds likely to be provided under existing arrangements?

YES _____ NO _____

## QUESTIONNAIRE AND DATA MATRIX

Name of person and organization responding.

_____ Date _____

Address _____

I. Landuse Category (See Data Matrix)

II. Identify the Geographical Distribution (location, number, acres etc. by county, other political unit or drainage basin where possible).

III. Pollution related to this landuse (see column headings on the Data Matrix). Type of constituents.

IV. Extent of Pollution, give lbs./acre, tons/mile$^2$, ppm etc. where possible.

A. Upland source areas above the river mouth. Distinguish where possible if pollution is of surface water (S.W.) ground water (G.W.) or both.

| Magnitude of problem | Unknown 1973 | Suspected 1973 | Known 1973 | Suspected 1980 | Inevitable 1980 | Suspected 2020 | Inevitable 2020 |
|---|---|---|---|---|---|---|---|
| Serious | | | | | | | |
| Moderate | | | | | | | |
| Low | | | | | | | |
| Not Detectable | | | | | | | |

Remarks, references, publications, reports, opinions etc.

Investigators (names, addresses etc.).

Organization.

Duration of Study.

Budget. Funded,_____Submitted for funding_____

Contemplated_____

To be done by In house personnel_____Contract to Universities_____

Companies_____

(F.) Future studies required but not now being investigated and not likely to be studied by 1975 as part of present programs. A priority listing would be helpful. Who might conduct these investigations?

(G.) Estimated dollars required for abatement measures to bring about compliance to meet existing State, Province, Federal etc. water quality standards.

| 1973 | 1980 | 2020 |
|---|---|---|
| | | |

Remarks:

(H.) Estimated dollars required to correct existing pollution problems the source of which cannot be attributed to present activities (problem may have developed before regulations and enforcement programs were enacted).

| 1973 | 1980 | 2020 |
|---|---|---|
| | | |

Remarks:

## Suggestions on the Questionnaire and Data Matrix

A single set of sheets should be prepared for each land use if possible and in the detail possible. This will help define problem types, seriousness of problem, ongoing programs etc. that will help the Land Drainage Reference Group formulate a study plan to be submitted to the International Joint Commission and later after new studies are completed (1973 to 1975) to document a find report to be transmitted to the I.J.C.

I. Land use categories - these have been identified on a data matrix and include the following: Agriculture-cropland; Agriculture-pasture; Agricultural-feed lots; Forestry; Urban and Industrial (including food processing but excluding point sources such as a sewage effluent discharge); Recreation (parks); Waste water irrigation; Utilities and Transportation (Roads, snow and ice control etc); Natural (ground water, stream bank and shoreline erosion etc.); Deep Well Disposal; Solid Waste Disposal (Open Dumps, Sanitary Landfills, etc.); Liquid Waste Disposal. Other subdivisions may be desirable.

II. Geographical distribution may be listed as data tables by county, drainage basin etc. or when possible shown on maps.

III. Pollution may include Nutrients, N, $PO_4$, K, etc., Sediment; Pesticides and related chemicals; Organic Wastes; Inorganic chemicals etc.

IV. Extent of pollution should be expressed in quantities where ever possible ppm, mg/liter, lbs/Acre, Tons/$mile^2$ etc.

A. By upland regions we mean within surface water and ground water basins above the mouth of a river entering one of the Great Lakes. It will be helpful if you can distinguish between pollution (known, unknown, suspected) within river and creed (S.W.) and within ground water (G.W.) that may or may not have reached a surface stream. Also it may be possible to distinguish where pollutants entrained in ground water will be discharged directly to the lake without reaching a river or stream.

It may be difficult to project to 1980 and 2020 but this will be helpful to the extent possible.

B. Lake sinks mean that pollutants have reached a lake through surface water or ground water flow.

V. Institutional arrangements. These may be assumed responsibilities or mandated obligations given to state or federal agencies, universities etc. They may be nonstructured in nature (research efforts of one or more individuals within a college or university) or may represent a highly structured program such as regulation and enforcement.

Under A Programs do or do not exist, giving the level of funding.

Under B Programs may exist but the job is not done. Pollution may be occurring because there is insufficient money for enforcement, legal mechanisms are lacking etc.

Under C,D,E Distinction should be made between basic research activities and more routine data gathering activities for policing purposes. A brief statement of objectives and the time frame of existing or proposed studies would be helpful. For more elaborate research programs that may provide significant results that can be extrapolated to other watersheds within the Great Lakes Basin, specific data would be helpful (title, objectives, investigators,

publications and reports etc.). This will aid in data, and in attempting to identify gaps in information on knowledge.

Under F Your group may have strong opinions about specific research and study needs based on first hand experience but will not be in a position to conduct these studies.

Under G Dollars required to bring about compliance means dollars to be spent by landfill operators to collect and treat landfill leachate, sewer authorities who must expand their plants, etc. Costs to groups currently in operation who must meet standards.

Under F Dollars required to correct or abate past pollution to be done at government expense. Leaky abandoned oil and gas wells; abandoned dumps and sanitary landfills, chemical spills from by gone days etc.

DATA MATRIX

| POLLUTANT / LAND USE | NUTRIENTS | SEDIMENTS | PESTICIDES | ORGANIC WASTES | INORGANIC CHEMICALS | |
|---|---|---|---|---|---|---|
| Agriculture | | | | | | |
| Forestry | | | | | | |
| Urban (Ind.) | | | | | | |
| Recreation | | | | | | |
| Utility (Transport) | | | | | | |
| Deep Well | | | | | | |
| Land Fill | | | | | | |
| Solid Waste Disposal | | | | | | |
| Liquid Waste Disposal | | | | | | |
| Natural | | | | | | |

Matrix Space

1. What is known about it?
2. Is it a pollutant to the Great Lakes?
3. To what extent?
4. From what cause and source?
5. What additional studies are required?
6. What are the estimated study costs?

## UNITED STATES - CATEGORIES ON LAND USE/WATER QUALITY RELATIONSHIPS

A1. Residential areas delineated by low, medium, and high densities, man-made hard surfaces less than 10 percent of area, between 10-25 percent of area and over 25 percent of area, respectively.

a. storm sewers (what washes in from surrounding area)

b. combined sewers (minimum--not point--conceptual)

c. excludes discharge of point sources

d. pesticides, herbicides, and nutrients

e. within sewered area

f. includes sediment production, particularly problems within collection system and then affecting Great Lakes waters

g. including urban-type animal wastes

A2. Commercial and industrial delineated by low, medium, and high densities, man-made hard surfaces less than 10 percent of area, between 10-25 percent of area and over 25 percent of area, respectively.

a. includes forest and agricultural-based industries

b. pesticides, herbicides, and nutrients

c. salt wells

d. includes sediment production

e. excludes discharge of point sources

A3. Transportation

a. highways

b. railroads

c. airports

d. utilities (transmission lines)

e. includes sediment production

f. pesticides, herbicides, and nutrients

A4. Extractive

a. mineral industry processing

b. metallic and non-metallic

c. sand and gravel

d. coal, limestone, iron ore, copper

e. salt wells

f. includes sediment or other production

A5. Pesticides, herbicides - Agricultural land with delineation by (a) row crops, (b) close-grown crops, (c) pasture and meadows, and (d) orchards and vineyards.

a. chemical runoff

b. legislation

c. only on agricultural land with four classifications above but also on other land not included in categories 1, 2, 3, 10, and 11 (high density)

A6. Nutrients - Agricultural land with delineation by (a) row crops, (b) close-grown crops, (c) pasture and meadows, and (d) orchards and vineyards.

a. nutrient runoff

b. legislation

c. fertilizers

d. only on agricultural land with four classifications above but also on other land not included in categories 1, 2, 3, 10, and 11 (high density)

A7. Sediments

a. excluding streambank erosion and lakeshore erosion

b. land erosion

c. gully erosion

d. erosion and sedimentation

e. includes sediment production on agricultural land but also on other land not included in categories 1, 2, 3, 10, and 11

f. legislation

A8. Animal Wastes

a. excluding that produced in categories 1 and 2 above

b. all inclusive agriculture-based animals except intensive animal feedlots (poultry, dairies, etc.)

c. legislation

A9. Intensive Animal Feedlots

a. runoff

b. controls

c. legislation

A10. Forestry

a. erosion and sedimentation, timbering

b. pesticides, herbicides, and nutrients

c. change in forest practices

d. clear cut or no clear cut

e. extensive recreational uses

A11. Recreation Land (private and public)

a. parks

b. cottage subdivisions

c. high density non-sewered residential areas

d. intensive recreational land use

e. ski slopes

f. recreational beaches

g. includes sediment production

A12. Undeveloped--no major use

a. natural pollution, miscellaneous

b. wetlands

c. bogs, natural loadings

A13. Liquid Waste Disposal Areas

a. spray irrigation

b. sludge deposits (municipal and industrial)

c. water with content carried to land

d. legislation

A14. Solid Waste Disposal Areas

a. sanitary landfills, municipal, and others

b. legislation

A15. Land Fills

a. by dry or wet methods

b. dredging

c. dredge spoil disposal areas

d. legislation

A16. Deep Well Disposal

a. industrial, agricultural, commercial

b. legislation

A17. Management and Control of Land Use/Water Quality Problems

a. develop standard form

b. all States surveyed

c. major contract

d. may use results of other 16 contracts

# APPENDIX 3

LAND USE CLASSIFICATION

1. URBAN - COMMERCIAL - INDUSTRIAL (Urban and Built-up)

   a. Residential

      1) Man-made hard surfaces less than 10 percent of area (low density)

      2) Man-made hard surfaces between 10-25 percent of area (medium density)

      3) Man-made hard surfaces over 25 percent of area (high density)

   b. Commercial and Industrial:

      1)
      2) Same as above
      3)

   c. Transportation

   d. Extractive

2. AGRICULTURE

   a. row crops

   b. close grown crops

   c. pasture and meadows

   d. orchards and vineyards

3. FORESTED LAND

4. RECREATION LAND

   a. park lands

   b. cottage subdivision

5. NO MAJOR USE

   a. water

   b. wetlands

   c. barren lands

SPECIALIZED CATEGORIES

LIQUID WASTE DISPOSAL AREAS

SOLID WASTE DISPOSAL AREAS

LAND FILL

DEEP WELL DISPOSAL

LAKESHORE AND RIVERBANK EROSION

INTENSIVE ANIMAL FEEDLOTS

HIGH DENSITY NON-SEWERED RESIDENTIAL AREAS

MINING ACTIVITIES

## SPECIALIZED LAND USE CATEGORIES DATA OUTPUT (U.S. ACTIVITY 2)

| | Inventory Data |
|---|---|
| 1. Liquid Waste Disposal areas (including both wastewater disposal system and sludge application areas) | name<br>location<br>type of application<br>type of effluent applied<br>acreage |
| 2. Solid Waste Disposal Areas | name<br>location<br>type<br>acreage |
| 3. Land fills (include dredge spoil disposal) | name<br>location<br>size |
| 4. Deep Well Disposal | location<br>depth<br>nature of wastes<br>quantity of wastes |
| 5. Lakeshore and River Bank Erosion | |
| (a) lakeshore erosion: | number miles of erosion by degree (critical, moderate; minimum)<br>maps approximate location |
| (b) riverbank erosion: | number of miles and approximate location of riverbank erosion areas by degree of severity |
| 6. Intensive Animal Feedlots | number of herds and cattle by county (source; Census of Agriculture) |
| 7. High-Density Non-Sewered Residential Areas | - number of houses by county not on public sewer systems (source; Census of Housing) |
| 8. Recreation Lands national, state, local and, to extent possible, private recreation areas | name<br>location<br>acreage |

# DATA COLLECTION GUIDELINES

## TASK B - ACTIVITY 4

| | Material | Data |
|---|---|---|
| 1. | Pesticides<br>- insecticides<br>- herbicides<br>- fungicides<br>- others | - acres treated by category (general chemical groupings) pesticide;<br>- quantities applied (by category)<br>- quantities and acres by major crop or use; (includes agricultural and other uses)<br>- general methods of application |
| 2. | Fertilizer | - quantities of fertilizer applied by analysis, including minor elements<br>- acres fertilized;<br>- quantities and acres by major crops;<br>- general methods of application |
| 3. | Road Salts<br>(De-icing Compounds) | - quantities used by chemical grouping; (for last 5 years);<br>- miles of road treated;<br>- average application rates |
| 4. | Agricultural Liming Materials<br>(U.S. only) | - quantities used;<br>- acres treated;<br>- application rates; |
| 5. | Agricultural Manure | - quantities used;<br>- acres treated;<br>- application rates;<br>- general methods of application |

# APPENDIX 4

CANADIAN WATERSHEDS*

## Grand River Basin

The Grand River is the largest river basin in south-western Ontario, draining an area of 2,600 square miles. The main stream rises in a massive swampy upland south of Georgian Bay at an elevation of 1,725 feet above sea level and runs a course of 180 miles to Lake Erie at Port Maitland. Three major tributaries, the Nith, Conestoga and Speed rivers, and numerous smaller streams feed the main channel.

### Physiography

The Grand River basin may be divided into an upper part where the river and its branches mostly flow in spillways, previously formed in the till plains and moraines and the lower part where the river has made its own channel across a lake plain. The upper section, above the City of Brantford, has an average gradient of about 8.5 feet per mile.

In the extreme upper reaches there has been very little valley cutting. Grades are low and deepening of the valley is held up by bedrock. Limestone is exposed near the Village of Grand Valley about 75 feet below the level of the adjacent plain. Drainage is poor on the plain above Grand Valley and swamps are prevalent, the largest of which is the Lutter Marsh covering about 10,000 acres.

From Grand Valley to Elora, 20 miles downstream the bed of the river is controlled by the bedrock and the valley varies from 60 to 100 feet in depth. It is flanked by gravel terraces indicating its earlier history as a glacial spillway.

In the vicinity of Elora, there occurs a definite break on the slope of the bedrock and the river has cut deep gorges in the limestone. The gorges end a short distance below Elora and give place to a wide, winding valley in alluvial gravels and occasionally till. From this point to the Town of Paris, the valley is 75 to 100 feet deep and between Paris and Brantford the valley is over 150 feet in depth. Below Brantford the valley is cut in the silt and clay of Lake Warren and the underlying boulder clay. Because of the low gradient, one foot per mile, very little valley cutting has occurred.

### Land Use

The Grand River basin has been developed extensively for urban and agricultural uses and to a lesser extent for recreational use.

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* See Figure (5) for locations.

The basin has a population of about 500,000 persons and includes the cities of Brantford, Kitchener, Waterloo, Cambridge and Guelph; the towns of Elmira, Fergus, Elora, Paris and Dunnville and many villages and hamlets.

Agricultural uses are extensive and varied. The Agricultural College of the University of Guelph is also centred in the Grand River basin.

The Grand River Conservation Authority has developed a number of recreation areas primarily around the numerous empoundments and reservoirs throughout the basin. These areas offer swimming, picnicing, boating, fishing and camping.

Streamflow

Continuous streamflow records are maintained at 26 gauging stations throughout the basin. The gauge closest to the river mouth is located at Brantford. This station measures the total flow from about 80 per cent of the basin. Records kept for 37 years indicate that the annual average flow at this point is 1850 cfs. The lowest flows usually occur during the month of August averaging 730 cfs; and the maximum and minimum daily flow values on record are 47,800 cfs and 24 cfs respectively. Since 1950, the minimum daily discharge on record is 212 cfs.

Water Quality Monitoring

River sampling for chemical, physical, biological and bacteriological water quality has been carried out for many years. Currently 34 stations are monitored on a routine monthly basis. This routing sampling program was established in 1964. The waters of the Grand River basin are enriched with organic materials and algal nutrients. The greatest loading pressures, evidenced by excessive growths of algae and aquatic plant life, occur in the heavily populated sections of the middle and lower basin, where numerous sewage treatment plants discharge to the river. All sewage treatment plants provide secondary treatment and will include phosphorus removal by the end of 1973. Land drainage also contributes varying amounts of polluting materials throughout the drainage system.

## Saugeen River Basin

The Saugeen River rises near the south-western Ontario community of Dundalk at an elevation of about 1,700 feet above sea level and meanders in a generally westerly direction to the Town of Walkerton where it turns northward and continues to meander to Lake Huron at Southampton. The main branch is about 115 miles in length and has an average gradient of 9.5 feet per mile. Four major tributaries, the North Saugeen River (31 miles), the Rocky Saugeen (31 miles), the South Saugeen (50 miles), the Teeswater River (46 miles), and numerous smaller streams feed the main channel. The total drainage area of the basin is 1,600 square miles.

## Physiography

The headwater areas of the basin can be described as rough and rocky land with large areas of swamp and non-productive woodlands. Cleared areas are primarily permanent pasture. The soil is loamy or gravelly. The Teeswater River which drains the south-western portion of the basin drains the Greenock swamp.

Above Walkerton, the several branches of the Saugeen flow in old glacial spillways with broad gravel terraces. Below Walkerton the river flows through the Horseshoe moraine in a valley about one-half a mile wide and 150 feet deep. North of the moraine there is an extensive sand plain formed by Lake Warren. In this area the valley is over 75 feet in depth and up to two miles in width. Within the valley are numerous sand and gravel terraces, remnants of former flood plains. Below Paisley there is another deep passage through a clay-till ridge and a few miles further downstream the river enters a former lagoon which was enclosed by the heavy Algonquin beaches at Port Elgin. From here to its mouth at Southampton the river valley seldom exceeds 50 feet in depth.

## Land Use

Land use in the Saugeen River basin is primarily agricultural with a large area of the basin permanent pasture. Intensive livestock and poultry operations and a wide variety of crops are also found in the area. Much of the land, particularly in the headwater areas, is swamp or unproductive woodland.

Urban development is sparse. The largest municipality, Hanover, has a population of 4,950. Other municipalities in the basin are Walkerton (4,300), Mount Forest (3,000), Durham (2,430), Southampton (1,815), Chesley (1,680), and Markdale (1,140).

The Saugeen Valley Conservation Authority has developed a number of recreational areas within the basin.

## Streamflow

Continuous streamflow records are maintained at three locations in the basin. The gauge closest to the river's mouth is located at Port Elgin. Records kept for this station since 1914 indicate that the mean daily flow is 1960 cfs, the lowest flows occur in August and September (average - 600 cfs) and the maximum flows occur in April (average - 5300 cfs). The extreme instantaneous flows on record are a maximum of 31,640 cfs and a minimum of 202 cfs.

Mean daily temperature in the Saugeen River basin in about 44 degrees Farenheit and the mean total precipitation is 35.9 inches.

## Water Quality

Routine sampling for chemical, physical, biological and bacteriological water quality has been carried out for many years. Currently 17 stations are monitored on a monthly basis.

Portions of the basin indicate nutrient enrichment most probably fron non-urban sources. Organic enrichment is evident below some of the municipalities. An intensive water quality investigation is currently underway in the basin to isolate pollution sources and recommend remedial action.

# Wilton Creek Basin

The Wilton Creek basin in eastern Ontario drains an area of 57 square miles with discharge to Lake Ontario at Hay Bay east of Napanee. The stream is 27 miles long and flows through a narrow basin.

## Physiography

The drainage basin is characterized by a thin veneer of overburden on a relatively flat-lying limestone plain of Ordovician Age. The soils which have developed from the overburden reflect the two major types of parental material; lacustrine clays and stony, sandy-silty tills. The lacustrine clays which are restricted primarily to the southern portion of the basin and adjacent low-lying areas form the Napanee and Lansdowne Soil Series. These soil types are rather impermeable, creating poor to imperfect drainage conditions. The glacial tills, lower in the stratigraphic sequence than the lacustrine clay, cover the majority of the basin and have the following soil types developed from them; Bondhead, Guerin and Farmington Series. Where these are shallow (3 feet), the relatively-good permeability of the soils coupled with the fractured nature of the underlying limestone bedrock create areas of very low soil moisture storage capacity and also areas where the risk of ground-water pollution is strong.

## Land Use

The shallowness and stony nature of the soil strongly restricts the land use within the basin. A land use survey conducted in 1969 by the Ministry of the Environment indicates that the breakdown for total acreage of the basin was: hay (4,028 acres), pasture (1,348), bush (3,054), scrub (1,000, swamp (640), corn (344), houses (318), oats (120), and wheat (8 acres).

The present residential population is estimated as approximately 800. The following small centres of population, in order of size, lie entirely within the basin: Harrowsmith, Wilton, Morven, and Violet.

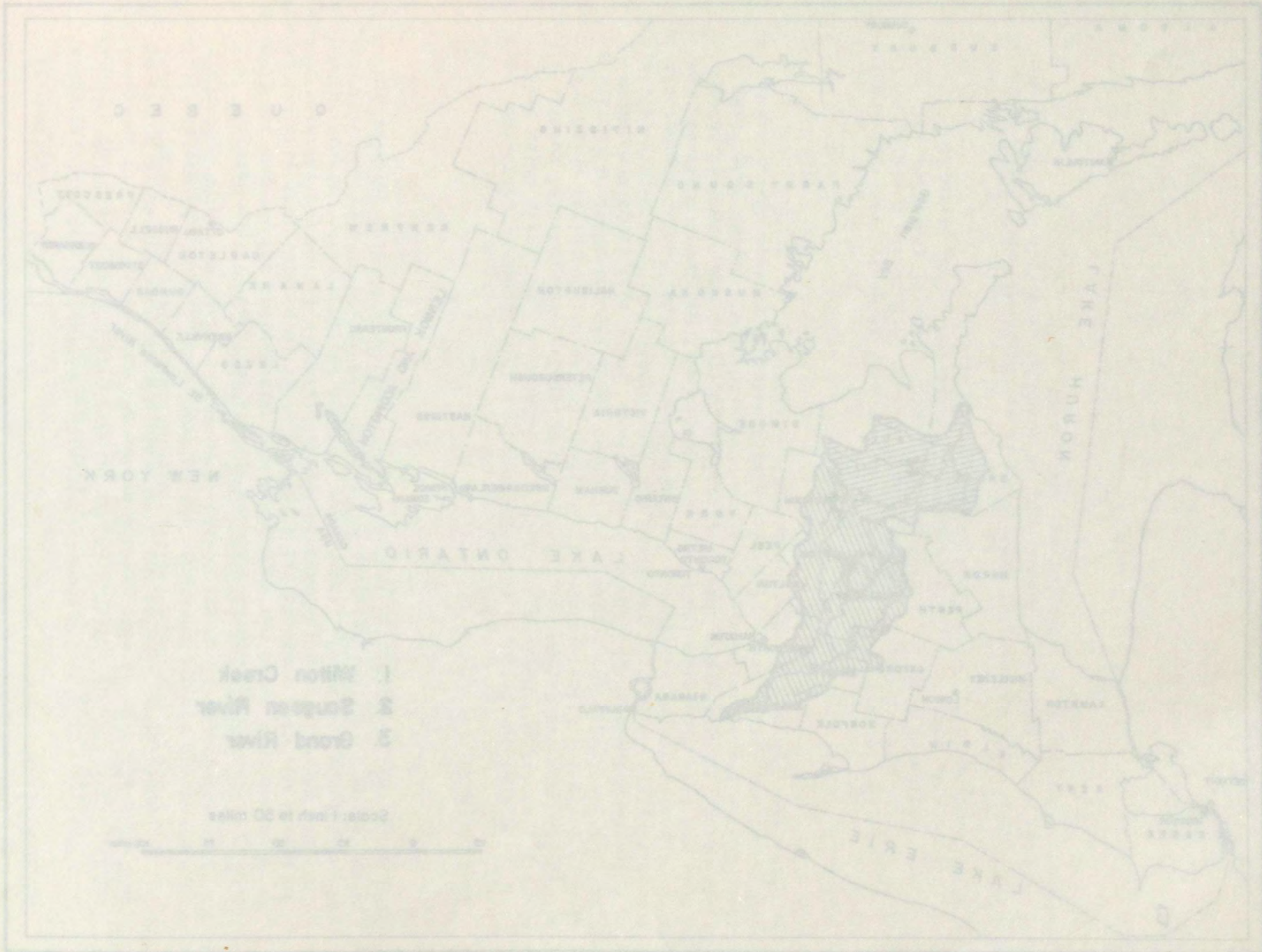
## Streamflow

There are two recording and two non-recording streamflow gauging stations in the basin. Mean daily flow is in the order of 50 cfs. The extreme instantaneous flows on record for the period October 1965 to 1972 are a maximum of 980 cfs on March 25, 1969 and a minimum of 0.20 cfs on July 17, 1966.

## Water Quality Monitoring

A water quality sampling station has been maintained on Wilton Creek since 1964. Records for this station, located about two miles from the river's mouth, indicate that water quality is generally satisfactory with low levels of organic material and normal dissolved oxygen concentrations. Nitrogen and phosphorus levels indicate slight nutrient enrichment. Bacterial populations are occasionally high but generally fall within the accepted limits for normal uses. There are no major point discharge pollution sources within the Wilton Creek basin.


Figure.5 Location of major Canadian watersheds proposed for Task C studies.



## FACTORS FOR SELECTION OF AGRICULTURAL REGIONS AND WATERSHEDS

A. Factors to be utilized in the preliminary phase of the study.

Purpose: To enable the principal "agricultural regions" to be identified within the Canadian Great Lakes Basin. An agricultural region is defined here as an area of similar soils (see table 1 for soil groupings), in the same climatic zone upon which an identifiable agricultural land use or combination of land uses exists.

1. Soils: Different soils are recognized by a grouping which reflects the potential of a soil to transfer a "pollutant" from the soil surface to a water system (surface or ground or both). The grouping takes into account soil texture, depth, slope and drainage class. Guidelines for this grouping are given in Table . Final determination of the groupings of individual soil series has been made by Dr. C. Acton, Soil Survey Unit, C.D.A., Guelph.

2. Agricultural Land Use: Livestock and crop types have been grouped where possible by management or other characteristics which give the members of each group a similar relationship with the physical environment (see table 2). An agricultural land use is defined as any individual livestock or crop type (or group) or any identifiable crop rotation or combination of livestock with crops.

3. Climate: A broad distinction has been made between the climatic zones of the region. Recognition is given to the higher snowfall, rainfall and runoff, and lower degree-days and shorter growing season of the central uplands. This is in contrast with the climate of the rest of the region which is lower in elevation, closer to, and more influenced by, the Great Lakes.

B. Factors to be utilized in the selection of watersheds for the detailed phase of the study.

1. Results of an analysis of data obtained from the preliminary phase of the study:

This data should indicate those agricultural regions from which significant quantities of any pollutant migrate to the Great Lakes Drainage System. The detailed phase of the study will have as its primary objective the isolation of the source(s) of the pollutants found.

2. Pesticide Usage Inventory:

Areas of intensive usage of pesticides or of a specific pesticide will be identified and consideration given to these areas in the selection of sub-watersheds for the detailed study.

3. Soil Erosion Studies:

In watersheds from which high sediment loads are found in the preliminary phase of the study, soil erodibility information will be used to plan studies to investigate the source and transport of these sediments.

4. Livestock Operations Inventory and Livestock Waste Runoff Studies:

In watersheds where livestock related pollution is found in the preliminary phase, the livestock inventory and waste runoff data will be used to plan studies to further investigate these sources.

TABLE 1.

Soil Potential for Pollutant Transfer

GROUP I Soils with high potential for contribution to surface water systems (streams & small lakes) and low potential for contributions to ground water.

Ia. fine textured profiles, low infiltration rate

| Profile Texture | Slope | Drainage class |
|---|---|---|
| clay, clay loams | All | good & imperfect |
| silty clays | " | " |
| Silty Clay loams | " | " |

Ib. medium textured profiles, low infiltration rate

| | | |
|---|---|---|
| loams | >6% | well drained |
| silt loams | >6% | " |
| loams | All | good & imperfect |
| silt loams | " | " |

Ic. coarse textured soils

| | | |
|---|---|---|
| sands or sandy loams over clay | >3% | good & imperfect |

Id. organic soils — All — tile drained or pumped

Ie. miscellaneous land types

bottom land

alluvium

escarpment

GROUP II Soils with moderate potential for contribution to both surface water and ground water.

IIb. medium textured profiles

| Profile Texture | Slope | Drainage class |
|---|---|---|
| loams | >6% | mainly imperfectly drained |
| silt loams | >6% | " |

GROUP III Soils with high potential for contributions to ground water; low potential for contributions to surface water.

IIIb. medium textured profiles

| Profile Texture | Slope | Drainage class |
|---|---|---|
| fine sandy loams | All | mainly poorly drained |
| gravelly loams | " | " |
| loam over gravel | " | " |

IIIc. coarse textured profiles

| | | |
|---|---|---|
| deep sands or sandy loams | " | " |
| sand or sandy loams over gravel | " | " |

IIId. shallow soils overlying bedrock

| | | |
|---|---|---|
| | " | " |

GROUP IV Soils with low potential for contributions to both surface water and ground water.

IVb. medium textured profiles

| Profile Texture | Slope | Drainage class |
|---|---|---|
| loams | >6% | mainly well drained |
| silt loams | >6% | " |

IVc. coarse textured profiles

| | | |
|---|---|---|
| sands or sandy loams over clay | >3% | All |

GROUP V Soils with high potential for contribution to both surface water and ground water.

Va. fine textured profiles

| Profile Texture | Slope | Drainage class |
|---|---|---|
| | All | poor |

| | | | |
|---|---|---|---|
| Vb. | medium textured profiles | Slope | Drainage class |
| | loams | All | poor |
| | silt loams | " | " |
| Vc. | Rock outcrop | | |

# PROGRESS IN COMPILATION AND PREPARATION OF EXISTING DATA

## Progress of Preparation

### 1. Livestock types, numbers, and densities and crop acreages

Information has been obtained from the 1971 Census of Agriculture (Statistics Canada). Both township summaries and enumeration area data are being used. Conversion of township census data to express livestock manure and fertilizer nutrient distribution has been completed as part of the C.D.A. Task Force Report, April 1973. This data has been reviewed and adjusted where necessary. Detailed census data has been obtained for enumeration areas, subject to the editing out of those enumeration areas with less than 10 farms, and some others where editing is necessary to maintain confidentiality. Mr. Marvin Kaplanski of the Scientific Applications Division of C.D.A. is in the process of printing computer-compiled maps of selected livestock and crop characteristics. These maps will be at a scale of 1:250,000, and will show the density distribution of different livestock types, and percentages of farm land in each of a number of major crops. Maps indicating livestock and fertilizer nutrient distribution will also be printed. These maps should be available by the end of November.

### 2. Soil survey reports and maps

Ontario Soil Survey - are being used for soil information. Assistance is being given by Dr. C. Acton, Soil Survey Unit, C.D.A., Guelph.

Photographic reductions have been made of the soil survey maps for the basin. These have been composited on a scale of 1:250,000 to correspond to the Canada Land Inventory Land Capability Maps and to the Land Directorate maps of watershed boundaries. Groupings of the soils have been made which reflect the criteria listed in Table . These groupings are being mapped on the 1:250,000 reduced soil maps, for later comparison with the census data maps mentioned in (1) above. These maps should also be available by the end of November.

### 3. Climatic information

Climatic information is being obtained from the Canada Land Inventory, Climates of Canada for Agriculture, C.L.I. Report No. 3, 1966, and the Climate of Southern Ontario, Brown, McKay and Chapman, D.O.T., Climatological Study #5, 1968.

The large number of climatic zones as outlined in the D.O.T. Climatological Study by Brown, McKay and Chapman, are considered to lack individual significance for a study of this type.* Consideration has been given to maps of precipitation, snowfall, runoff, growing degree days and the climatic zones mentioned above. A zone of higher rainfall, snowfall, runoff, growing degree days and the climatic zones mentioned above. A zone of higher rainfall, snowfall and runoff and lower growing degree days has been outlined as shown in Figure 6.

4. Pesticide Usage Inventory

Mr. Murray Raich, O.M.A.F. Economics Branch, Toronto, and Dr. R. Franks, O.M.A.F., Guelph, are in the process of compiling data on pesticide usage in the Canadian Great Lakes Basin, from a recent survey commissioned for this purpose. The information will be utilized to determine the types of pesticide analyses to be made in the preliminary phase of the Task C study. It will also be used as a guide to the selection of sub-watersheds for inclusion in the detailed phase of the study, for the detailed phase of the study, for the detailed study of pesticide movement from agricultural land.

The mapping scale and type of maps to be produced are still to be determined.

5. Soil Erosion Studies

Dr. G. Wall, C.D.A. Soil Survey Unit, Guelph, is in the process of developing maps of soil erosion potential. Dr. T. Dickinson, Professor of Hydrology, University of Guelph, is preparing information from existing sediment load data and stream flow characteristics. The erosion potential maps and sediment and stream flow information, together with sediment data obtained during the preliminary phase of the study, will be used to guide the selection of sub-watersheds for inclusion in the detailed phase. These sub-watersheds will be used for the detailed study of soil erosion, and sediment transportation processes, from agricultural land.

Maps will probably be compiled at a scale of 1:250,000.

*Personal Communication. D.M. Brown, Department Land Research Science, University of Guelph

6. Livestock Operation Inventory

With the assistance of Mr. B. Ryerson, Canada Centre for Remote Sensing and Mr. Laurie Philpotts, Farm and Rural Development Division, Economics Branch, C.D.A., an animal operations inventory is being compiled jointly by the Engineering Research Service and the Soil Research Institute, C.D.A.

Airphotos are being used to determine the type, location and estimated size of livestock operations in Southern Ontario. The Airphotos on a scale of 4 in. to 1 mile, are from both the Ontario Ministry of Natural Resources and the Department of Energy, Mines and Resources.

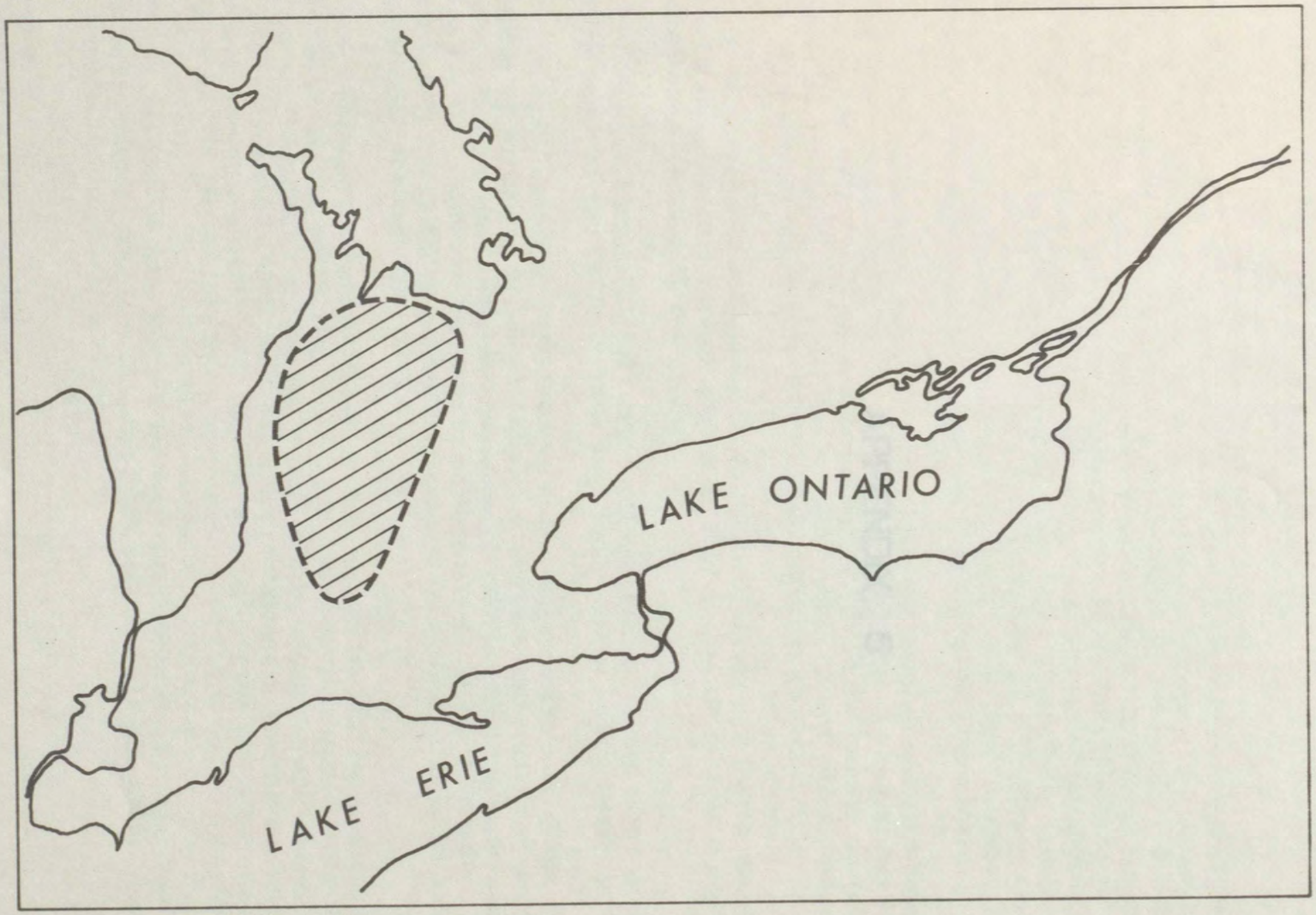



FIGURE 6

Map Showing Region of High Rainfall, Snowfall and Runoff, and Low Growing Degree Days.

LAKE ONTARIO
LAKE ERIE

# APPENDIX 5

U.S. WATERSHEDS *

## Genesee River Basin

The Genesee River drains some 2,384 square miles in Central New York and another 96 square miles in North-Central Pennsylvania. The watershed is roughly rectangular in shape, running north-south, and is about 100 miles long and 40 miles wide. The river flows north from Pennsylvania through New York to Lake Ontario. In its course, it intersects the Barge Canal just south of Rochester and continues on through the city. The Genesee River discharge averages about 2,726 cfs near Rochester, and the river flow is carefully regulated by a series of dams in and near the city. Three substantial tributaries enter the Genesee River just upstream of Rochester: Black Creek (mean discharge 101 cfs), Oatka Creek (mean discharge 195 cfs), and Honeoye Creek (165 cfs).

The basin has a humid climate with cold winters and mild summers. The average yearly temperature in the lower basin is 50°F. In the higher elevations the average is 44°F. Average annual precipitation is 34 inches, decreasing from a high of 42 inches in the upper basin to 28 inches in the lower basin. The entire watershed is subject to local cloudburst-type storms.

A summertime deficiency of rainfall often occurs in the Genesee Basin. This deficiency extends through the upper four inches of soil as a regular occurrence during part of the summer.

A wide variety of soil types and geochemical areas exist as one moves from the mouth of the basin at Lake Ontario up to the upland areas in Pennsylvania.

Topographically, the Genesee River Basin consists of three terraces separated by northward facing escarpments. The sourthernmost terrace is the Allegheny Plateau whose northernmost edge is the Portage Escarpment which cuts across the basin north of Mt. Morris on an east-west line. The soils in this area are siltstone, shale and sandstone mixed on glacial till with moderate to somewhat poor drainage qualities.

Between the Portage Escarpment on the south and the Niagara Escarpment in Rochester on the north lies the Erie and Huron Plains area. This area has a rolling surface with long, gradual slopes except along the tributary streams which lie in deep ravines. Here the soils are predominately limestone with shale and sandstone, on glacial till with good to moderately good drainage. There is clay concentrated in the subsoil.

The narrow lake plain within the City of Rochester, north of the Niagara Escarpment, consists of lacustrine silt and clay deposits. These soils are imperfectly to poorly drained.

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* See Figure 7 for locations.

A wide area of land use activities is represented in the basin as shown in the accompanying Table.

GENESEE BASIN LAND USE

| Land Use | Square Miles | % |
|---|---|---|
| Urban, Commercial, Industrial | 99.7 | 4 |
| Residential | 52.5 | 2 |
| Commercial and Industrial | 15.3 | 1 |
| Transportation | 8.9 | 1 |
| Extractive | 23.0 | 1 |
| Agriculture | 1017.8 | 43 |
| Row & Closegrown crops | 46.8 | 2 |
| Pasture & Meadows | 969.3 | 41 |
| Orchards & Vineyards | 1.7 | 1 |
| Forested Land | 1125.5 | 47 |
| Recreation Land | 33.5 | 1 |
| No Major Use | 88.7 | 4 |
| Water | 25.0 | 1 |
| Wetlands | 63.1 | 3 |
| Barren Lands | .6 | 1 |
| Miscellaneous | 18.8 | 1 |
| Public Land | 14.0 | 1 |
| Urban Inactive & Construction | 4.8 | 1 |
| | 2384 | 100 |

The largest concentrate of urban and residential area is in the Rochester Metropolitan area where the population grew from 615,044 in 1950 to 882,667 in 1970. All of this growth has occurred in the suburban areas since the central city population in 1950 was 332,488 and fell to 296,233 in 1970. This population is concentrated along the main stem of the Genesee River and near Lake Ontario. Rochester itself is heavily industrialized. The area is served by the Barge Canal, five railroads, five major highways (including the New York State Thruway) and three airlines. The Barge Canal, in particular, is still used to move bulky goods like oil, petroleum products, fertilizer and scrap.

The basin north of suburban Rochester is for the most part sparsely populated and consists of primarily agricultural lands with some forested areas. Although the agriculture is predominantly dairy, there are extensive truck and row crop areas with a prevalence of vegetable crops and fruit orchards. Corn is the major crop. Oats, wheat and barley combined occupy about the same acreage as corn.

## Menomonee River Basin

The 136 square mile Menomonee River watershed is located in the southeastern corner of Wisconsin and discharges to Lake Michigan at the City of Milwaukee. This highly urbanized watershed encompasses all or parts of four counties and 17 cities, villages and towns and currently contains a resident population of about 400,000 persons (2,940 persons per square mile). Existing urban land uses range from an intensely developed commercial-industrial complex in the lower quarter of

the watershed to low to medium density residential areas in the center half of the watershed, while the upper quarter is in the process of being converted from rural to urban land use as reflected by scattered urban development. The irregular topography of the watershed results from the effects of glaciation. Heterogeneous glacial drift covers the entire watershed and the dominant soil types tend to be poorly drained. The long-term average discharge from the watershed is 66 cfs but flood flows as high as 15,000 cfs have been recorded.

The basin has a typical humid climate, with mild summers and cold winters. The annual average temperature is 50°F with mean daily temperatures ranging from 21°F in January to 71°F in July. Annual average precipitation is 31 inches (40 inches of snow).

Soils are generally somewhat poorly to poorly drained with a few areas of well drained soils in the uplands.

## Felton-Herron Creek and Mill Creek Basins

The general location of the Felton-Herron Creek and Mill Creek watersheds are shown in Figure 7. The Felton-Herron Creek subwatershed is a small drainage basin that lies almost entirely within the boundaries of the 6,000 acre campus of Michigan State University. It is tributary to the Red Cedar River which flows into the Grand River a few miles downstream from the City of East Lansing. The topography is moderately rolling and the area includes a complex variety of soil types, ranging from sand and gravel to heavy clays and muck soils. The land was partially under cultivation until approximately 10 years ago. Since that time much of the land has reverted to old-field succession with the exception of cultivated plots presently serving the initial effort in a hydrological evaluation of spray irrigation. In addition a section of the watershed is covered by second-growth mixed hardwood forest and a smaller section is in a pine plantation. In many ways, the area that has been developed is a microcosm of the drainage basin of the Great Lakes.

The control of this site unit is designed to give complete flexibility in rates of application and in effluent quality for the research and demonstration purposes. Within this system is a single watershed with adjunct discharge to a second major watershed and to microwatersheds within the spray irrigation unit. The entire complex consists of approximately 530 acres of mixed soil type terrain with a vegetative complex representative of much of the surface vegetation cover of the Great Lakes states. Within this facility are all of those components necessary to study the physical, chemical, and biological impact of wastewater on a representative environment and one that will allow prediction and extrapolation both in the short-term and long-term.

Mill Creek arises from within the well known "Peach Ridge" fruit farming area in Kent County of southwest lower Michigan. The stream flows through approximately 20 orchards for approximately 10 miles before its confluence with the Grand River near the City of Comstock Park. The stream, for the last 4 miles, is potentially a trout stream. Orchards are of various sizes and employ different cultural practices for similar crops such as apples, peaches, pears, cherries and grapes. The study section of this basin is approximately 20 $mi^2$ in area and sandy loam soils predominate. A nearby stream, the Rogue River, has served as a control

stream during the conduct of these studies and could also serve a similar function for the expanded studies.

Insecticide, fungicide, herbicide and fertilizer usage in the Mill Creek basin are intensive. Of particular interest is the practice of removing all ground vegetation to increase crop yields. The younger farmers in the basin generally employ such techniques while older farmers allow grass to cover the entire orchard. These contrasting practices are spacially separated within the basin and offer an opportunity to assess the impact of differing cultural practices within what might otherwise be considered a single land use.

## Maumee River Basin - Ohio

A detailed description of the Maumee River Basin and of the Black Creek Watershed in Allen County Indiana is presented in the Black Creek Study. Only pertinent information concerning the major portion of the Maumee River Basin which lies in Ohio will be presented herein.

The Maumee River watershed represents that segment of the Great Lakes Basin that drains into the western end of Lake Erie (Fig. ). The Maumee River originates at Fort Wayne, Indiana where the St. Marys and St. Joseph Rivers converge and flows 128 miles in a northeasterly course to Lake Erie at Toledo, Ohio.

The Maumee River Basin has an areal extent of 6,586 square miles of which 74% of it (4,856 square miles) lies in Ohio. This area includes all or portions of the following 17 counties: Allen, Auglaize, Defiance, Fulton, Hancock, Hardin, Henry, Lucas, Mercer, Paulding, Putnum, Seneca, Shelby, Van Wert, Williams, Wood, and Wyandot. Approximately 72% of the population of the Basin live in Ohio of which 76% live in the larger urban centers which include Toledo, Lima, Findlay, Defiance and Bowling Green. In spite of the high urban population the major land use is agricultural as evidenced by the fact that only Allen and Lucas counties have less than 93% of the land area in agricultural use. The principle crops include corn, soybeans, wheat and oats. The practice of fall plowing is a common management procedure associated with growth of these crops.

The Maumee River Basin consists of two physiographic regions, namely, a Till Plain and a Lake Plain. In Ohio the Till Plain comprises about 40% of the area and the Lake Plain 60%. Topography ranges from gently undulating to rolling in the Till Plain sector, particularily along the periphery portions in Indiana and Michigan, to a nearly flat featureless plain in the Lake Plain sector. The average gradient across the entire Maumee River Basin is less than 1%. Thus, the area is weakly dissected by the Maumee River and its major tributaries including the Auglaize, Blanchard, St. Joseph, Ottawa, and Tiffin Rivers. The Lake Plain represents a portion of the abandoned floor of glacial Lake Maumee which occupied the basin in late Pliestocene time (Late Wisconsin age) about 12,000 years ago. Silurian and Devonian limestones, dolomites, and shales represent the chief bedrocks of the Basin and are covered with a mantle of Pleistocene deposits ranging up to 400 feet in thickness; however, in the eastern portion of the basin these materials average less than 75 feet and the bed of the Maumee River itself is often on the bedrock surface.

Soils in the Maumee River Basin are developed from three major types of geologic materials: clay loam, silty clay and clay till deposits; lacustrine clays; and lacustrine (beach) sands and gravels. In the Ohio sector of the Basin, soils derived from these materials comprise, 58%, 18%, and 7% of the area, respectively, or 42%, 13% and 5% of the entire Basin. Because of the low gradient and weak dissection in the Basin over 50% of the soils in the Ohio sector are poorly drained. This has given rise to numerous man-made drainage ditches criss-crossing the area.

The major till derived soils of the Till Plain are Morley, Blount, Pewamo and in the Lake Plain St. Clair, Napponee, Hoytville, and Wetzell. They are developed in illitic-rich till deposits ranging from 35 to 50% in clay content and 20 to 25% in calcium carbonate equivalent. Surface horizons range from loam or silty clay loam to clay loam in texture while subsoils are generally clay texture. The two most extensive soils of this group are Blount and Hoytville which comprise over 35% of Ohio's sector of the Basin. The predominant clay minerals are illite and vermiculite. There is a progressive increase in illite and decrease in vermiculite with depth in these soils from the surface to geologic materials as a consequence of decreasing weathering intensities with depth. This affords an unique opportunity to utilize clay mineralogy to differentiate sediments of surficial versus geological origin.

The most extensive lacustrine clay-derived soils of the Lake Plain include Roselms, Paulding, Latty, Fulton, and Toledo. These soils plus associated members comprise over 18% of Ohio's sector of the Basin or over 13% of the entire Basin. Excluding Toledo, this group of soils is found exclusively in Ohio and form a most important component to the Maumee River Basin because of their fine texture (50 to 80% clay) and susceptibility to erosion. In spite of the nearly level tablelands occupied by Paulding, Latty and Toledo soils, their fine surface textures, slow permeability, and practices commonly employed to improve drainage make these soils potential contributors to sediment production in the Basin. Perhaps even more importantly are soils such as Roselms and Fulton which occur along valley sides of weakly dissected portions of the Basin. These soils are highly susceptible to erosion when fall plowed because of fine surface textures (60 to 80% clay) sloping landscape positions and saturated soil conditions during Winter and early Spring. The Paulding Basin which includes a high percentage of these soils in Paulding, Defiance, Putnam and Lucas Counties is dissected by several major rivers: Maumee, Auglaize, Blanchard, and numerous tributaries of same. These are direct arteries for sediment production to the mouth of the Maumee River.

The clay mineral composition of lacustrine clay-derived soils is similar to till-derived soils of the Basin.

In general, soils developed in coarser-textured lacustrine beach deposits are considered a less serious threat to water quality of the Basin. These soils comprise a relatively small area, are highly pervious, and are less susceptible to erosion. The Black Creek Watershed of Indiana has a disproportionately high percentage of such soils (25%) in contrast to their percentage in the Ohio sector (7%) of the Basin. This is a consequence of the fact that a beach ridge traverses the Black Creek Watershed, but such features comprise a small percentage (5%) of the entire Basin.

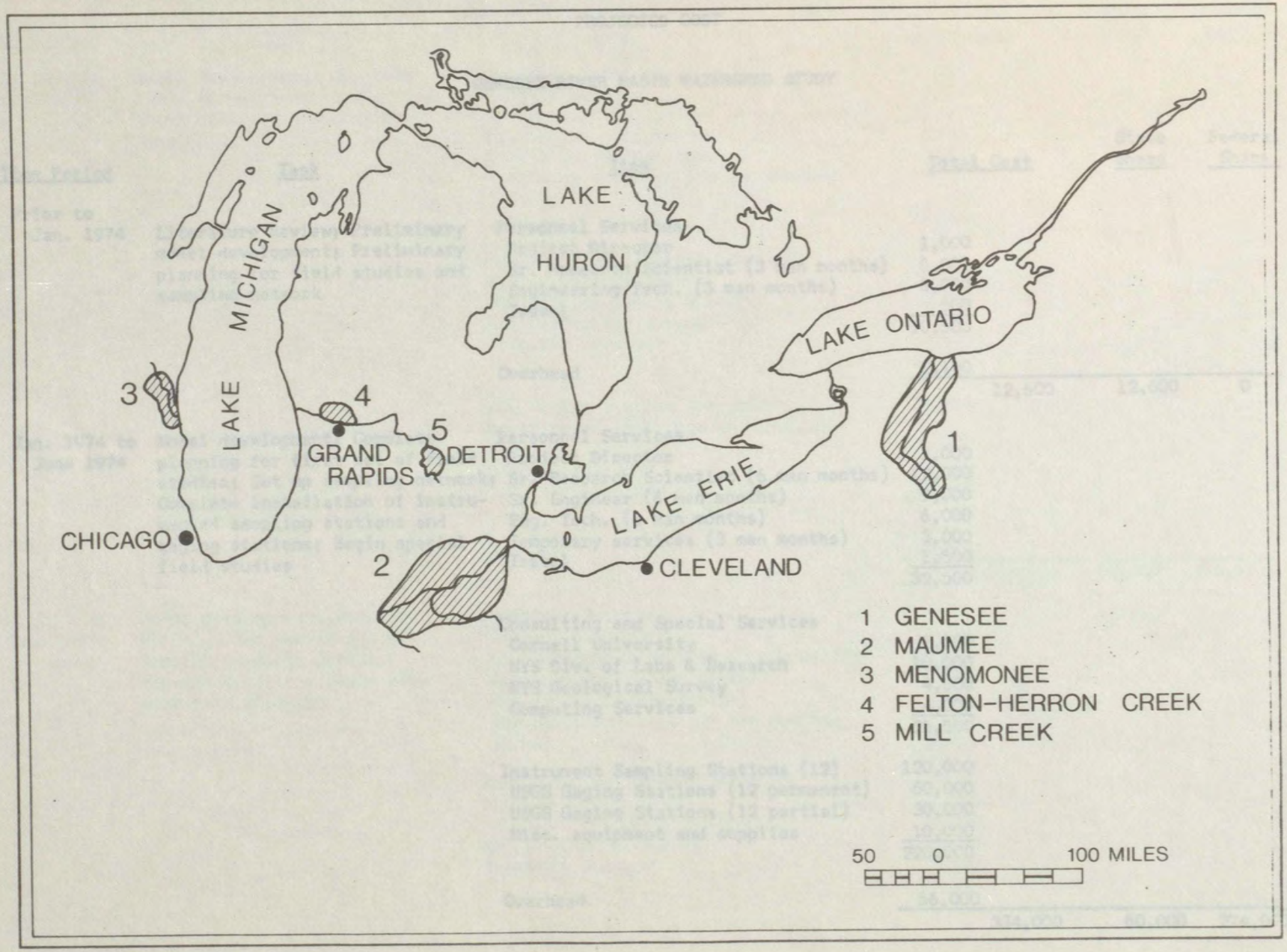


FIGURE 7

A-V-1

Location of major U.S.A. watersheds proposed for Task C studies.

FIGURE 7

Location of major U.S.A. watersheds proposed for Task C studies.

PROJECTED COST

GENESEE RIVER BASIN WATERSHED STUDY

| Time Period | Task | Item | Total Cost | State Share | Federal Share |
|---|---|---|---|---|---|
| Prior to Jan. 1974 | Literature Review; Preliminary model development; Preliminary planning for field studies and sampling network | Personnel Services | | | |
| | | Project Director | 1,000 | | |
| | | Sr. Research Scientist (3 man months) | 6,000 | | |
| | | Engineering Tech. (3 man months) | 3,000 | | |
| | | Travel | 500 | | |
| | | | 10,500 | | |
| | | Overhead | 2,100 | | |
| | | | 12,600 | 12,600 | 0 |
| Jan. 1974 to June 1974 | Model development; Complete planning for first set of field studies; Set up sampling network; Complete installation of instrumented sampling stations and gaging stations; Begin special field studies | Personnel Services | | | |
| | | Project Director | 1,000 | | |
| | | Sr. Research Scientist (6 man months) | 12,000 | | |
| | | Sr. Engineer (6 man months) | 9,000 | | |
| | | Eng. Tech. (6 man months) | 6,000 | | |
| | | Temporary services (3 man months) | 3,000 | | |
| | | Travel | 1,500 | | |
| | | | 32,500 | | |
| | | Consulting and Special Services | | | |
| | | Cornell University | 7,500 | | |
| | | NYS Div. of Labs & Research | 10,000 | | |
| | | NYS Geological Survey | 4,000 | | |
| | | Computing Services | 4,000 | | |
| | | | 25,500 | | |
| | | Instrument Sampling Stations (12) | 120,000 | | |
| | | USGS Gaging Stations (12 permanent) | 60,000 | | |
| | | USGS Gaging Stations (12 partial) | 30,000 | | |
| | | Misc. equipment and supplies | 10,000 | | |
| | | | 220,000 | | |
| | | Overhead | 56,000 | | |
| | | | 334,000 | 60,000 | 274,000 |

| Time Period | Task | Item | Total Cost | State Share | Federal Share |
|---|---|---|---|---|---|
| July 1974 to Dec. 1974 | Model development; Complete first set of special studies; Begin network sampling; Plan second set of special studies | **Personnel Services** | | | |
| | | Project Director | 1,000 | | |
| | | Sr. Research Scientist (6 man months) | 12,000 | | |
| | | Sr. Engineer (6 man months) | 9,000 | | |
| | | Eng. Tech. (6 man months) | 6,000 | | |
| | | Temporary services (12 man months) | 12,000 | | |
| | | Travel | 2,000 | | |
| | | | 42,000 | | |
| | | **Consulting and Special Services** | | | |
| | | Cornell University | 10,000 | | |
| | | NYS Div. of Labs & Research | 5,000 | | |
| | | NYS Geological Survey | 10,000 | | |
| | | Computer Services | 7,500 | | |
| | | | 32,500 | | |
| | | **USGS Gaging Station Operation** | 30,000 | | |
| | | **Operation of Instrumented Sampling Stations** | 30,000 | | |
| | | **Chemical Analyses** | 50,000 | | |
| | | **Misc. supplies and equipment** | 10,000 | | |
| | | | 120,000 | | |
| | | **Overhead** | 39,000 | | |
| | | | 233,500 | 50,000 | 183,500 |
| Jan. 1975 to June 1975 | Model development; complete planning for second set of special studies; Continue network sampling; Begin network data analysis | **Personnel Services** | | | |
| | | Project Director | 1,000 | | |
| | | Sr. Research Scientist (6 man months) | 12,000 | | |
| | | Sr. Engineer (6 man months) | 9,000 | | |
| | | Eng. Tech. (6 man months) | 6,000 | | |
| | | Temporary services (12 man months) | 12,000 | | |
| | | Travel | 2,000 | | |
| | | | 42,000 | | |
| | | **Consulting and Special Services** | | | |
| | | Cornell University | 10,000 | | |
| | | NYS Div. of Labs & Research | 4,000 | | |
| | | NYS Geological Survey | 10,000 | | |
| | | Computer Services | 7,500 | | |
| | | | 31,500 | | |

| Time Period | Task | Item | Total Cost | State Share | Federal Share |
|---|---|---|---|---|---|
| Jan. 1975 to June 1975 (continued) | | USGS Gaging Station Operation | 25,000 | | |
| | | Operation of Instrumented Sampling Stations | 25,000 | | |
| | | Chemical Analyses | 50,000 | | |
| | | Misc. Supplies and Equipment | 7,500 | | |
| | | | 107,500 | | |
| | | Overhead | 36,000 | | |
| | | | | 217,000 | 50,000 | 167,000 |
| July 1975 to Dec. 1975 | Refine model to fit Genesee River Basin; Begin 2nd set of special studies; Continue network sampling and data analyses | Same as for Jan. 1975 to June 1975 | | 217,000 | 50,000 | 167,000 |
| Jan. 1976 to June 1976 | Refine model to fit Genesee River Basin; Continue 2nd set of special studies; Continue sampling and data analyses | Same as for Jan. 1975 to June 1975 | | 217,000 | 50,000 | 167,000 |
| July 1976 to Dec. 1976 | Refine model to fit Genesee River Basin; Continue 2nd set of special studies; Continue sampling and data analyses | Same as for Jan. 1975 to June 1975 | | 217,000 | 50,000 | 167,000 |
| Jan. 1977 to June 1977 | Complete model development; Complete sampling; Complete data analyses | Same as for Jan. 1975 to June 1975 | | 217,000 | 50,000 | 167,000 |
| July 1977 to Dec. 1977 | Document results; varify and document model; Prepare final report | Personnel Services | | | | |
| | | Sr. Research Scientist (6 man months) | 12,000 | | | |
| | | Eng. Tech. (6 man months) | 6,000 | | | |
| | | Travel | 1,000 | | | |
| | | | 19,000 | | | |
| | | Consulting and Special Services | | | | |
| | | Cornell University | 15,000 | | | |
| | | NYS Div. of Labs & Research | 5,000 | | | |
| | | NYS Geological Survey | 5,000 | | | |
| | | Computer Services | 5,000 | | | |
| | | | 30,000 | | | |

| Time Period | Task | Item | Total Cost | State Share | Federal Share |
|---|---|---|---|---|---|
| July 1977 to Dec. 1977 (continued) | | Overhead | 10,000 | | |
| | | | 59,000 | 25,000 | [illegible] |
| | | TOTAL COST | $1,724,100 | 397,600 | 1,326,500 |

# LIST OF WATER QUALITY STUDIES WHICH HAVE BEEN CONDUCTED IN THE MENOMONEE RIVER WATERSHED

1. Wisconsin Department of Natural Resources, "Report of Investigation of Pollution of Surface Waters in Milwaukee County and that Portion of the Root River System Draining from Waukesha County through Milwaukee County Conducted During 1952 and 1953" (no date).

2. Wisconsin Department of Natural Resources, "Report on a Field Investigation of Surface Water Quality in Southeastern Wisconsin in the Summer of 1962", (no date).

3. Southeastern Wisconsin Regional Planning Commission, "Water Quality and Flow of Streams in Southeastern Wisconsin," Technical Report No. 4, November, 1966.

4. Wisconsin Department of Natural Resources, "Report on an Investigation of the Pollution of the Milwaukee River, its Tributaries, and Oak Creek Made During 1968 and 1969", (no date).

5. U. S. Geological Survey, "Water Resources Data for Wisconsin", Annual Reports for 1967, 1968, 1970 and 1971.

6. Wisconsin Department of Natural Resources, "Report on an Investigation of the Pollution in the Milwaukee River Basin Made During 1966 and 1967", January, 1968.

7. Zanoni, A., "Eutrophic Evaluation of a Small Multi-Land Use Watershed U.S. Water Resources Center,Technical Report, June 1970.

8. Citizens for Menomonee River Restoration, "The Cresote Problem in the Little Menomonee River", 1972.

9. Marquette University, "Lower Menomonee River--Selected Biological, Chemical, and Physical Parameters", 1972.

10. U.S. Environmental Protection Administration and the Ecology Division of Rex Chainbelt Inc., "Screening/Flotation Treatment of Combined Sewer Overflows", January, 1972.

11. Wisconsin Department of Natural Resources-SEWRPC, Annual Sampling Program, 1968-1973, SEWRPC files.

Budget for Proposed Menomonee River Watershed Study

| | | Phase 1 4/1/74- 9/31/74 | Year 1 7/1/74- 6/30/75 | Year 2 7/1/75- 6/30/76 | Year 3 7/1/76- 6/30/77 | Year 4 7/1/77- 12/31/77 | Total |
|---|---|---|---|---|---|---|---|
| Project Administration - WDNR | | | | | | | |
| A. Project Associate | Salary | $ 3,085 | $ 12,957 | $ 13,605 | $ 14,285 | $ 7,500 | $ 51,432 |
| | Fringe Benefit 7.5% | 231 | 972 | 1,020 | 1,071 | 563 | 3,857 |
| B. Travel and Report Preparation, etc. | | 250 | 1,000 | 1,000 | 1,000 | 2,500 | 5,750 |
| C. Overhead | 14.4% | 36 | 2,150 | 2,250 | 2,355 | 1,521 | 8,312 |
| Subtotal | | 3,602 | 17,079 | 17,875 | 18,711 | 12,084 | 69,351 |
| Water Monitoring Activities | | | | | | | |
| A. Sub-contracted to USGS | | | | | | | |
| 1. Capital Items - Monitoring Stations | | 100,000 | | | | | 100,000 |
| 2. Monitoring Station Maintenance | | | 60,000 | 60,000 | 60,000 | | 180,000 |
| 3. Personnel - Sediment Station Aid | | | | | | | |
| | Salary and Fringe Benefit | | 10,000 | 10,500 | 11,025 | | 31,525 |
| Subtotal | | 100,000 | 70,000 | 70,500 | 71,025 | 0 | 311,525 |
| B. Sub-contracted to WDNR | | | | | | | |
| 1. Laboratory Support | | 25,000 | 105,000 | 105,000 | 105,000 | | 340,000 |
| 2. Personnel - Field Coordinator | | | | | | | |
| | Salary | 2,427 | 10,193 | 10,703 | 11,238 | 5,921 | 40,482 |
| | Fringe Benefit | 182 | 765 | 803 | 843 | 444 | 3,037 |
| 3. Truck for Field Sample Collection | | 3,000 | | | | | 3,000 |
| 4. Truck Operation | | 250 | 1,000 | 1,000 | 1,000 | 500 | 3,750 |
| 5. Miscellaneous Travel | | | 1,000 | 1,000 | 1,000 | 500 | 3,500 |
| 6. Overhead | | 4,444 | 16,986 | 17,065 | 17,148 | 1,061 | 56,704 |
| Subtotal | | 35,303 | 134,944 | 135,571 | 136,229 | 8,426 | 450,473 |
| Total to WDNR (Includes Admin.) | | 38,905 | 152,023 | 153,446 | 154,940 | 20,510 | 519,824 |
| Supporting Services | | | | | | | |
| SCS, NOAA, Additional Computer Time, Etc. | | | 50,000 | 50,000 | 50,000 | | 150,000 |
| Subtotal | | | 50,000 | 50,000 | 50,000 | | 150,000 |
| Sub-contract to Southeastern Wisconsin Regional Planning Commission | | | | | | | |
| A. Project Management | | | | | | | |
| 1. Personnel | Salary | | 8,500 | 9,000 | 9,500 | 5,000 | 32,000 |
| | Fringe Benefit | | 1,700 | 1,800 | 1,900 | 1,000 | 6,400 |
| 2. Equipment, Supplies, Travel | | | 2,600 | 2,100 | 2,100 | 1,150 | 7,950 |
| 3. Overhead | | | 2,550 | 2,700 | 2,850 | 1,505 | 9,605 |
| Subtotal | | | 15,350 | 15,600 | 16,350 | 8,655 | 55,955 |
| B. Assembly, Interpretation and Transmittal of SEWRPC Data | | | | | | | |
| 1. Personnal | Salary | | 14,000 | 14,850 | 15,700 | 8,275 | 52,825 |
| | Fringe Benefit | | 2,800 | 2,970 | 3,140 | 1,655 | 10,564 |
| 2. Equipment, Supplies, Travel | | | 4,600 | 4,100 | 4,100 | 2,050 | 14,850 |
| 3. Overhead | | | 4,200 | 4,455 | 4,710 | 2,485 | 15,850 |
| Subtotal | | | 25,600 | 26,375 | 27,650 | 14,465 | 94,090 |
| C. Development of Computer File Systems, Etc. | | | | | | | |
| 1. Personnel | Salary | | 23,000 | 23,850 | | | 46,850 |
| | Fringe Benefit | | 4,600 | 4,770 | | | 9,370 |
| 2. Equipment, Supplies, Travel | | | 14,450 | 13,650 | | | 28,100 |
| 3. Overhead | | | 6,900 | 7,155 | | | 14,055 |
| Subtotal | | | 48,950 | 49,225 | | | 98,175 |
| Total to SEWRPC | | | 89,900 | 91,200 | 44,000 | 23,120 | 248,220 |
| Sub-contract to University of Wisconsin System Through the Water Resources Center - Special Studies, Interpretation of Data, Model Development, Etc. | | | | | | | |
| A. Personnel | | | | | | | |
| 2 Project Associates | Salary | 6,250 | 26,250 | 27,560 | 28,900 | 15,200 | 104,160 |
| | Fringe Benefit | 950 | 3,998 | 4,190 | 4,400 | 2,310 | 15,848 |
| | Overhead | 3,500 | 14,700 | 15,430 | 16,200 | 8,550 | 58,380 |

| | | Phase 1 4/1/74-9/31/74 | Year 1 7/1/74-6/30/75 | Year 2 7/1/75-6/30/76 | Year 3 7/1/76-6/30/77 | Year 4 7/1/77-12/31/77 | Total |
|---|---|---|---|---|---|---|---|
| 8 Research Assistants 50% Time | Salary | $ 8,700 | $ 36,800 | $ 38,800 | $ 40,800 | $ 21,420 | $146,520 |
| | Fringe Benefit | 390 | 1,656 | 1,746 | 1,836 | 965 | 6,593 |
| | Overhead | 3,500 | 20,610 | 21,730 | 22,850 | 12,000 | 80,690 |
| 1 Secretary | Salary | 1,800 | 6,930 | 7,035 | 7,385 | 3,880 | 27,030 |
| | Fringe Benefit | 418 | 1,610 | 1,635 | 1,716 | 902 | 6,281 |
| | Overhead | 1,008 | 3,881 | 3,930 | 4,136 | 2,173 | 15,128 |
| 3 Technicians | Salary | 6,750 | 28,350 | 29,760 | 31,255 | 16,409 | 112,524 |
| | Fringe Benefit | 1,027 | 4,312 | 4,528 | 4,754 | 2,495 | 17,116 |
| | Overhead | 3,780 | 15,876 | 16,670 | 17,503 | 9,190 | 63,019 |
| Hourly Help 160 Hours/Month | Salary | 1,440 | 6,144 | 6,450 | 6,775 | 3,600 | 24,409 |
| | Overhead | 806 | 3,440 | 3,612 | 3,793 | 2,016 | 13,667 |
| Subtotal | | 40,319 | 174,557 | 183,086 | 192,303 | 101,110 | 691,375 |
| B. Special Groundwater Study | | | 30,000 | 20,000 | | | 50,000 |
| C. Supplies | | 5,000 | 10,500 | 12,500 | 12,500 | 4,000 | 84,500 |
| D. Capital Items (Special Sampling & Analyses) | | 2,500 | 30,000 | 25,000 | 5,000 | 1,000 | 63,500 |
| E. Travel | | 1,000 | 2,500 | 2,500 | 2,500 | 1,000 | 9,500 |
| F. Publications and Reporting | | 300 | 1,000 | 1,000 | 1,000 | 2,000 | 5,300 |
| G. Computer Time | | 2,000 | 3,000 | 4,000 | 4,000 | 4,000 | 17,000 |
| H. Data & Info. Retrieval | | | 2,000 | 3,000 | 2,000 | | 7,000 |
| I. Communications (Local Public Meetings, Newspaper, TV Coverage) | | 1,000 | 4,000 | 5,000 | 2,000 | | 12,000 |
| Subtotal | | 11,800 | 83,000 | 73,000 | 29,000 | 12,000 | 208,800 |
| Total to U.W. | | 52,119 | 257,557 | 256,086 | 221,303 | 113,110 | 900,175 |
| Grand Total | | $191,024* | $619,480 | $621,232 | $541,268 | $156,740 | $2,129,744 |
| Totals by Agency | WDNR | $ 38,905 | $152,023 | $153,446 | $154,940 | $ 20,510 | $ 519,824 |
| | USGS | 100,000 | 70,000 | 70,500 | 71,025 | 0 | 311,525 |
| | SEWRPC | 0 | 89,900 | 91,200 | 44,000 | 23,120 | 248,220 |
| | UW-WRC | 52,119 | 257,557 | 256,086 | 221,303 | 113,110 | 900,175 |
| | Miscellaneous | 0 | 50,000 | 50,000 | 50,000 | 0 | 150,000 |
| | | $191,024 | $619,480 | $621,232 | $541,268 | $156,740 | $2,129,744 |

*Personnel requirements for Phase 1 are uncertain - estimate based on optimum staffing.

Budget breakdown by task and fiscal year.

| Activity | Source | Apr. 1974 to July 1974 $ Ongoing | Apr. 1974 to July 1974 $ Suppl. | Fiscal Year 1974 - 75 $ Ongoing | Fiscal Year 1974 - 75 $ Suppl. | Fiscal Year 1975 - 76 $ Ongoing | Fiscal Year 1975 - 76 $ Suppl. | Fiscal Year 1976 - 77 $ Ongoing | Fiscal Year 1976 - 77 $ Suppl. | Totals |
|---|---|---|---|---|---|---|---|---|---|---|
| TASKS 1 & 5 - Water Balance Studies | EPA | | $ 46,000 | | $ 81,000 | | $ 78,800 | | $ 79,300 | $285,100 |
| | *NF | $11,500 | | $ 47,600 | | $ 50,000 | | $ 50,000 | | $159,100 |
| TASK 2 - Land Irrigation - Soil, Nutrient, Vegetation Monitoring | EPA | | $ 39,800 | | $ 85,000 | | $ 88,000 | | $ 88,000 | $300,800 |
| | NF | $20,400 | | $ 40,000 | | $ 40,000 | | $ 40,000 | | $140,400 |
| TASK 3 - Land Irrigation - Microbiological Monitoring | EPA | | $ 6,000 | | $ 39,700 | | $ 33,000 | | $ 34,000 | $112,700 |
| | NF | $11,500 | | $ 47,000 | | $ 48,000 | | $ 50,000 | | $156,500 |
| TASK 4 - Land Irrigation - In-Stream Processes | EPA | | $ 6,000 | | $ 48,200 | | $ 48,000 | | $ 48,700 | $150,900 |
| | NF | $20,100 | | $ 47,600 | | $ 50,000 | | $ 50,000 | | $167,700 |
| TASK 6 - Orchard - Water Quality & Soil Pesticide Studies | EPA | | $ 12,000 | | $ 32,000 | | $ 29,000 | | $ 30,000 | $103,000 |
| | NF | $ 5,000 | | $ 10,000 | | $ 10,000 | | $ 10,000 | | $ 35,000 |
| Ongoing Totals | | $68,500 | | $192,200 | | $198,000 | | $200,000 | | $658,700 |
| Suppl. Totals | | | $109,800 | | $285,900 | | $276,800 | | $280,000 | $952,500 |

*Non Federal sources (State of Michigan and Foundations).

WORK PLAN AND BUDGET SUMMARY

| Time Period | Task | Item | Budget |
|---|---|---|---|
| April 1, 1974-<br>June 30, 1974 | Plan for field and lab. studies; initiate installation of sampling equipment; consider parameters to monitor in consideration of model; consult with Purdue personnel developing model for Black Creek Watershed Study; progress report. | Personnel | $ 5,673 |
| | | Supplies & Equipment | 28,000 |
| | | Travel | 2,500 |
| | | Publication | 250 |
| | | Indirect Costs | 4,295 |
| | | | $40,718 |
| July 1, 1974-<br>Dec. 31, 1974 | Complete installation of sampling equipment; initiate lab. clay dispersion studies; initiate lab. sorption-desorption and equilibrium studies; analyze physical, chemical, and mineralogical properties of solution and sediments collected; consult with Purdue personnel concerning model development; progress report. | Personnel | 24,662 |
| | | Supplies, Equipment, & Maintenance | 11,500 |
| | | Travel | 3,500 |
| | | Publication | 500 |
| | | Indirect Costs | 17,120 |
| | | | $57,282 |
| | | Sub-Total | $98,000 |
| Jan. 1, 1975<br>June 30, 1975 | Continue lab. studies and monitoring of sediment yields and properties in the Basin as described previously; prepare bi-annual report. | Personnel | 24,662 |
| | | Supplies, Equipment, & Maintenance | 3,000 |
| | | Contract Analyses (Special samples) Computer time. | 2,000<br>5,040 |
| | | Travel | 1,250 |
| | | Publication | 500 |
| | | Indirect Costs | 17,120 |
| | | | $53,572 |
| July 1, 1975-<br>Dec. 30, 1975 | Continue clay dispersion and other lab. studies; continue field monitoring of sediments and solution and continue lab. analyses of same; consult on model development; continue lab. analyses of same; prepare bi-annual report. | Personnel | 25,888 |
| | | Supplies, Equipment, & Maintenance | 3,000 |
| | | Contract Analyses (special samples) | 2,000 |
| | | Computer time | 2,520 |
| | | Travel | 1,250 |
| | | Publication | 500 |
| | | Indirect Costs | 17,972 |
| | | | $53,130 |
| | | Sub-Total | $204,702 |

WORK PLAN AND BUDGET SUMMARY

| Time Period | Task | Item | Budget |
|---|---|---|---|
| Jan. 1, 1976-<br>June 30, 1976 | Continue field and laboratory sampling and analyses; consult with Purdue personnel on model development; prepare semiannual report. | Personnel | $25,888 |
| | | Supplies, Equipment, & Maintenance | 3,000 |
| | | Contract Analyses (special samples) | 2,000 |
| | | Computer Time | 2,520 |
| | | Travel | 1,250 |
| | | Publication | 500 |
| | | Indirect Costs | 17,972 |
| | | | $53,130 |
| July 1, 1976-<br>Dec. 31, 1976 | Continue field and laboratory sampling and analyses; consult with Purdue personnel on model development, prepare semi-annual report. | Personnel | 27,175 |
| | | Supplies, Equipment, & Maintenance | 3,000 |
| | | Contract Analyses (special samples) | 2,000 |
| | | Computer time | 3,024 |
| | | Travel | 1,250 |
| | | Publication | 500 |
| | | Indirect Costs | 18,862 |
| | | | $55,811 |
| | | Sub-Total | $108,941 |
| Jan. 1, 1977-<br>June 30, 1977 | Complete field and laboratory sampling and analyses; submit data and consult with Purdue personnel on refinement and testing of model; prepare final report. | Personnel | 27,174 |
| | | Supplies & Maintenance | 3,000 |
| | | Contract Analyses (special samples) | 2,000 |
| | | Computer time | 2,520 |
| | | Travel | 1,250 |
| | | Publication | 1,000 |
| | | Indirect Costs | 18,863 |
| | | | $55,807 |
| | | Grand Total | $369,450 |