WORKING DRAFT

N.W.R.I. RESEARCH PROJECTS

A Compendium of the Freshwater Research Program

at

The National Water Research Institute

Environment Canada

1986-1987

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INTRODUCTION

The National Water Research Institute (NWRI), part of the Conservation and Protection Service of Environment Canada (DOE), plays the lead role in developing the scientific expertise and knowledge required by the department to understand and resolve water issues of national significance. Fundamental to this role is the conduct of a broad program of interdisciplinary research in the Great Lakes Basin and across Canada.

This compendium describes the current (1986-87) activities and long-term objectives of the research program at NWRI.

To ensure scientific excellence and credibility for its research, the institute participates fully in both the Canadian and international water science communities. Because of its expertise, NWRI also serves as principal science advisor and science spokesperson within DOE on water quality and related issues, offers functional guidance to operational water programs, provides leadership in developing multi-agency programs on emerging and poorly understood issues and represents DOE and Canada in national and international water science fora.

Research at NWRI is organized on the basis of major projects, each of which addresses an important issue of scientific or management priority to Environment Canada. This program structure was introduced in late 1985 to ensure planning flexibility, to promote an interdisciplinary focus within the research program and to improve resource efficiency. In addition, the institute is organized administratively into five science divisions, along disciplinary lines. These are supported by centralized staff- and research-support divisions. To ensure integration, chiefs of divisions also serve as managers of projects, with assistance from project liaison scientists.

The institute's current projects are grouped into four general categories in this compendium: toxic chemicals research (both priority areas and processes); acid rain research; water management and development research; and methods development for environmental sensing and interpretation. All of the projects by their nature are long term in duration, typically 4-6 years. Some are new initiatives and some are multidisciplinary amalgamations of existing studies which will be completed in the next 1-2 years. New initiatives each year are expected to comprise 5-10% of the total research program. Every effort is made to build regional C&P research needs into the annual planning process, consistent with the overall research strategy of the institute.

The project management system at NWRI is only in its first year and this is the first edition of the annual project compendium. As the research managers and scientists at the institute gain experience with the multidisciplinary approach, refinements to, and possible consolidation of, projects may prove to be beneficial. Comments on both the substance of projects and on the format of this compendium are, therefore, most welcome.

TOXIC CHEMICALS PROJECTS

Priority Processes Research

GROUNDWATER CONTAMINATION

SYNOPSIS:

By undertaking field, computational and laboratory studies to examine the migration and fate of toxic contaminants in the subsurface, expertise in contaminant hydrogeology is created. Benefits derived include the development of guidelines for waste site assessment and remedial measures for aquifer restoration.

ISSUE AND RATIONALE:

Groundwater pollution, arising from waste-disposal sites and pesticide application, can cause the contamination not only of wells but also of surface waters such as the Great Lakes.

Ground waters are particularly important in supplying municipal, agricultural and industrial needs in southern Ontario, the St. Lawrence valley and the Maritime provinces. Aquifers, the groundwater reservoirs, are threatened with contamination by pesticide and fertilizer residues and industrial and municipal wastes.

However, it is the migration of groundwater contamination from dump sites and landfills through fractures in rocks and its subsequent discharge to the rivers and lakes of the Great Lakes system than has aroused the most concern in recent years. In its 1985 report to the IJC, the Great Lakes Water Quality Board called for "programs to establish the impact of contaminated groundwater on the surface waters of the Great Lakes Basin ecosystem". The IJC, in its second biennial report in 1984, called for research into groundwater sampling and the development of protocols for the monitoring of toxic waste sites. Programs based on these recommendations form the basis of the NWRI groundwater contamination project.

PROJECT OBJECTIVES:

There are three general objectives. The first is to understand the physical and chemical controls on contaminant migration and fate in sedimentary rock aquifers, such as the limestones of the Niagara region which are contaminated with liquid industrial wastes, or the sandstones of PEI which are contaminated with pesticides. The second is to develop and/or apply operational tools for hazardous-waste site assessment and aquifer restoration, such as groundwater sampling protocols and computer codes to determine the optimum decontamination of an aquifer. The final objective is to draw upon the expertise developed in pursuit of the first two objectives to give advice on groundwater pollution matters of Federal concern in Eastern Canada.

RESEARCH PROGRAM:

The research program is focussed on the migration and fate of toxic contaminants in groundwater at several field study sites which have been instrumented with monitoring systems installed in drilled boreholes. The field sites provide the data which is analysed with the help of laboratory experiments and mathematical models at NWRI. The research program is comprised of several studies which are described below.

Field studies of groundwater contamination require that the hydraulic and chemical properties of the groundwater flow system be thoroughly investigated so that the physical and chemical controls on contaminant migration and attenuation might be deduced. In the field sites established in fractured sedimentary rock aquifiers along the Niagara River and on PEI, the initial emphasis is on the hydraulic testing of the aquifer to determine the hydraulic and transport properties of the aquifer systems (e.g. the hydraulic conductivity, groundwater velocity and dispersivity). Hydraulic heads are also measured to provide a three-dimensional groundwater flow pattern at each study site. Chemical testing, (i.e. inorganic, organic and isotopic analyses), is used to understand the origin, evolution and degree of contamination of the groundwaters.

Hydraulic and chemical data are interpreted with the aid of numerical and analytical computer codes involving solution to the groundwater flow and solute-transport equations and with chemical-speciation and mineral-dissolution models based on low-temperature aqueous thermodynamics.

Laboratory experiments are used to investigate physical and chemical mechanisms which are occurring or are suspected of occurring at the field sites. An example of such an experiment is the study of the transport of toxic solutes and solvents in laboratory columns to determine their velocity and dispersion during transport and the degree of solute attenuation due to sorption, hydrolysis and biodegradation.

CURRENT ACTIVITIES:

1. Niagara Field Study: The Niagara Field Study for 1986/87 will include: vertical and horizontal hydraulic tests of the Lockport Dolostone and Rochester Shale; chemical sampling of boreholes on Navy Island and on the Mainland; a 3-D numerical model of groundwater flow in the Niagara Falls region; the design and application of a numerical model and grid for simulating the transport of non-aqueous phase liquids beneath the Niagara River from S Area, Hooker/Occidental plant, Niagara Falls, N.Y.; development of an experimental technique for investigating the fluid dynamical properties of aqueous and non-aqueous solutions in a one-metre by one-metre quarried rock sample; and the preparation of a progress report on the above.

2. PEI Field Study: At the PEI field sites: install new piezometers at Tryon, Mill Valley, New Annan, and Kensington sites; conduct preliminary hydraulic and chemical testing at all field sites; select a model to describe aldicarb migration and fate, and conduct preliminary trials; and prepare a progress report.

3. Advisory Program:

   i) Develop a joint MOE/DOE program to study groundwater pollution in the Sarnia area of the St. Clair River Valley.
   ii) Develop, with scientists at AECL's Chalk River Nuclear Laboratories, a computer model of radionuclide transport, arising from radioactive waste disposal at Chalk River during the 1950s.
   iii) Develop a computer model of toxic chemical migration and fate at Transport Canada's Gloucester Landfill (near Ottawa) and determine optimal remediation strategies.

PROJECT CONTACTS:

MANAGER:	R. Allan	336-4678
PROJECT LIAISON SCIENTIST:	R.E. Jackson	336-4587

STUDY LEADERS	PROJECT COMPONENT	TELEPHONE #
R.E. Jackson	Hydrogeology and aqueous chemistry of radionuclides, pesticides and toxic chemicals	336-4587
K.S. Novakowski	Hydrogeology of fractured rock, contaminant transport in fractured media	4610
P. Lapcevic	Hydrogeology	4597
M. Priddle	Ground water chemistry of toxic chemicals	4597

WATER-AIR EXCHANGE OF ORGANIC CONTAMINANTS ("TOXIC RAIN")

SYNOPSIS:

The project will produce a model suitable for predicting the concentrations and fluxes of persistent, toxic organic chemicals in an aquatic-air ecosystem. This will be applied to a small lake from the Turkey Lake's area (Canadian shield) and to Lake Ontario.

ISSUE AND RATIONALE:

The extent of pollution of some of Canada's waters is widespread and has been observed in places that preclude any local or even regional industrial or municipal sources. The deposition of some of the more toxic and persistent chemicals from the atmosphere to the water has been identified as a major input mechanism to the Great Lakes by the Science Advisory Board of the International Joint Commission. Other work has indicated that much of the deposited material is re-volatalized. There are several processes which are believed to potentially contribute to the net movement from or to the atmosphere: dry particulate deposition; rainfall including particulates; aerosol and particulate injection into the atmosphere from turbulent water surfaces; and the vapour phase exchange of organics.

The problem of atmospheric deposition is not one restricted to the Great Lakes but is universal to all of Canada and for that matter, the world. Our present knowledge of the processes in vapour phase exchange is limited. The transfer mechanisms are poorly understood and can be predicted only for a few relatively low molecular weight "gases" such as oxygen, carbon dioxide, argon, etc. Transfer rate constants need to be determined for representative persistent organic chemicals in order to evaluate the existing theories and empiricisms about such transfers.

The actual concentrations of these chemicals in the water and the relevant portion of the atmosphere are needed. For water these must be for the "dissolved" fraction while the vapour state requires them for both the vapour phase and the particulate phase for different size fractions. These concentrations must be determined to provide the input into numerical, predictive models which utilize not only water-air transfer rates but also rate constants for physical movements and chemical and biological transformations.

PROJECT OBJECTIVES:

Activities under this project are intended to develop the technical ability to determine the atmospheric contribution to the loadings of persistent toxic contaminants to the aquatic environment. Lake Ontario and a smaller waterbody

from the Turkey Lakes experimental watershed will be used as illustrations of this ability. The predictions will be derived by modelling both concentrations and fluxes of chemicals from various relevant compartments of the ecosystem.

RESEARCH PROGRAM:

Current theories to predict the transfer of chemical substances from surface waters to air and the reverse will be evaluated.

The rate of loss of several persistent organic chemicals from bulk surface water in a closed wave flume will be determined under a variety of conditions of turbulence (wave action) and air-flow (wind speed). These data will be used to determine the bulk transfer coefficients which will then be compared with theoretically derived ones.

Instrumentation for determining the concentrations of toxic organic chemicals in rain, snow, vapour phase and particulates is available or at an advanced state of testing. Prototype testing, in co-operation with AES and WQB, will be undertaken.

Following prototype evaluation, the equipment will be deployed first at the Turkey Lakes site where residues in the atmospheric sub-compartments as well as in water, sediment and biota will be determined.

Data from the Turkey Lakes study, together with information on various atmospheric and other process rates and on the physical regime of one of the three lakes will be incorporated and tested in a numerical model to be developed.

The model, subsequent to its successful validation, will be applied to Lake Ontario. Specific data will be gathered for testing of the model on this larger system. A 'representative compound' approach will be employed, using BHC/lindane and the chlorobenzenes which have been observed environmentally.

Atmospheric data for a broader range of chemicals from other locations in Canada will be collected to enable extrapolation outside the Great Lakes region.

CURRENT ACTIVITIES:

1. Analytical Methods Development: Sensitive analytical methods for alpha-BHC and the chlorobenzenes in air and water will be developed and evaluated in small laboratory microcosm.

2. Organochlorine Concentrations: Concentrations of organochlorine compounds (pesticides and PCBs) in rain will be reported for the Great Lakes and several other regions of Canada for 1984 and 1985. The report for the Great Lakes region will evaluate progress in establishing a network of organic sampling sites in Ontario Region. Interaction with the Great Lakes Region of the U.S. Environmental Protection Agency will be needed.

3. Sampler Evaluation: An evaluation of prototype atmospheric precipitation samplers will be undertaken, in collaboration with WQB, IWD.

4. Turkey Lakes Feasibility Study: A feasibility study at the Turkey Lakes will be undertaken and samples collected and analysed. From the preliminary results, an intensive sampling program will be designed to test and validate a distribution model. Sampling will focus on alpha-BHC and the chlorobenzenes in all parts of the ecosystem. Similar samples, especially those of atmospheric wetfall and dryfall, will be collected for the Lake Ontario system to permit later conversion of the model to this system.

5. Literature Review and Evaluation: A post-doctoral fellow will be engaged and methods for estimating transfer coefficients of persistent organic chemicals between water and atmosphere will be evaluated.

PROJECT CONTACTS:

MANAGER:	J. Lawrence	336-4927
PROJECT LIAISON SCIENTIST:	W. Strachan	336-4775

STUDY LEADERS	PROJECT COMPONENT	TELEPHONE #
B.G. Oliver	Volatalization of Organics from Water	336-4604
W. Strachan	Air-water toxic chemical processes	4775

NUTRIENT/CONTAMINANT INTERACTIONS

SYNOPSIS:

This project will determine the extent to which lake trophic status (nutrient levels and productivity) affects the rates of bioaccumulation, biodegradation and sedimentation of organic contaminants and hence the degree of vulnerability of lake food chains to a given contaminant burden. If contaminant levels and trophic status prove to be inversely related, then phosphorus and contaminant remediation plans will need to be jointly optimized. The influence of nutrients on the pathways and fate of contaminants will be determined be laboratory, lake-enclosure and open-lake experiments.

ISSUE AND RATIONALE:

Research and management of the eutrophication and contaminants issues have, for a variety of historical reasons, been undertaken separately. Contaminants research has largely focused on the source, identification, and fate of priority toxicants in areas of concern and has only recently moved towards pathways and ecological impacts. The effects of eutrophication, on the other hand, are well known and the basic management strategy has been to minimize phosphorus inputs, without consideration of other interactions.

Some recent evidence suggests, however, that the availability of organic contaminants to lake biota, particularly at higher levels of food webs, may be inversely related to the nutrient status and thus the biological productivity of a lake. Such a relationship, if confirmed, would have major implications for the management of both nutrients and contaminants. Continuing reductions in phosphorus loadings to the G. Lakes could serve unintentionally to maximize exposure of fish and other biota to contaminants already present in the system, irrespective of source control or remediation efforts. In such cases it would be necessary to optimize lake trophic status so as to minimize contaminant impacts. Research to define the predictive relationships between nutrients and contaminants is clearly needed before improved (and possibly less expensive) management strategies can be developed.

PROJECT OBJECTIVES:

This project will attempt to characterize and quantify the critical processes which may control the interaction of nutrients and contaminants in lakes. If appropriate, guidelines will also be developed to assist in setting optimum nutrient loadings for contaminant control.

RESEARCH PROGRAM:

Research will be carried out to confirm or reject the general hypothesis that nutrients influence organic contaminant availability through three critical processes: bioaccumulation, biodegradation and sedimentation. Bioaccumulation may be lower in eutrophic lakes relative to oligotrophic lakes for the same volumetric burdens of contaminants, because a smaller volume of eutrophic water is required to support the food chain. Biodegradation of contaminants may be enhanced in eutrophic systems where bacterial decomposers are more abundant and active. Also chemical decomposition of some organics may occur more rapidly when sorbed to algae present in high concentrations. Lastly, some contaminants are sedimented from the water column in association with refractory organic carbon, which is produced and settled more rapidly in eutrophic lakes.

A multidisciplinary experimental approach will be employed with the following elements:

1. Laboratory Microcosms

   As a prerequisite for later field experiments, radioactive contaminants will be added to simple microcosms to determine the influence of nutrient and organic substrate on microbial biodegradation.

2. Lake Enclosures

   Selected contaminants will be added at sublethal levels to natural populations in large lake enclosures, augmented with different levels of nutrients. Bioaccumulation and biodegradation rates will be measured, compared to the microcosm results and related to nutrient loadings. The effects of dissolved and colloidal organic matter on biodegradation, photodegradation and sedimentation will also be examined.

3. Open Lake Experiments

   A series of headwater lakes, differing in hardness and trophic state but devoid of point-source contaminant inputs, will be selected. The partitioning of existing (airborne) contaminants between water (soluble and particulate phases), sedimenting material and sediments will be measured and related to the nutrient loadings of the lakes. Focus will be on the processes and rates of contaminant sedimentation and release from sediments. Such lakes will also provide information on the fate of "toxic rain".

CURRENT ACTIVITIES:

1. Existing Data Review

Historical data on the relative distributions of contaminants among the various lake components (water, biota, detritus, sediments) will be collated and examined statistically for covariation with lake trophic state (phosphorus, chlorophyll) and other important lake characteristics (hardness, pH, mean depth, etc.).

2. Microcosm/Limnocorral Experiments

Preliminary lab and field enclosure experiments will be undertaken to work out methods, develop experimental protocols, choose appropriate model contaminants and obtain preliminary partitioning data. Colloids important in contaminant transport will also be isolated and examined by electron microscopy.

3. Headwater Lakes

An appropriate set of connected headwater lakes will be selected. Preliminary data on contaminant identification, food-chain partitioning and sedimentation rates will be obtained. New techniques for isolating and fractionating lake particles will be developed.

PROJECT CONTACTS:

MANAGER:	R.J. Allan	336-4678
PROJECT LIAISON SCIENTIST:	D. Lean	336-4783

STUDY LEADERS	PROJECT COMPONENT	TELEPHONE #
J. Barica	Nitrogen contamination	336-4785
M.N. Charlton	Sedimentation of contaminants	4758
B.K. Burnison	Trophic state effect on contaminant biodegradation	4706
D.R.S. Lean	Trophic state effect on contaminant pathways; nearshore-offshore exchange	4783
G.G. Leppard	Organic-colloid/contaminant associations	4787
T.P. Murphy	Effect of oxygen on phenol degradation	4602
S.R. Esterby	Nutrients/contaminant covariation	4790
K.K. Kwan	Microbiological and toxicant screening	4579
J. Carey	Organic contaminants pathways	4693
D. Liu	Biotechnological contaminants removal	4576

CONTAMINATED SEDIMENTS

SYNOPSIS:

Contaminated sediments represent a significant problem as an in-situ pollution source in the Great Lakes. Investigations will be carried out to determine and quantify pathways of contaminants in Great Lakes sediment to obtain information on their release to the overlying water and to the biological system. This information will be used as input to remedial action plans for the rehabilitation of the Great Lakes.

ISSUE AND RATIONALE:

Bottom sediments of the Great Lakes accumulate many contaminants and provide an excellent record of pollution in the drainage basin. Past studies of Great Lakes sediments focused on the distribution and concentration of contaminants. Distribution maps of metals and PCBs in Great Lakes sediments have provided early information on the occurrence and concentrations of these contaminants in surficial sediments. Analyses of radio-dated cores revealed historical trends in pollution status at many areas of the Great Lakes. Concentration profiles of contaminants in sediments indicated some natural burial after pollution sources were eliminated. However, very little information is available on processes which control the pathways of contaminants in sediments, such as transport across or between lakes, uptake and effects of different contaminants on biota, and the role of sediment-associated biota on the transformation of contaminants into other phases of the aquatic ecosystem. Even after elimination of pollution sources, redistribution by physical processes concentrates contaminated sediments in areas of accumulation. These areas may pose a threat to benthic biota, and, under certain conditions, leak contaminants to the overlying waters. Consequently, the role of sediments as a pollution source has to be accounted for in developing remedial action for rehabilitation of the Great Lakes.

PROJECT OBJECTIVES:

The overall objective of the project is to develop a thorough understanding of biological, geochemical and sedimentological processes which define pathways, availability and release of contaminants in sediments of the Great Lakes.

RESEARCH PROGRAM:

1. Determine historical inputs of contaminants by dating sediments, construct concentration profiles of contaminants in sediments and correlate the results with industrial/agricultural sources. A general statement on the status and trends of contamination in many areas of the Great Lakes, in particular, in IJC Areas of Concern, will result.

2. Summarize contaminant pathways through the non-biological compartments of the sediment, quantify resuspension and sedimentation rates and determine the partitioning of contaminants between different sediment size fractions, the concentration of contaminants in sediment-pore water and the rates of diffusion to the sediment-water interface.

3. Evaluate the impact of biological processes controlling release of contaminants into pore-water and at the sediment-water interface; quantify bioavailability of contaminants in sediments; determine the effects of microbes on the transport of sediment contaminants; and quantify the transfer of sediment contaminants to lakewater and biota. Some processes will be studied at only one area, but the results will be used for modelling general processes.

4. Define the role of sediments as a pollution source by modelling the physical, chemical and biological processes which control the pathways of contaminants in sediments.

CURRENT ACTIVITIES:

1. Historical Inputs of Contaminants

Contaminants will be determined in radio-dated sediment cores obtained at selected areas.

2. Analytical Techniques

Methods for a quantitative determination of some non-conventional elements and compounds will be developed, for example, for nitrogen-containing PAH's, beryllium and thallium. The presence of these elements and compounds in sediments will help to identify specific pollutant sources in specific lake drainage basins.

3. Resuspension and Sedimentation Rates

Preliminary studies will determine rates of resuspension and sedimentation of particles of different grain size in areas of concern and in depositional zones. The relationship between contaminants and sediment particle-size will be investigated.

4. Contaminant Bioavailability in Sediments

Investigations will be carried out on partitioning of contaminants between sediment, pore water and sediment biota. The availability of metals in the sediment will also be assessed by metal speciation and accumulation in biota.

5. Sediment Microbiology

Changes in microbial populations in contaminated sediments will be investigated and the relationships between microbial populations and the form(s) of contaminants in the sediment (and pore water) evaluated.

PROJECT CONTACTS:

MANAGER:	R. Allan	336-4678
PROJECT LIAISON SCIENTIST:	A. Mudroch	336-4707

STUDY LEADERS	PROJECT COMPONENT	TELEPHONE #
B.G. Oliver	Bioavailability, kinetics of organics in contaminated sediments	336-4604
D.L.S. Liu	Contaminants removal by biotechnology	4576
E. Nagy	Polynuclear hydrocarbons (PAHs) in freshwater	4685
S.R. Joshi	Sediment transport of radionuclides	4573
Y.K. Chau	Bioconcentration, aquatic pathways of alkyllead compounds	4707
A. Mudroch	In-situ sediment metals behaviour	4707
F.I. Onuska	In-situ sediment pollution by heteroaromatic compounds	4635
S.S. Rao	Microbial response to sediment toxics	4924
F. Rosa	Lake Erie sediment loadings	4547
A. Abbott	Sediment phosphorus bioavailability	4550
D.C.L. Lam	Sediment contaminant models	4916
N.A. Rukavina	Sedimentology of contaminants	4880

PESTICIDES FATE AND EFFECTS IN SURFACE AND GROUND WATER

SYNOPSIS:

This project will generate information on the nature, extent and effects of contamination of the aquatic environment resulting from pesticide use. This information will be used for the establishment of water quality guidelines and criteria, and in the evaluation of pesticide registration data.

ISSUE AND RATIONALE:

There are approximately 500 pesticides registered by Agriculture Canada for use in this country. Concerns regarding human safety and adverse environmental effects have been identified with regard to many of these pesticides as well as potential new ones. It is imperative that these concerns be addressed in order for Agriculture Canada to assess fully the impacts of pesticides and, in some cases, re-evaluate their use in Canada. DOE, through NWRI, has an important role to play in providing information to assess the hazards posed by pesticides in aquatic ecosystems.

The hazard of toxic substances to organisms, whether in water or sediment, is a function of (1) their toxicity, and (2) their concentration and persistence. Traditionally, pesticide research at NWRI has focussed on chemical aspects, such as analytical methods and the distribution, persistence and fate of pesticides. This is necessary and will continue as part of the project. However, additional research involving physical and biological methods, processes and effects must be undertaken. Of particular concern is the use of biological monitors; physical, chemical and biological removal mechanisms; persistence and fate in specific aquatic compartments; and identification of effects on aquatic organisms, populations and communities.

Pesticide contamination of groundwater is an environmental concern, particularly in the Maritimes where groundwater supplies most of the total water used (100% in PEI, 64% in NB and 45% in NS).

PROJECT OBJECTIVES:

The objective of the project is to develop sufficient understanding of the nature, extent and effects of pesticide contamination in the aquatic environment in order to evaluate/re-evaluate the use of pesticides in Canada.

RESEARCH PROGRAM:

1. Selection of the pesticide to be investigated in accordance with: Pest Control Products Act or Environmental Contaminants Act priority lists; regional considerations; and/or perceived gaps in the scientific literature.

2. Establish methods of analysis for relevant media, as necessary.

3. Establish the environmental occurrence of the pesticide.

4. Establish the environmental persistence and fate of the pesticide in the relevant aquatic compartments (water, sediment, biota, etc.) from the point of view of physical, chemical and biological removal mechanisms, in addition to water flow.

5. Determine the effects of pesticides on aquatic organisms, populations and communities. These range from subtle, sublethal effects to large-scale mortality.

CURRENT ACTIVITIES:

1. Organic Methods Development The objective is to develop analytical methods for dinoseb and some pyrethroids in water and sediment. Aldicarb is a carbamate which is proving to be persistent in ground water. Dinoseb is a dinitrophenol herbicide and insecticide used fairly heavily in the Fraser River valley and Atlantic Canada. Pyrethroids are toxic to aquatic invertebrates; the compounds of concern are deltamethrin, fenvalerate, permethrin and cypermethrin.

2. Migration and Fate of Aldicarb in Ground Waters The migration and fate of aldicarb applied during potato farming will be studied at 2 P.E.I. field sites. Hydraulic and chemical tests will be conducted and a model selected to describe aldicarb migration and fate.

3. Contaminant Pathways in Fluvial Systems Work on the photodegradation of the lampricide 3-trifluoromethyl-4-nitrophenol (TFM) will be completed, and an assessment of the photoreactivity of dinoseb initiated.

4. Fate of Amines in Aquatic Ecosystems A preliminary study will be carried out on the persistence, fate and effects on aquatic invertebrates of the pyrethroid, deltamethrin. In addition, previous work on industrial chemicals (amines, dyestuffs) in the Yamaska River Basin in Quebec will be extended to examine the aquatic occurrence, persistence, fate and effects of pesticides in the basin. Twenty-six percent of all pesticides used in agriculture in Quebec are used in the Yamaska River Basin, particularly triazines and triazoles, amides, carbamates, organophosphates and phenoxyacids. The work this year will be on identification and selection of candidates for further study.

5. Biomonitors of Aquatic Contamination The use of clams, leeches and fish as biomonitors of pesticide/chlorophenol/dioxin contamination of the Rainy, South Nation and Yamaska Rivers will be assessed.

6. Microbial Dechlorination of Contaminants In some aquatic ecosystems, such as shallow ponds, reductive pathways of degradation may be more important than oxidative pathways. A study has been initiated on the reductive dechlorination of chlorinated pesticides.

PROJECT CONTACTS:

MANAGER:	R. Allan	336-4678
PROJECT LIAISON SCIENTIST:	R.J. Maguire	336-4776

STUDY LEADERS	PROJECT COMPONENT	TELEPHONE #
R.J. Maguire	Fate of amines in aquatic ecosystems	336-4776
H.B. Lee	Analytical methods development (aldicarb, dinoseb, pyrethroids)	4645
R.E. Jackson	Aldicarb migration and fate in ground water	4587
J.H. Carey	Fate of TFM, dinoseb and deltamethrin in water	4693
J.L. Metcalfe	Biomonitors of aquatic contamination	4685
R.M. Baxter	Anaerobic degradation of pesticides	4778

TOXIC CHEMICALS - FATE AND EFFECTS

SYNPOSIS:

This project will produce measurements and estimates of important environmental characteristics of toxic chemicals, such as: partitioning coefficients, adsorption and degradation rates, acute and sublethal toxicities, and mathematical models of the properties, environmental pathways and effects of these compounds. Such information will be used to improve toxic chemicals management in the aquatic environment.

ISSUE AND RATIONALE:

Toxic chemicals enter the aquatic ecosystem primarily from industrial and municipal effluents. However, in some localities urban runoff and leachates from waste dumps are also significant sources. Numerous examples for each of these sources exist, such as on the St. Clair, Niagara and St. Lawrence rivers. Several thousand contaminants have been identified in the water, sediments, air and biota, but only a few of these compounds have adequately been defined in terms of their environmental pathways and effects.

This project addresses existing knowledge gaps on the properties and pathways (partitioning, bioaccumulation, degradation, persistence, volatilization), as well as fates and effects (transformation, deactivation, acute and sublethal toxicities, chronic exposure effects) of known or suspected environmental contaminants in surface and ground water. Because the rate of introduction of new compounds exceeds that of resolution of their environmental processes and effects, the research program includes structure-activity relationships which allow estimation of toxic characteristics from both structural parameters and the properties of similar compounds.

Chemical pollution of Canadian surface and ground waters is an issue of public concern which has been recognized in several statutes, including the Canada-USA Agreements on Great Lakes Water Quality, the Environmental Contaminants Act, the Canada Water Act, and various federal-provincial agreements. This project is relevant to both general and regional objectives for toxic substances research.

PROJECT OBJECTIVES:

To determine chemical, physical and biological properties of known and suspected environmental contaminants and model compounds by laboratory and field investigations. The objectives include the characterization of surface and ground water contaminants by chemical and biological means as well as the characterization of single chemicals and selected mixtures.

RESEARCH PROGRAM:

Research involves the extraction, separation and analysis of a variety of compounds by modern instrumentation such as electron capture detection, gas chromatography/mass spectrometry, and Microtox analyzer for the determination of persistence and degradation, bioaccumulation and depuration of compounds by bacteria, fungi and yeasts. Also included are laboratory determinations of rates and products of such transformations, development of analytical techniques, and mathematical modelling of such properties and effects.

The research will be carried out by progressive development of data and models interactively with other ongoing studies and programs. The biodegradation tests will utilize previously developed fermentors and yeast culturing techniques. Partitioning studies will be in collaboration with ongoing field activities in the St. Clair and St. Lawrence Rivers. Toxicity determinations will be done with the Microtox analyzer and will investigate the effects of single compounds and of complex effluent plumes in receiving waters. Structure-activity relationships and ecosystem modelling will make use of previously developed correlations and submodels where possible.

CURRENT ACTIVITIES:

1. Toxicities and Quantitative Structure-Activity Relationships: Determine acute/sublethal toxicities of contaminants and model compounds; develop quantitative structure-activity relationships; and hold a QSAR workshop.

2. Amines and Azaarenes: Determine chemistry, fate and effects of amines and azaarenes in surface water and surface microlayer.

3. Biodegradation: Determine biodegradation potential and toxicity of compounds with bacteria, fungi and yeasts.

4. Halogenated Contaminants: Determine partitioning, accumulation and depuration of halogenated contaminants with sediments and benthic organisms.

5. Modelling: Develop/adapt computer models for representation of observed distributions and relationships.

PROJECT CONTACTS:

MANAGER:	R. Allan	336-4678
PROJECT LIAISON SCIENTIST:	K. Kaiser	336-4756

STUDY LEADERS	PROJECT COMPONENT	TELEPHONE #
K. Kaiser	Quantitative Structure Activity Relationships (QSAR), QSAR Workshop, MISA	336-4756
D.L.S. Liu	Degradation, biotechnology (bacteria)	4576
K. Kwasniewska	Degradation, toxicity (fungi)	4576
R.J. Maguire	Amines, toxicity and degradation	4776
W. Strachan	Modelling of distributions and fluxes	4775

NEARSHORE/OPEN LAKE INTERACTIONS

SYNOPSIS:

This project will provide and integrate knowledge and expertise on the physical and sedimentological processes which control the transport and transformation of contaminants in the nearshore zone of the Great Lakes. The results will be communicated to the wide community of Great Lakes users concerned with water supply, recreation, pollution control and water level effects. Synthesis of existing data, specific field experiments, model development and user consultation will be undertaken.

ISSUE AND RATIONALE:

The nearshore zone, the boundary layer between the beach and the open lake, is the zone most immediately impacted by waste disposal, contaminated runoff, and water withdrawal. With the exception of atmospheric deposition, environmental stresses on the Great Lakes are initiated in the nearshore zone. Flows in this zone depend on local conditions of wind and stratification, bottom topography, and open lake (large scale) circulations. Situations may vary from protracted episodes of alongshore flow with the potential for transporting contaminants long distances at relatively high concentrations, to episodes of accelerated offshore movements and contaminant dispersal associated with upwelling events. In view of the natural affinity of many contaminants for suspended particles, the processes of sediment deposition, resuspension, distribution, and transport all require quantitative assessment for the nearshore zone. Since 1973, coastal climatology research at NWRI has collected, analysed, and disseminated physical data on the nearshore zone. Systems modelling of this data has proven valuable for interpretive and integrative purposes.

Improved quantitative assessment of nearshore contaminant distributions (statistical properties of distributions, relation of distributions to significant meteorological events, etc.) would be very useful to a wide community of Great Lakes users. Among them are municipal authorities (domestic water supply, bathing beaches, harbours), provincial agencies (sport fishing, tourism, pollution control), special interest groups (charter boat operators, environmental groups) and industry. Improved prediction of storm surges can alleviate damage to shore structures both in the short term, through adequate warning, and in the long term by guiding design. Among responsible authorities, jurisdictions tend to overlap and mandates are not clearly established, hence experience and expertise developed through this project can be valuable assets to an improved "user network".

PROJECT OBJECTIVES:

1. To assemble and interpret data on physical, biochemical and sedimentological processes in the Great Lakes coastal zones. Past and ongoing research on nearshore/open lake interactions will be synthesized and the results disseminated for the benefit of a wide community of users.

2. To organize and conduct site and process-specific experiments on water circulation and sediment resuspension and transport in the coastal zone and to develop new technologies for the study of this complex environment.

3. To develop or improve predictive models of nearshore tracer distributions for application in contaminant and nutrient assessment in specific areas of concern.

RESEARCH PROGRAM:

Because of the many overlapping jurisdictions in this area, it is important to seek and to validate a mandate for cooperative scientific activity. Organization of a Nearshore Zone Users' Workshop which would draw together government (federal and provincial) scientists and managers; municipal health, recreation, and water supply officials; consulting engineers; charter-boat operators; and environmental groups is under consideration. The goals of the workshop would be: communication of research results, articulation of problems facing particular groups of users, encouragement of active collaboration across administrative boundaries, and enhanced recognition of NWRI as a centre of expertise and information.

At the same time the existing data base of physical, biochemical and geological information relating to the coastal zone will be analyzed and reported. Some completed physical experiments await analysis and some sedimentological data require editing and archiving.

In subsequent years field programs in the coastal zone will be conducted as required. Research at specific problem areas may be needed. Basic understanding of nearshore sediment transport, deposition, and resuspension will require specialized process studies and new techniques for sampling in the dynamic and variable coastal zone may be required. Shallow, wave-dominated zones require rapid sampling of currents and time-series measurements of concentrations of biochemical parameters and suspended solids are currently difficult.

Lastly, new and improved predictive models of nearshore tracer distributions will be developed. The feedback loop of this process can frequently lead to sharply-defined process experiments.

CURRENT ACTIVITIES:

Assembly of a data base for the 1984 Lake Ontario upwelling experiment will be completed. This project is in an early development phase and it is anticipated that activity will increase progressively in coming years.

PROJECT CONTACTS:

MANAGER:	E.D. Ongley	336-4913
PROJECT LIAISON SCIENTIST:	F. Boyce	336-4921

TOXIC CHEMICALS PROJECTS

Priority Areas Research

ST. LAWRENCE RIVER: TOXIC CHEMICAL SOURCES, PATHWAYS, FATE AND EFFECTS

SYNOPSIS:

This project will produce a comprehensive data base on the nature, amounts, and environmental impact on water quality of toxic metals and organic compounds in the St. Lawrence River from its source at Lake Ontario to the freshwater-saltwater interface in the upper estuary. This information will provide the basis for an effective management strategy for St. Lawrence River restoration.

ISSUE AND RATIONALE:

The nearly 3000 km of shoreline along the St. Lawrence River is the home of Canada's second largest city and numerous industries, the majority of which discharge their wastewater directly into the river with little or no treatment. Concern is enhanced by the fact that the St. Lawrence River also receives contaminants from the Great Lakes, acting as a corridor through which toxic chemicals are ultimately discharged to the Gulf of St. Lawrence.

The St. Lawrence River provides a classic case of management problems resulting from a variety of conflicting uses. For example, its shores are now the home of 80% of Quebec's population and nearly five million Quebecers draw their drinking water from the river. The river and its inshore areas are also a rich and diversified environment for freshwater and marine fauna and wildlife, and thus provides recreation for many thousands. It is also, however, a vital factor in Canada's social and economic development, as a navigable waterway, as a source of water for industrial needs, and as a receiving body for municipal and industrial wastes.

PROJECT OBJECTIVES:

The objectives of this project are: (1) to define the nature and amount of contaminants entering the St. Lawrence River from Lake Ontario and from Canadian and U.S. sources upstream of the Quebec border; (2) to identify the nature and amount of contaminants from Quebec sources and define the water quality impact zones; (3) to establish if the Mirex found in eels and beluga whales originates in Lake Ontario; and (4) to determine the impact on the environmental quality of the upper estuary from contaminants supplied by upstream sources.

The first objective will assist interprovincial/international negotiations preparatory to implementation of strategies for river restoration. The second objective will provide data for pollution control evaluation and the establishment of monitoring programs. Objective #3 will assist Canada/U.S. negotiations regarding upstream U.S. remedial measures.

RESEARCH PROGRAM:

Accomplishment of the objectives of this project relies on the availability of acceptable and sensitive analytical methodology. It also requires intensive sampling of all environmental compartments throughout the river and upper estuary under different hydrological regimes and along multiple transects across the river. Sampling will focus on presumed hot spots (tributary mouths, municipal and industrial discharge sites) and the entrance, mid-point and outflow of the transient depositional zones, namely the four lakes in the system. In the upper estuary three master stations located between Quebec City and the Saguenay River will be sampled over at least two tidal cycles to investigate the effect of the saline intrusion and the turbidity maximum on the environmental mobility, bioavailability and residence time of the contaminant burden of the freshwater regime. At the Saguenay River, the geochemical behaviour of contaminants peculiar to this river will be determined along a much sharper salinity gradient. This work will provide a complementary picture of processes occurring at the master stations upstream. Collaborative work with researchers at the Champlain Centre for Marine Science and Surveys and the Canadian Wildlife Service (Quebec Region) will be necessary to assess the effect of contaminants on the reproductive capacities of aquatic biota and wildlife species.

CURRENT ACTIVITIES:

1. Water Quality Impact Zones: Volatile organic compounds and trace metals will be determined for water samples in order to establish the extent of water quality impact zones and the degree of contamination. Split samples will be analyzed for acute toxicity and abundance of fungi and yeasts to further delineate impact zones. Areas to be sampled include: Maitland-Cornwall-Massena; Montreal (several locations); Tracy-Sorel-Yamaska-St. Francois-Nicolet; Trois Rivieres; and Quebec City - upper estuary. Sampling will occur at low flow in June-July (1986) using intensive grid selection methods.

2. Selected Contaminants: Distribution coefficients of selected contaminants will be determined for large-volume water samples (APLE samples) and suspended particulates at the locations noted above.

3. Mirex: At selected stations particulate material will be analyzed for Mirex (with GC-MS confirmation) to identify the transport of this compound to the upper estuary.

4. Sediment Analyses: Surficial river-bottom sediments will be sampled along the 800 km course of the river. These will be analyzed for metals, PCB's, OC's, CB's, nitro-compounds, PAH's and other contaminants in order to identify their distribution and determine possible source relationships.

PROJECT CONTACTS:

MANAGER:	R. Allan	336-4678
PROJECT LIAISON SCIENTIST:	K. Lum	336-4617

STUDY LEADERS	PROJECT COMPONENT	TELEPHONE #
Y.K. Chau/G. Bengert	Organolead compounds	336-4707
S.R. Joshi/ J. FitzGerald	Radiodating cores; radionuclides in suspended particulates	4573
K.L.E. Kaiser/ M.E. Comba	Volatile halocarbons; mirex; OC's, PCB's, PAH's; microtox	4756
K. Kwasniewska	Fungi and yeasts	4576
K.R. Lum	Inorganics - metals, metalloids bioavailability	4617
R.J. Maguire	Amines in Yamaska R.	4776
A. Mudroch	Lac St. Pierre sediment geochemistry	4707
B.G. Oliver	Chlorobenzenes in sediments and suspended material	4604
J.P. Coakley	Sedimentology and geology	4881
P.F. Hamblin	Physical transport and circulation	4921

UPPER GREAT LAKES CONNECTING CHANNELS: CONTAMINANT PATHWAYS AND FATE

SYNOPSIS:

The overall objective of this bi-national study is to complete remedial action plans for the Detroit R., L. St. Clair, St. Clair R. and St. Mary's R. In collaboration with Ontario, Michigan and federal U.S. scientists, NWRI will carry out investigations designed to identify problems and assess the efficacy of potential remedial programs, through an understanding of the fate, transformation and pathways of the pollutants of concern. Recommendations will also be developed for a surveillance program to monitor the results of remedial programs and to give early warning of new problems which may arise.

ISSUE AND RATIONALE:

Heavy urban and industrial development has taken place along these commercial shipping corridors of the Great Lakes system. These same water bodies serve as municipal water supplies, sources of cooling water for various industries and as recreational areas for swimming, boating and fishing. In addition, some areas serve as important habitat for a wide variety of fish, birds and other animals. The various uses have come into conflict over the years. The earliest concerns were bacterial contamination, phenols, metals, phosphorus and mercury. Most of these problems have been reduced significantly. Today, attention is focussed on toxic chemicals.

These areas have been designated as 'Problem Areas' by the IJC since 1974. The specific objectives of the 1978 Great Lakes Water Quality Agreement are exceeded and there is impairment of beneficial uses.

Research is needed to better understand the nature of the problems, particularly the problem of chlorinated organics, and to establish how contaminants of concern move through the ecosystem. Current and historical sources have to be researched. Finally, adequate models must be developed to answer such questions as how long do particular chemicals remain dissolved; how quickly do they move into sediments and food chains; how long will contaminants reside in a lake like L. St. Clair; and how quickly will remedial action take effect in the system.

PROJECT OBJECTIVES:

NWRI research activities are designed to fill in major gaps in our understanding of the pathways and response to contaminant sources in the Connecting Channels.

Specific objectives for toxic trace metals (mercury, cadmium, lead and alkyllead), organic chemicals (PCBs, chlorobenzenes, PAHs and chlorostyrenes), and nutrients are: to identify sources, partitioning patterns between dissolved and suspended sediments, historical loading trends, and residence times of contaminated sediments; to assess ecosystem health; to develop calibrated dynamic models of these contaminants for L. St. Clair and the river channels; and to operate a quality control program with advisory services and interlaboratory studies.

RESEARCH PROGRAM:

The concentration of organic and inorganic contaminants in water, suspended sediments and bottom sediments from the area will be examined to identify sources and to study the partitioning of chemicals between dissolved and suspended sediment phases. Historical loading patterns of metals and organics will be evaluated using sediment cores from Lakes St. Clair and Western Lake Erie. Toxic trace metals such as mercury, lead, cadmium, etc., will be studied as well as organometallic compounds such as alkylleads. PCBs, chlorobenzenes, PAHs, and chlorostyrenes are the major classes of organic chemicals that will be quantified. The loadings of contaminants to the study area from urban runoff will be measured, sediment distribution maps will guide the sediment sampling program and measurements of sediment transport through the study area will be used to establish the residence time of contaminated sediments in the system.

Ecosystem "health" will be assessed using bacteria and macroinvertebrates. The bioavailability of sediment-associated metals and organics will be established and from these data, attempts will be made to identify the chemicals responsible for sediment toxicity in the indicator tests. Potential anaerobic and aerobic degradation routes of the dominant chlorinated organics will be assessed in the laboratory and field. Water movements and sediment resuspension will be studied in Lake St. Clair and western Lake Erie.

Data from the above projects will be used to develop models that will trace the pathways and predict the distribution of contaminants in the study area. A quality assurance program will be established so that all data generated in these UGLCC projects will be of the highest quality required to meet the study objectives.

Some work will also be conducted on eutrophication and the potential effects of eutrophication on contaminant pathways in the ecosystem. Historical data for the UGLCC, including the St. Mary's River, will be examined. The bioavailability of phosphorus in sediments will also be studied. Loadings of dissolved and suspended sediment-associated nutrients will be measured and a eutrophication model for the study area developed.

CURRENT ACTIVITIES:

1. Sources and Pathways

a) Volatiles. This work will include a report on 1984 and 1985 data collected from the Detroit/St. Clair system as well as a survey of volatile contaminants under ice cover in Lake St. Clair.

b) PAH's and Urban Runoff. A study of PAH sources and distributions and urban runoff quality in Sarnia and Sault Ste Marie will be completed.

c) Trace Metals. Sampling for trace metal analyses will be expanded to the St. Clair, Detroit and St. Mary's rivers.

d) Sediments. Sediment coring in Lake St. Clair and the St. Clair River will be undertaken to supplement 1984-85 data. A final report on mass storage in sediments, maps of compound distributions and historical loading patterns will then be prepared. Sounding and coring data for physical characteristics and distribution of bottom sediments in the Detroit/St. Clair system will also be undertaken.

Studies of suspended sediments and settling/resuspension processes will include: data collection and a report on contaminants in suspended sediments; estimation of settling and resuspension rates by ^{234}Th and ^{7}Be analyses; resuspension processes and dispersion in Lake St. Clair and western Lake Erie; and development of surface wave/sediment resuspension relationships for Lake St. Clair.

2. Ecosystem Health

Ecosystem health will be examined in 1986/87 via: a video camera survey of the upper St. Clair River bed; application of the Adenylate Energy Charge (AEC) measurement of environmental stress in the St. Clair River; assessment of anaerobic biodegradation of chlorinated benzenes and the toxicity of the waste liquid discharge from Dow Chemical Canada Inc.; and a report on the distribution and density of yeasts and fungi in Lake St. Clair.

3. Models

A eutrophication model for Lake St. Clair, including suspended and dissolved materials as well as exchange with lake sediments, will be developed. TOXFATE modelling will be used to test the model ranking method for toxic chemicals in the UGLCC Study.

4. Quality Assurance

All UGLCC Work Group plans will be reviewed for quality assurance. In addition at least 4 interlaboratory quality control studies for toxic metals and organics will be undertaken. Findings and recommendations will be reported to the Activity Integration Committee of the UGLCCS Study.

PROJECT CONTACTS:

MANAGER:	G.K. Rodgers	336-4888
PROJECT LIAISON SCIENTIST:	B. Oliver	336-4604

STUDY LEADERS	PROJECT COMPONENT	TELEPHONE #
G.K. Rodgers	St. Clair River monitoring (ROV camera)	336-4888
K.L.E. Kaiser	Volatile organic contaminants	4756
B.G. Oliver	Chlorinated hydrocarbons in sediment and biota	4604
D. Liu	Anaerobic biodegradation & toxicity	4576
K. Kwasniewska	Accumulation/toxicity of organic contaminants by yeasts & fungi	4576
E. Nagy	Polynuclear hydrocarbons	4685
Y.K. Chau	HPLC for adenylate energy charge measurements	4707
A. Mudroch	Mercury in the St. Clair River	4707
R. Platford	Partitioning of radionuclides	4778
M. Donelan	Sediment resuspension/wave relationships, Lake St. Clair	4879
N. Rukavina	Lake & river sediments - distribution & occurrence	4880
J. Marsalek	Urban runoff, bed transport and contaminant mixing	4899
M. Charlton/	Contaminated sediment movement, L. Huron -	4758
H.F. Dobson	L. Erie	4667
P. Manning	Phosphorous, iron, heavy metal availability in sediments	4787
T.J. Simons	Eutrophication modelling	4915
E. Halfon	Modelling of contaminant fate, St. Clair River	4917
C.R. Murthy	Sediment resuspension - Lake St. Clair	4920
R.P. Bukata	Satellite assessment of sediment, Lake Huron-Erie	4670
A.S.Y. Chau	Quality Assurance	4653

HAMILTON HARBOUR REHABILITATION

SYNOPSIS:

This project will investigate methods and equipment for improving hypolimnetic oxygen levels and for precipitating and flocculating suspended solids, phosphorus, toxic metals, and toxic organic compounds in Hamilton Harbour. Investigations will be conducted on the harbour oxygen budget, microbial metabolism, water turbidity, and nitrogen and sulphur reactions. The study should produce improved models for oxygen consumption, water balance and temperature patterns for Hamilton Harbour. Products from this project will result in technology transfer and data in support of the Hamilton Harbour Remedial Action Plan. The results will have possible policy implications for DOE activities relating to Lake Ontario contaminant loadings.

ISSUE AND RATIONALE:

Hamilton Harbour is one of the most polluted of the IJC Areas of Concern which lie exclusively within Canada. The harbour was specifically flagged by the IJC Water Quality Board in June, 1986, as requiring a remedial action plan (RAP). Recently, industry, public representatives, and all 3 levels of government have begun to co-operate in the development of the harbour RAP.

Several contaminants, including Zn, Fe, Cd, chlorophenols and biological oxygen demand, continue to exceed provincial guidelines despite recent improvements in harbour water quality. Of particular concern is the low oxygen concentration in the hypolimnion which limit microbial activity and fish productivity. In addition, the harbour sediments, particularly those in the southeast, are too contaminated for open water disposal.

Hamilton Harbour water exchanges with water from Lake Ontario, thus contributing to the total contaminant burden in the lake.

Studies are required in order to quantify contaminant levels in water and sediment and to identify and test remedial technologies for oxygenation and chemical precipitation of phosphorous and suspended solids. This information will provide critical, direct contributions to the Hamilton Harbour RAP and will assist in identifying the significance of pollutant loads to Lake Ontario, relative to other Areas of Concern (such as Toronto Harbour and the Niagara River).

PROJECT OBJECTIVES:

The objectives for this project are to identify and test economical and efficient harbour rehabilitation technologies; quantify effects on nutrients, major ions and chlorinated phenol decomposition; and improve models for oxygen, temperature and water balance.

RESEARCH PROGRAM:

1. Install and evaluate oxygen injection equipment, utilizing locally available, industrial supplies of oxygen and monitor the dispersion of oxygenated water in the harbour using automated sensors. The efficiency of toxic contaminant degradation resulting from oxygenation will be measured. This will be derived from the response of a model compound (a chlorinated phenol) in limnocorrals.

2. Develop and test methodologies to flocculate and precipitate phosphorous, toxic metals, toxic organic compounds, and suspended solids. Methods will employ lime injection techniques.

3. Important associated limnological investigations will be undertaken. These will include measurements of rates of nutrient reactions which influence the oxygen budget, microbial metabolic activity, water turbidity and the reactivity of iron (using Mossbauer spectrometry). Quantification of nitrogen and sulphur reactions using bottle incubations with stable or radioactive isotopes will also be undertaken and improved quantification of sediment oxygen demand attempted.

4. Data from this study will be employed to develop improved models for oxygen consumption, water balance, and temperature patterns for Hamilton Harbour.

CURRENT ACTIVITIES:

1. Oxygen Injection

   Install and evaluate oxygen injection equipment and monitor the plume of oxidized water.

2. Lime Injection

   The effect of lime injection on the precipitation of phosphorous and suspended solids will be evaluated.

3. Modelling

   Models for oxygen, temperature, and water balance will be evaluated.

PROJECT CONTACTS:

MANAGER:	J. Barica	336-4785
PROJECT LIAISON SCIENTIST:	T. Murphy	336-4602

STUDY LEADERS	PROJECT COMPONENT	TELEPHONE #
P.G. Manning	Metal contaminants in sediments	336-4787
M.N. Charlton	Oxygen regime & sedimentation rate	4758
T.P. Murphy	Oxygen injection and liming restoration	4602
E. Nagy	Polynuclear hydrocarbon (PAH) contamination	4685
A. Mudroch	Availability of metal contaminants	4707
W. Schertzer	Thermal structure	4915

NIAGARA RIVER CONTAMINATION

SYNOPSIS:

This project is designed to provide basic information regarding the extent and nature of contamination in the Niagara River - Lake Ontario system. Loadings to Lake Ontario and the ultimate fate of toxic chemicals will be investigated. Models will be developed which, along with other forms of data syntheses, will assist in the design of monitoring programs, policy formulation and strategies for rehabilitation.

ISSUE AND RATIONALE:

The Niagara River has been consistently identified by the IJC as a Class 'A' Area of Concern. The IJC's "Special Report on Pollution in the Niagara River" (1981) made specific recommendations for monitoring studies and for limitations to additional discharges. The first major scientific compendium on the nature of the Niagara River-Lake Ontario pollution problem was released in early 1983 as a special issue of the Journal for Great Lakes Research. Much of the work described in this issue was based on studies conducted by scientists at NWRI. The 1983 report of the WQB/IJC concluded that remedial measures currently in operation would not resolve the identified environmental problems. The bilateral Niagara River Toxics Project, initiated to coordinate the investigations of toxic chemicals entering the river, submitted the final report to sponsoring governments with specific recommendations. The report has identified 261 chemicals of concern in the Niagara River system. Of these, 57 require immediate attention because they are found at levels greater than or equal to environmental or human health criteria, or they are considered to pose a risk based upon the screening procedures employed. The significance of exposure to, or the effects of, most of these chemicals, either individually or in combination, is presently unknown. The presence of toxic chemicals in the Niagara River and adjacent Lake Ontario waters has resulted in occasional violations of GLWQA water quality objectives, commercial fishing bans or consumption restrictions, and elevated public concern about drinking water supplies.

PROJECT OBJECTIVES:

Through comprehensive research, monitoring, modelling and information synthesis this project will a) develop data on the nature, degree and the extent of contamination of the Niagara River-Lake Ontario system by organic and inorganic substances; b) determine the loadings, transport and fate of toxic chemicals from the Niagara River to Lake Ontario; c) develop models and methodologies appropriate for information synthesis in order to design suitable surveillance and monitoring plans and to develop rehabilitation strategies; and d) provide an authoritative scientific rationale for U.S./Canadian negotiations on the extent of U.S. impacts on the Niagara River.

RESEARCH PROGRAM:

1. Data Base on Extent of Contamination

Research activities will focus on the estimation of the degree of environmental hazard posed by zones of impact on ambient water quality and identification of hot spots as part of a strategic objective to source control of toxic chemicals.

2. Loadings, Transport and Fate of Toxic Chemicals

Research activities will focus on loading estimates to Lake Ontario using appropriate numerical/statistical models, physical characteristics of the Niagara River plume in Lake Ontario (which is primarily responsible for the transport and distribution of toxic chemicals), development of synthesis models to simulate the transport and fate of selected toxic contaminants in the Niagara River-Lake Ontario system.

3. Models and Methodologies

The research results will be synthesized to advise IWD/Ontario Region and MOE on suitable surveillance and monitoring plans, and to assist in developing management options and policy evaluations for restoration of the Niagara River-Lake Ontario ecosystem.

4. Policy Advice

Provide an authoritative scientific rationale for determining Canadian options in U.S./Canada negotiations, which are acceptable to all parties.

CURRENT ACTIVITIES:

1. Niagara River Plume

Delineation of the physical characteristics of the Niagara River Plume in Lake Ontario from Lagrangian drifter data. Optical transmission, conductivity and EBT surveys; remote sensing and satellite imagery data.

2. Loadings Estimates

Evaluation of numerical/statistical techniques for loadings estimation from Niagara River to Lake Ontario.

3. Contaminant Transport Model

Development and evaluation of a contaminant transport model to simulate fate and pathway of Niagara River contaminants in Lake Ontario. A preliminary report summarizing the implications of the Niagara River Project on the transport and fate of toxic contaminants in Lake Ontario will be completed.

PROJECT CONTACTS:

MANAGER:	E.D. Ongley	336-4913
PROJECT LIAISON SCIENTIST:	R. Murthy	336-4920

STUDY LEADERS	PROJECT COMPONENT	TELEPHONE #
C.R. Murthy	Physics, Niagara R. plume	336-4920
D.C.L. Lam	Modelling toxics transport, fate, pathways in Niagara R. plume-L. Ontario	4916
A. El-Shaarawi	Estimation of loadings, Niagara R. to L. Ontario; policy advice	4584
M.E. Fox/J. Carey	Transport of selected organochlorines	4604

THE FRASER RIVER ESTUARY: CONTAMINANT PATHWAYS

SYNOPSIS:

This project will result in detailed knowledge of the pathways of transport, degradation and bioaccumulation of chlorinated phenols and related contaminants in the Fraser River Estuary. These compounds will then be used as models to determine the pathways of other contaminants in this system. It is expected that this knowledge base will be of considerable use in the formulation of water quality objectives and a monitoring program for the system.

ISSUE AND RATIONALE:

Chlorophenols are widely used in the Canadian lumber industry for wood protection and preservation. They enter the aquatic environment from lumber operations and various other sources. They are very toxic to aquatic life and technical-grade chlorophenols can contain a number of impurities, such as dioxins, that are also of concern from a toxicological viewpoint. Although there is a great deal of published literature on various aspects of chlorophenol fate, few studies of chlorophenol pathways have been done at actual sites of chlorophenol contamination. Previous NWRI studies have demonstrated that chlorophenol degradation is very site-specific and depends upon such parameters as depth, turbidity and type of benthic substrate. The Fraser River is an important location to study chlorophenol fate because the river and its estuary support one of the largest commercial fisheries in North America. In addition, the two most important chlorophenols in Canada, 2,3,4,6-tetrachlorophenol (2,3,4,6-TeCP) and pentachlorophenol (PCP), are both used extensively in the lower mainland area of British Columbia, thereby providing the opportunity for comparative studies.

The recently approved Fraser River Estuary Management Program calls for the development of a water quality plan for the estuary. Under the implementation strategy of the agreement, IWD/P&Y Region is expected to be a major participant in the design of the plan, which calls both for the setting of objectives and the establishment of a monitoring program for contaminants. In July, 1985, participants at the Fraser River Estuary Toxic Chemicals Workshop identified a number of substantial gaps in knowledge which need to be addressed by research before a scientifically-defensible, water quality plan can be developed. Because of the impossibility of studying each contaminant in detail, the workshop recommended that PCP and 2,3,4,6-TeCP be chosen as 'benchmark' chemicals to be subjected to detailed pathway research within the estuary.

PROJECT OBJECTIVES:

The objective of this project is to determine the actual pathways of transport, accumulation and degradation of contaminants in the Fraser River Estuary and to understand the factors controlling the relative importance of these processes under ambient environmental conditions. In addition, information on the sources of contaminants to the system and their relative importance will be obtained and combined with hydrodynamic data to produce a contaminant transport and fate model for the estuary.

RESEARCH PROGRAM:

1. Identification of toxic chemicals present in the Fraser River and formulation of a site specific contaminants list. Activities in support of this objective will centre on sampling and analysis of river water, suspended solids, sediment and biota to identify contaminants present.

2. Pathways of transport, accumulation and degradation of chlorophenols in the Fraser River Estuary. The degradation rates of chlorophenols in various compartments of the estuary will be determined from a combination of field investigations and laboratory studies. The accumulation of chlorophenols in Fraser River biota will be investigated in the field and pathways of accumulation identified. The factors controlling the physical state and ultimate fate of these compounds in the system will also be determined.

3. Modeling of chlorophenol transport and fate. Measurements of temperature, conductivity, light transmission, water movement (from drogue studies) and chlorophenol distribution will be made in the lower estuary. These data will be combined with existing physical simulation models to develop contaminant transport models for the two 'benchmark' chlorophenols.

CURRENT ACTIVITIES:

1. Contaminants List

   Water, fish and suspended and bottom sediments from selected locations throughout the estuary will be analysed by capillary column gas chromatography and GC/MS to determine the identities of the major contaminants. Initial emphasis will be on saturated hydrocarbons, polycyclic aromatic hydrocarbons and organochlorine contaminants in fish and sediment.

2. Chlorophenol Pathways

A series of laboratory experiments on the photodegradation kinetics of 2,3,4,6-TeCP and PCP will be conducted and used to predict photochemical half-lives for surface waters of the estuary throughout the year. The identity and distribution of chlorophenols in the organs of several fish species will also be investigated. Emphasis will be placed on variations of chlorophenol identities and levels in the fish relative to size, location and species. Stomach contents of several species will be determined to evaluate the importance of food source in controlling chlorophenol accumulation.

3. Model Development

A series of experiments on distribution and rates of transport of chlorophenols in the Main Arm and North Arm will be conducted. Drogues will be deployed as markers of individual water masses in an attempt to follow these 'plugs' of water from Port Mann to the sea. Water will be sampled periodically and profiles of temperature, transmission and conductivity will be obtained. A survey of existing hydrodynamic models will be initiated to find one suitable for use in developing a contaminant fate model.

4. In-situ Optical Properties

A study of water quality variability in British Columbia river systems is being initiated jointly with Water Quality Branch, P&Y Region. Activities include: (a) direct measurements of in-situ subsurface spectral irradiance at such sites as the Fraser, Thompson and Columbia Rivers; (b) the procurement of Landsat Thematic Mapper data as required; and (c) the development of appropriate interpretation methodologies.

5. Interlaboratory Quality Assurance

An interlaboratory study (maximum 6 laboratories) on the analysis of PCP and 2,3,4,6-TeCP in both naturally contaminated and spiked samples of fish homogenates will be implemented.

PROJECT CONTACTS:

MANAGER:	R.J. Daley	336-4503
PROJECT LIAISON SCIENTIST:	J.H. Carey	336-4693

STUDY LEADERS	PROJECT COMPONENT	TELEPHONE #
J.H. Carey	Contaminants list, chlorophenols	336-4693
D. Lam/R. Murthy	Contaminant fate, modelling	4916/ 4920
R. Bukata	Optical properties, remote sensing	4670
B. Lee	Interlaboratory QA	4645

ACID RAIN PROJECTS

TITLE: LRTAP ACIDIFICATION PROCESSES

SYNOPSIS:

This project seeks to develop scientific expertise regarding definition and understanding of the hydrogeochemical processes which control the impact of LRTAP on Canadian surface water resources. Such expertise will be used to quantitatively assess the effect of "acid rain" on the aquatic environment during both the acidification and later recovery stages, and also, will provide support and leverage for the negotiation of emissions reduction. Research methodologies include both generalized mass balance studies and specific investigations into the pathways and importance of specific chemicals in watersheds.

ISSUE AND RATIONALE:

The Long Range Transport of Airborne Pollutants is well recognized as a high priority research issue by the scientific community and all levels of government. The occurrence of lake and stream acidification in response to atmospheric deposition is well documented for a small number of localized situations where the influence of a nearby source is obvious. Coupled with the fact that highly acidic precipitation is now falling over much of eastern Canada, concern exists for the regional condition of the large aquatic resource located in this area. If the same sequence of chemical and biological effects observed in localized cases is manifested at the regional scale, then the social and economic consequences will be devastating. However, it is not clear at present whether regional acidification does proceed in the same manner. We also have a poor understanding of both how quickly regional acidification is progressing and how reversible it may be if the magnitude of acidic deposition is decreased by emission controls in the future.

PROJECT OBJECTIVES:

This project will attempt to assess the consequences of regional-scale acidification by developing a quantitative understanding of the hydrogeochemical factors which control the process in specific watersheds. This information will then be extrapolated using available aquatic and terrestrial data. Hence, project objectives focus on determining the sources of both anthropogenic and natural acidifying substances, as well as other airborne contaminants, and defining their pathways and ultimate fate. Similarly, emphasis is placed on elucidating the biogeochemical mechanisms by which the aquatic and associated terrestrial ecosystems deal with these contaminants.

RESEARCH PROGRAMS:

Project objectives will be met by undertaking a complementary set of general and specific research programs.

1. Determination of mass budgets for lakes and associated terrestrial watersheds in the Turkey Lakes Watershed (near Sault Ste. Marie, Ontario) will allow evaluation of the relative importance of the sources and sinks of either acids or alkalinity on a basin scale; also it will provide information on the temporal and spatial variability of the components. Comparison of the results with the findings of similar studies conducted elsewhere in eastern Canada will permit extrapolation to a regional scale.

2. Complementary studies include: quantification of the factors controlling short term (i.e. episodic) acidification events; evaluation of the role of organic matter in the acidification process; elucidation of the detailed processes associated with the sulphur cycle in lakes (including potential alkalinity generation); quantification of metal mobilization (particularly Al) that may accompany lake acidification; development of a capability to predict planktonic assimilation of S and N (and associated alkalinity generation); and determination of the reversibility of the acidification process. The specific biogeochemical information derived from these studies will refine our understanding of the factors controlling surface water acidification, and will be used to explain many of the deviations observed in the broader mass-budget investigation. All of these studies employ well established methodologies or involve an innovative re-application of such methodologies.

CURRENT ACTIVITIES:

1. Turkey Lakes Hydrogeochemical Responses

   Measure year-round the hydrological budget and the chemistry of precipitation, lake water, and stream water. Assess the importance of groundwater to the hydrological and chemicals budgets. Prepare reports on 1983-84 mass balance data and on alkalinity sources in the watershed.

2. Geochemical Response of Drainage Basins

   Relate mass budget studies in the Turkey Lakes Basin to the influence of LRTAP. Assess snowpack storage and release of acids associated with variations in stream and lake pH during spring melt. Prepare reports on snowpack mass budget and on meltwater interaction with soils. Investigate temporal and spatial variations in the concentration and speciation of aluminium in headwater streams and Batchawana Lake.

3. Aquatic Effects Assessment

Review and report on current state of knowledge of LRTAP with respect to effects on aquatic ecosystems.

4. Sulphur in Acid Sensitive Lakes

Complete reports on mass and isotopic balances for S in the Turkey Lakes Watershed. Undertake laboratory and field studies of organosulphur compounds to determine their influence on the sulphur budget of lakes and the extent of alkalinity production associated with the sulphur cycle. Prepare preliminary report on organosulphur compounds.

5. Dissolved Metals in Acid Sensitive Lakes

Complete report on metal cycles in Ontario lakes, complete analyses of 1985-86 field samples, sample Kejimkujik Lake (Nova Scotia) and develop an auto method for analysis of dissolved aluminium species.

6. Dissolved Organic Matter

Complete analyses of 1985-86 samples and prepare reports on bog drainage, Kejimkujik studies, and all LRTAP natural acidity investigations in Nova Scotia.

7. Internal Alkalinity Production

Review relevant literature on sediment and water column alkalinity generation; analyze pore-water samples to determine gradients in relevant chemical species (Turkey Lakes and Kejimkujik); measure SO_4 and NO_3 assimilation by lake plankton; and develop predictive relationship between simple limnological variables and SO_4 assimilation at Turkey Lakes, Haliburton and Dorset.

8. Organic Matter Degradation

Continue experiments to evaluate the effects of acidification on organic matter degradation in sediments of low-pH lakes.

PROJECT CONTACTS:

MANAGER:	J. Barica	336-4785
PROJECT LIAISON SCIENTIST:	D. Jeffries	336-4781

STUDY LEADERS	PROJECT COMPONENT	TELEPHONE #
D.S. Jeffries	Chemical limnology, general geochemistry	336-4781
R.G. Semkin	Geochemistry, chemistry of atmospheric deposition	4781
J.O. Nriagu	Geochemistry, especially sulphur cycle; isotope geochemistry	4784
H. Wong	Lake sediment chemistry	4784
R.A. Bourbonniere	Surface water organic carbon chemistry	4547

LRTAP MODELLING/MONITORING RESEARCH

SYNOPSIS:

This project aims at designing a monitoring and information strategy through the use of simulation models and statistical methods which will be used to assess aquatic impacts due to acidic deposition and to evaluate remedial strategies and policy options. Knowledge from this project on information synthesis, emission-impact scenarios, effective monitoring strategies, data quality control and uncertainty analysis will form the basis for establishment of LRTAP guidelines and criteria for acid-load reductions.

ISSUE AND RATIONALE:

The Canadian government has identified acid rain as one of its highest priorities. This priority is manifested in bilateral (U.S. - Canada) and federal-provincial agreements, and understandings in regards to scientific investigations, monitoring and interpretation. This project identifies two key components of the LRTAP program: (a) the assumption of lead role by NWRI for guidance of the directorate program on monitoring and interpretation, and (b) modelling research to assess monitoring performance, extrapolation activities and policy alternatives.

PROJECT OBJECTIVES:

To develop a monitoring and information synthesis strategy designed to:

a) evaluate the effect of planned reductions in Canadian emissions, including considerations of recovery of aquatic systems;
b) differentiate between Canadian and foreign sources relative to impacts on Canadian aquatic systems;
c) develop short and long term emission-impact scenarios for the development of policy options; and
d) develop models and methodologies appropriate for information synthesis, policy evaluation, and data quality control.

RESEARCH PROGRAM:

1. Development of evaluation techniques for the purpose of improved LRTAP monitoring, including strategies for interim improvements by analysing various interpretative and extrapolative methods regarding existing monitoring data.

2. Development of hydrological and hydrogeochemical models for the analysis of stress-response relationships using data for a number of Canadian watersheds under various acidic deposition rates and different soil zones. Verification of these models using both watershed data and multi-disciplinary research results.

3. Refinement and enhancement of existing models used in the U.S. - Canada Memorandum of Intent (1980). Evaluation of these models with both research and monitoring data will provide feedback to the National LRTAP Assessment Program. The models will also be updated to provide emission-impact scenarios and uncertainty analysis.

4. Improvement in the quality of data generated by LRTAP laboratories, using data quality control and evaluation procedures and developing statistical methods for multiple series measurements and paleo-environmental trend analysis.

CURRENT ACTIVITIES:

1. Monitoring and Interpretation

Review existing agreements and arrangements for data collection and synthesis by federal and provincial agencies. Develop and implement a program for technology transfer from existing IWD and external research programs for the purpose of improved monitoring, and recommend interim improvements in monitoring program to regional offices. Provide functional guidance for interpretive activities including consultation with regional and HQ offices. Develop, recommend and make appropriate changes in LRTAP monitoring and interpretive strategies for Canadian aquatic systems. Define and improve the quality of data generated by laboratories for the federal-provincial LRTAP program.

2. Modelling and Information Synthesis Research

Develop methods for (a) grouping variables measured on ordered samples which will be of use in determining which diatom species have similar depth profiles in a sediment core, and (b) assess error limits on pH inferred from diatom indices using statistical methods of calibration. Continue validation of the cation denudation rate (CDR) model: data from LRTAP monitored rivers and, if available, long term monitored data for soft water lakes in Ontario will be evaluated for CDR response to changing deposition rates. Validate watershed acidification models through synthesis of research results and data collected at calibrated watersheds (Turkey Lakes, Dorset, Lac Laflamme and Mersey River) and establish time changes and stress-response relationships for different emission-impact scenarios. Determine regional linkages between aquatic acidification and terrestrial sensitivity for analysis of resources at risk in Quebec by integrating both aquatic and terrestrial monitoring data based on microcomputer model applications.

PROJECT CONTACTS:

MANAGER:	E.D. Ongley	336-4913
PROJECT LIAISON SCIENTIST:	D. Lam	336-4916

STUDY LEADERS	PROJECT COMPONENT	TELEPHONE #
K. Aspila	Interlaboratory Quality Control	336-4638
S. Esterby	Statistical analysis of LRTAP data	4790
M. Thompson	Cation denudation rate model	4513
D. Lam	Watershed acidification model	4916
A. Fraser	Operational acid precipitation models	4611
(vacant)	LRTAP monitoring research	

METHODOLOGY DEVELOPMENT PROJECTS

for

ENVIRONMENTAL SENSING and INTERPRETATION

BIOMONITORING METHODOLOGY DEVELOPMENT

SYNOPSIS:

This project will result in new or improved field and laboratory methods for assessing water quality and the health of aquatic ecosystems using biomonitoring techniques. Biological species, including plants, microbiota, and macroinvertebrates, will be identified, assessed, and evaluated with regard to their capacities for the determination and surveillance of environmental contamination.

ISSUE AND RATIONALE:

Biological methods in the water quality assessment field are used for two main reasons: determination or continued surveillance of gross contamination in the environment, and determination of gross ecological effects.

The strengths of biological methods lie primarily in the close simulation of biomonitors with the biological systems under study. Often the biomonitor will be part of that biological system. Thus, aquatic organisms provide monitoring capabilities which take into account the actual responses of organisms or populations to environmental variables including other pollutants with which interactions may occur. In contrast, chemical measurements, however precise, still have to be interpreted in context of a complex set of factors operating within ecosystems. Interpretations of precise chemical measurements obtained from laboratory dose-response experiments are unlikely to be wholly reliable guides to what happens in field conditions. The degree of effect of the pollutant may vary according to the presence or absence of other stresses on the biological system which in turn may produce interaction effects which could be antagonistic, additive or synergistic.

PROJECT OBJECTIVES:

The objectives of this project are: to develop new and improved biomonitoring techniques for the assessment of water quality and the "health" of aquatic ecosystems; to evaluate microbiological techniques for the assessment of mutagenic and toxic properties of waters and effluents; to develop, assess and field-evaluate more sensitive and reliable sampling and analysis techniques for bacterial, fungal, viral and biochemical indicators in natural waters, wastewaters and sediments; and to articulate the benefits of biomonitoring in departmental monitoring programs.

RESEARCH PROGRAM:

Three main areas are being addressed in this research project.

1. Use of higher and lower plants as biomonitors of metal deposition from both atmospheric and hydrological sources. This work emphasizes the imputs from mining and smelting operations and coal-fired power plants. In addition, background (baseline) data is collected from remote areas to assess the impact of localized sources.
2. Use of macroinvertebrates as biomonitors of contaminants, both metals and organic.
3. Use of microbiological and biochemical indicators of toxic substances in aquatic ecosystems.

Biomonitoring species are selected on the basis of the following criteria: ability to bioaccumulate (qualitatively and quantitatively); geographical and seasonal availability; specificity of uptake; repeatability; and collection and analysis cost.

In all cases, background data from water and sediments are collected to validate the biomonitoring methodology. It is anticipated that laboratory ecosystems will be set up in the future to do more detailed work on biomonitoring methodologies. At present, most work is field oriented.

CURRENT ACTIVITIES:

1. Biomonitoring

   a) Determine the feasibility of aquatic macrophytes for biomonitoring the deposition of As, Se, Hg and Cd from mining activities.
   b) Determine the feasibility of ombrotrophic Sphagnum mosses as biomonitors of metal and sulfur deposition from coal-fired power plants.
   c) Assess the potential of aquatic macroinvertebrates for monitoring health of aquatic environments, with emphasis upon the Ottawa and Rainy rivers and a river in the Atlantic Region.

2. Biochemical

   a) Evaluate the use of ATP and the S.O.S. chromotest for toxicant screening.
   b) Develop methods for adenylate energy charge (AGC) measurement as a biochemical parameter for biological monitoring of environmental stress.

3. Inventory/Information

a) Prepare inventory of available biological methods for water quality monitoring.
b) Revise the IWD Microbiological Methods Manual for Water, Wastewater and Sediments.
c) Hold the 3rd International Symposium on Toxicity Testing and the 1st Biennial Water Quality Symposium.

PROJECT CONTACTS:

MANAGER:	J. Lawrence	336-4927
PROJECT LIAISON SCIENTIST:	B. Dutka	336-4923

STUDY LEADERS	PROJECT COMPONENT	TELEPHONE #
B.J. Dutka	Toxicity Screening; Symposia; methods manual	336-4923
J. Metcalfe	Clam biomonitoring, Ottawa River	4685
R. McInnis	Microbiological support	4579
Y.K. Chau	Adenylate energy charge methods	4707
W. Glooschenko	Macrophyte biomonitoring; methods inventory	4786

CHEMICAL METHODOLOGY DEVELOPMENT

SYNOPSIS:

The mandate of the project is to advance knowledge and provide expertise on aquatic analytical chemistry. The project is essential for the successful management and utilization of water resources and for research on water pollution, especially the identification of emerging problems.

ISSUES AND RATIONALE:

Successful solutions to environmental problems require the availability of accurate, precise and rapidly-produced analytical data. Every departmental program which relies on the collection of aquatic data is dependent on the availability of sound methodology and adequate quality assurance.

This project develops and evaluates analytical methodologies (including sample collection, preservation, extraction, pre-concentration, clean-up and analysis) for the measurement of chemical parameters in water, sediment and biota. Improvements to existing methods in terms of precision, accuracy, detection limits, cost effectiveness, automation and speciation are an integral part of the program.

Project activities include provision of advanced analytical methodology support and transfer to IWD laboratories, NWRI scientists, the GLWQP, and other clients, as well as implementation of interlaboratory quality assurance programs for regional, national, LRTAP, PPWB and GLWQP laboratories.

PROJECT OBJECTIVES:

a) To develop new and improved analytical methods as well as screening and sampling procedures which are accurate, cost-effective, sensitive and unambiguous for the identification and quantification of contaminants in aquatic ecosystems.

b) To play the lead role in documentation, validation and standardization of analytical methodologies and implementing quality assurance and control programs to ensure accuracy, compatability and reliability of analytical data.

c) To provide a service of sophisticated instrumentation and facilities such as gas chromatograph - mass spectrometry and the Clean and Hazardous Chemicals Laboratory.

d) To transfer developed methods and technologies to the national and regional laboratories of IWD and to other clients.

RESEARCH PROGRAM:

Analytical methods will be developed for organic and inorganic parameters in a variety of environmental substrates. These include state-of-the-art techniques such as high performance gas chromatography, high-pressure liquid chromatography, emission and absorption spectroscopy, flow-injection analysis, and radioimmunassay and electrochemical techniques. Both broad screening techniques and detailed quantitative techniques will be developed, as will improved sample collection and extraction techniques.

Interlaboratory quality assurance studies will be conducted for federal, provincial, university and private laboratories producing analytical data for departmental programmes. Methodology evaluation and preparation of reference materials will be carried out in support of these quality assurance studies.

CURRENT ACTIVITIES:

1. Analytical/Methodological

   a) Implement dense-gas chromatography in tandem with low-resolution mass spectrometry for analyzing priority organic contaminants.
   b) Develop electrochemical and flow-injection analytical methods to improve economy and efficiency of operations in WQB laboratories.
   c) Develop screening methods for interferences in sediment and large-volume water concentrates prior to G.C. and capillary G.C. analysis.
   d) Develop clean-up procedures suitable for analysis of dioxins, furans and sulphur-containing compounds.
   e) Develop a method for simultaneous determination of 5 anions and up to 5 cations.
   f) Evaluate preservation techniques for chlorobenzenes, PAH's and acid herbicides.
   g) Improve methods for analyzing and identifying taste and odour compounds in water.

2. Laboratory Services

   a) Provide the service of the Clean and Hazardous Chemicals Laboratory.
   b) Automate and computerize laboratory analytical systems for application in WQNL.

3. Field Samplers

   a) Develop large-sample extractor for field use.
   b) Develop an automated inverval water sampler and a high resolution horizontal water sampler.

4. Quality Assurance

   a) Conduct QA to ensure that data generated by WQB, PPWB, and provincial laboratories are of good and comparable quality.

PROJECT CONTACTS:

MANAGER:	J. Lawrence	336-4927
PROJECT LIAISON SCIENTIST:	I. Sekerka	336-4657

STUDY LEADERS	PROJECT COMPONENT	TELEPHONE #
F. Onuska	SCF chromatography	336-4635
P. Goulden	Water extraction, new compound analysis	4658
I. Sekerka	Electrochem, FIA	4657
B.F. Scott	Analysis of concentrates	4596
I. Sekerka	Technology Transfer	4657
I. Sekerka	Clean & Hazardous Chemical Laboratory	4657
J. Sherry	Radioimmunoassay	4926
H. Alkema	WQB, PPWB, Fed/Prov Q.A.	4645
V. Cheam	Inorganic Methods	4645
H.B. Lee	Preservation	4645
H.B. Lee	CRM's	4645
N. Madsen	Water samplers development	4762
B. Brownlee	Taste/Odour compounds in drinking water	4783

WATER QUALITY MONITORING AND MODELLING RESEARCH

SYNOPSIS:

This project provides scientific leadership, consultation, and advice regarding aquatic data collection, synthesis, and interpretation. It is intended to complement and enhance numerous research and monitoring programs undertaken in support of DOE's mandate. Studies are conducted both separately and jointly with other research and operational units of the department, in particular with the regional components of C&P. This project involves research into scientific techniques as well as actual data synthesis and interpretation.

ISSUE AND RATIONALE:

Research and monitoring in support of environmental programs requires highly specialized and reliable techniques for data collection, systhesis and interpretation. Strategies and techniques related to sampling, analysis, and modelling have to be developed or modified on a case-by-case basis as there are few 'off-the-shelf' manuals in this area. Further, environmental data collection tends to be very expensive, hence, cost efficiency demands maximization of output with minimal repetition of effort. The results of this work should thus lead to improved efficiency and reliability. Accuracy is very critical because the results of research and monitoring programs form the basis of departmental strategies and policies. They must therefore be defensible in national and international forums.

PROJECT OBJECTIVES:

The objectives of this project are to provide: (1) direct consultation and support to the components of C&P in the form of scientific leadership in areas of data collection technology and information processing and analysis; (2) indirect support in the form of consultation and technology/information transfer; and (3) a formal linkage between the scientific community in NWRI and Water Quality Branches for the purpose of problem identification and research program formulation.

RESEARCH PROGRAM:

This project involves data collection as well as the use of existing data. These are analysed and advice is provided accordingly. Specific activities vary according to departmental programs (C&P and other clients) and priorities. It is fundamental that the long-term activities of this project remain adaptable and flexible.

CURRENT ACTIVITIES:

1. Data Collection/Analysis Technology

   a) Complete a statistical study to estimate frequency of contaminant sampling in the Niagara River.
   b) Complete Mackenzie River study on hydrocarbon and metals flux and make recommendations on monitoring strategies.
   c) Prepare assessments of scale effects in sediment-associated chemical data in rivers and on toxic chemicals sensing in fluvial systems.
   d) Test various methods of diurnal oxygen curve analysis using data from Canagagigue Creek, and apply to data from other Canadian Rivers.

2. Indirect Support to IWD

   a) Publish the proceedings of the Workshop on the Statistical Aspects of Water Quality Monitoring.
   b) Install a one-dimensional water quality model on CCIW computers.
   c) Conduct experiments on the effects of suspended sediment on the mixing characteristics of rivers.
   d) Develop the 'RIVMIX' model for the case of unsteady pollutant sources.

3. Direct Support to WQB

   a) Revise WQB data analysis and presentations manual.
   b) Organize a joint workshop with IWD on the Niagara River surveillance program.
   c) Meet with WQB personnel on a regular basis via the joint Working Group on Monitoring.

PROJECT CONTACTS:

MANAGER:	E.D. Ongley	336-4913
PROJECT LIAISON SCIENTIST:	A. El-Shaarawi	336-4584

STUDY LEADERS	PROJECT COMPONENT	TELEPHONE #
A. El-Shaarawi	WQB manual; Niagara R. sampling strategy; workshop proceedings	336-4584
S.R. Esterby	WQB manual	4790
B. Brownlee	Modelling of diurnal oxygen	4783
L. Lau	RIMIX model; river mixing	4897
E.D. Ongley	Mackenzie River study	4913

GREAT LAKES SURVEILLANCE INTERPRETATION

SYNOPSIS:

This project is responsible for the collation, analysis and interpretation of the vast quantity of data generated in the Great Lakes Surveillance Program. Timely and effective analysis is required in order to fulfill Canada's commitments under The Great Lakes Water Quality Agreement. Results from this project include reports on water quality trends and the "health" of the lakes, input for program planning and Agreement review, departmental policy formulation, and interlaboratory quality control studies.

ISSUE AND RATIONALE:

Surveillance activities on the Great Lakes are required under the terms of the U.S./Canada Great Lakes Water Quality Agreement (1978). The activities are shared by various Canadian and U.S. agencies and involve the monitoring of several chemical and physical parameters in order to identify long-term trends in the water quality of the lakes. Results from this monitoring are utilized to report on the health of the lakes, to develop new programs or adjust existing programs for improving Great Lakes' water quality, and as input for reviewing and revising the Water Quality Agreement.

During the course of surveillance work a great deal of information is obtained. It is essential that this data be collated, analysed and interpreted quickly and effectively. Techniques for data handling must be developed and the information processed for timely input into status reports and, ultimately, departmental policy decisions.

PROJECT OBJECTIVES:

1. To interpret research and surveillance information and prepare recommendations on efficient methods of sampling and trend detection.

2. To research lake processes and improve our understanding of the lake's response to management programs.

3. To determine the spatial and temporal distribution of microbial biomass and develop a microbiological water quality index parameter.

4. To conduct interlaboratory quality control studies for labs which contribute data to the IJC under the Great Lakes International Surveillance Plan.

RESEARCH PROGRAM:

1. The research program utilized expertise in limnology, statistics, chemistry, and physics. Great Lakes surveillance data are examined in new ways which reveal whether the original assumptions were correct or whether the surveillance effort can be conducted more efficiently.

2. Additional research is done to understand the response to changes occurring as a result of lake management and this information is used to refine expectations and provide the basis for future management efforts.

3. Remote means of sensing the environment are investigated through physical experiments designed to eventually allow some surveillance of waters by satellites or aerial photography.

4. Special samples of water, fish and sediments are distributed to Great Lakes laboratories for comparison of analytical results and identification of laboratories which may be producing biased data.

CURRENT ACTIVITIES:

1. Data Collection and Program Design

   Evaluate within-laboratory and sampling components of variability in the Great Lakes surveillance data. Continue microbial biomass data collection in conjunction with the IWD-OR in the Great Lakes Basin during surveillance cruises in 1986-87.

2. Interpretation

   Evaluate the associate between chlorophyl *a* and physical and chemical factors in Lake Ontario.

3. Satellite Surveillance

   Evaluate sediment concentration measurements utilizing the Multispectral Optical Monitoring System (MOMS). Delineate temporal changes in areal extent of coastal wetlands in the Point Pelee, Rondeau, and Long Point regions of Lake Erie, utilizing existing airborne and satellite data. Design, procure and establish an operational digital analysis and display system.

4. Interlaboratory Quality Control

   Obtain various fish and sediment reference materials from agencies within the Great Lakes Basin and contract-out analyses of the constituent content of the reference fish and sediments. Prepare, verify and distribute interlaboratory studies on total phosphorous in water, organics in fish, organics in sediment and metals in sediments.

PROJECT CONTACTS:

MANAGER:	J. Barica	336-4785
PROJECT LIAISON SCIENTIST:	M. Charlton	336-4758

STUDY LEADERS	PROJECT COMPONENT	TELEPHONE #
S.S. Rao	Microbiology	336-4924
K. Aspila	Q.C. studies	4638
S.R. Esterby	Statistics	4790
A.H. El-Shaarawi	Statistics	4584

WATER MANAGEMENT and DEVELOPMENT PROJECTS

FLOODING AND ICE

SYNOPSIS:

All river developments affect the ice cover and ice production regime. Expertise and knowledge of ice jams, frazil ice production, and ground ice are essential to adequately address questions relating to energy production, flooding, river flow measurement in winter, and northern development. Specific outputs from the project include the ability to forecast, control and prevent ice jams; to predict effects of ice on river flow; to better understand ice mechanics and ice jam release characteristics; and to improve data collection instrumentation.

ISSUE AND RATIONALE:

Flooding of rivers is a natural, recurring phenomenon which is difficult to predict and control. Open-water flood flows react with the bed to modify resistance to flow. As a result the prediction of flood levels from measurements of river conveyance during normal conditions is quite unreliable. When ice is present the problem is compounded. Navigation improvements or dams which create open water where none existed before can create large quantities of frazil ice with unforeseen results.

The formation of frazil ice may change the available flow areas and alter the stage-discharge relationships. Unstable ice covers may form jams, creating restrictions which lead to flooding. Stable ice covers also alter the flow regime, steepening the river slope relative to open-water slopes for the same discharge.

Once ice jams have occurred there is little known about the best way to release them, and there is no routine way to compute the flood wave levels when an ice jam does let go. The study of floods and control of the damage they cause are major national activities within IWD. Better ways to analyse and compute floods are necessary.

PROJECT OBJECTIVES:

Project objectives are: to develop scientific and engineering knowledge of flow in ice-covered rivers enabling reliable and sound assessments to be made of flood risks and damage, and to improve the prediction of the frequency and severity of ice jams; to develop procedures for the destruction of ice jams once formed or for the prevention of ice jams; to develop better ways to measure winter flows in rivers.

RESEARCH PROGRAM:

This project will concentrate on developing methods, theories, and models to handle all types of river ice problems. Specifically, the research program will include: forecasting, control and prevention of ice jams; prediction of the effects of ice on winter flows; development of a knowledge of river ice mechanics and release of ice jams; and the development of measurement and data collection techniques and instrumentation.

CURRENT ACTIVITIES:

1. Ice Jams and Floods

Theories and models for ice jams and ice break-up will be developed, as well as methods to improve the management of ice-covered rivers to reduce flooding. Additional data to verify theories and models will be obtained from field observations in the Thames and Grand Rivers. A numerical model will be developed to calculate the velocity distribution of a non-prismatic river or channel partially covered by ice.

Field tests to obtain the alogrithm which describes ice sheet strength will be completed. This data is essential to develop a model for ice sheet break-up.

Laboratory tests of methods to release grounded ice jams require a new artificial ice which represents, to scale, all the controlling parameters. Further development of the new modelling material will proceed.

2. Frazil and Anchor Ice

Theories and methods will be developed to predict the effect of frazil ice formation in channel conveyance and on the production of anchor ice, and to predict the distribution of frazil ice concentrations in the flow cross-section. Field data from the Beauharnois Canal and the Lachine Rapids will be used to investigate the effects of frazil concentrations in the conveyance, and to investigate the occurrence and growth of ground ice.

PROJECT CONTACTS:

MANAGER:	T.M. Dick	336-4738
PROJECT LIAISON SCIENTIST:	S. Beltaos	336-4898

STUDY LEADERS	PROJECT COMPONENT	TELEPHONE #
S. Beltaos	Ice jams and floods	336-4898
G. Tsang	Frazil and anchor ice	4622

INTER-BASIN WATER TRANSFER

SYNOPSIS:

Proposals and studies to promote inter-basin transfer of water are now active. Engineering and economic knowledge by the proponents of these proposals is more advanced than current environmental knowledge of the repercussions of such major diversions. Research is thus required to develop expertise, authority and knowledge of environmental effects in order to permit a balanced analysis of proposals.

ISSUE AND RATIONALE:

Canada faces predictable imbalances of water supply and demand in certain areas. On a continental basis, there have been proposals to rearrange the distribution of water to meet perceived developing shortages of water. Water is essential for economic growth. Water shortages directly affect industrial growth and inhibit agricultural development. Some proposals to transfer water could affect the Great Lakes Basin.

In addition to the demographic demands on water, there is also the possibility that climatic change will gradually alter the historical supply. Loss of supply may engender demands for large scale water transfer in order to sustain existing industry and agriculture.

Water shortages are made worse by burgeoning pollution loads which, in addition to restricting free access to clean water, also endangering public confidence in the safety of water supplies. This may, in turn, lead to demands for transfers of "safe water". For example, proposals to bring water to Metro Toronto from Lake Huron have been reported in Ontario.

Problems created by the transfer or recycling of water are very similar in all regions, including the Great Lakes Basin. Water transfers bring change to both the ecosystem and to the socio-economic system. In the latter case, water could become a much more important economic factor to Canadian development.

PROJECT OBJECTIVES:

Because of all the above noted pressures, it is imperative that the environmental repercussions of inter-basin transfers of water (and especially the research required to properly evaluate such schemes) be explored.

Specific objectives include: establishment of the physical, chemical, and biological effects of large scale transfers of water from one watershed to another; and communication to IWD managers and to engineers and planners in Canada the results of the research. This project is at an early stage of development.

RESEARCH PROGRAM:

Certain consequences from diversions can be deduced by application of existing knowledge. However, specific effects from diversions are best evaluated by a systematic study of case histories; an interdisciplinary approach is required.

To examine current knowledge on interbasin water transfers a Symposium on Environmental Repercussions from Inter-basin Transfers of Water will be held. Based on the results of the Symposium, one or two case studies with sufficient data to test models and theories will be identified. Within five years enough data should be available to reach general conclusions and identify the typical results of diversions. In addition to these case studies, general work undertaken on modelling of rivers, will be used.

CURRENT ACTIVITIES:

1. Symposium

   A symposium on "Environmental Repercussions Caused by Inter- basin Transfers of Water" will be organized.

2. Subaqueous Erosion in the Great Lakes

   Geologic characteristics which control evolution of the Great Lakes shores will be established. Parameters significant to mathematical modelling will be identified. Subaqueous erosion will be compared to local wave climates, to sort, type, and to bottom roughness. Methods to measure erodibility for both remoulded and undisturbed samples will be developed.

3. Shore Reactions

   Methods to predict the effect of water load on the shores of lakes and reservoirs, especially where mean levels are changed by diversion, will be developed. Wave prediction procedures, based on recent developments, will be refined and put into operation to obtain wave climate data at specific sites. Existing shoreline models will be tested and verified against field data.

4. Mobile Boundary River Flows

Improved theories on the transport of water and sediments in alluvial rivers will be developed so as to predict the response of rivers to dams and diversions. A report on the conveyance or rugosity of alluvial channels will be completed. Experiments on the response time of sand waves to unsteady flow and on the shear stress critical to bed movement will be carried out. In addition, experiments on meandering flows will continue.

PROJECT CONTACTS:

MANAGER:	T.M. Dick	336-4738
PROJECT LIAISON SCIENTIST:	Y.L. Lau	336-4897

STUDY LEADERS	PROJECT COMPONENT	TELEPHONE #
J.P. Coakley	Subaqueous environments	336-4881
Y.L. Lau	Mobile & boundary flows	4897
M.G. Skafel	Shore restorations	4736

WATER RESOURCES MODELLING

SYNOPSIS:

Management of water resources in all its aspects requires knowledge and understanding of how water behaves and interacts with the land and air. Environmental assessments are incomplete without comprehension of physical behaviour. The ability to predict the effects of man-made or natural changes affecting water resources is essential to sound management decisions. This project is aimed at developing models to enable such predictions.

ISSUE AND RATIONALE:

Water is dynamic. It is continually moving and changing its form, appearing as gas, liquid or solid. Water resource management deals with water as a liquid and sometimes as ice. Understanding the dynamics of water and the reactions with its interfaces, either air or sediment, is necessary to ensure successful development or to avoid or mitigate environmental problems.

Water and ice transport other substances in a dissolved or suspended form. In lakes and reservoirs, nutrients, pollutants and suspended sediment from erosion are dispersed throughout the body of water. In rivers and reservoirs, pollutants, nutrients and sediments are conveyed in suspension or by movement near the bed.

Water reacts with its boundaries. The air-water boundary transmits energy to create motion, or to receive or loose mass and radiant energy. The mobile boundaries react by accreting, by eroding or changing form to resist water movement.

Increased environmental concerns and the high costs of water resource developments demand much better planning. Planning requires prediction of effects from proposed water projects. Reliable predictions require models with firm scientific foundations.

PROJECT OBJECTIVES:

1. To produce theories, methods and models in the short and long term to permit reliable analysis and prediction of the physical effects relating to natural changes or man made interventions in rivers or lakes.

2. To develop expertise and knowledge in selected areas and communicate new scientific findings developed at NWRI and elsewhere to managers and engineers in DOE and Canada.

RESEARCH PROGRAM:

There are three main thrusts to river studies in this project:

1. To describe the physical processes of dispersion and mixing in the river mass itself, including unsteady state situations, using the computer model, RIVMIX.

2. To describe river bed roughness in relation to flow and to develop a model for overbank flow.

3. To predict the transport of sediments, the meandering of rivers and the factors controlling river behaviour, plan form, and breadth, using the MOBED computer model.

Lake Program

There are three thrusts to lake studies in this project:

1. To describe and predict the forces on the surface of the water caused by the wind, including prediction of wave frequency and height.

2. To determine vertical mixing of the water body caused by waves and wind which affects or controls evaporation and the transfer and transport of gases, nutrients and pollutants.

3. To determine the lake bed reactions caused by waves and currents which erode, resuspend and redistribute sediments. Resuspension is an important factor in the movement and availability of contaminants.

CURRENT ACTIVITIES:

Water and Sediment Transport

The successful and reliable MOBED model was developed for one dimension. This study will expand the model to two dimensions which will therefore enable it to predict lateral channel movement. A report on sampling strategies for bed load measurement will also be completed.

Air-Water Interactions

An analysis of wave orbital velocities and the surface turbulence will be completed to obtain a statistical distribution of velocities and pressures. The results are directly useful for any calculations related to marine structures. Further field measurements of wave dissipation and pressures at the interface will be undertaken from the experimental wave tower. A new parametric wave prediction model will be developed for shallow waters. Such models are a necessary first step for studies on resuspension and transport of wave driven suspensions.

Blowout of Subaqueous Oil Wells

Experiments to develop and test a theory or model for the behaviour of a buoyant plume of oil and gas will be carried out.

PROJECT CONTACTS:

MANAGER:	T.M. Dick	336-4738
PROJECT LIAISON SCIENTIST:	B. Krishnappan	336-4766

STUDY LEADERS	PROJECT COMPONENT	TELEPHONE #
G. Tsang	Gas oil plumes	336-4622
B.G. Krishnappan	Water and sediment flow	4766
M.A. Donelan	Air/water interactions	4879

SMALL-LAKE RESTORATION (MACROPHYTES)

SYNOPSIS:

The aim of this project is to develop expertise in small lake restoration techniques, other than on-shore loading reduction, and to examine areas or topics of concern related to eutrophication for which on-shore reductions have not brought about the desired progress.

ISSUE AND RATIONALE:

Small lakes and embayments often require additional restoration measures after nutrient and/or contaminant loading reductions. Shortages of water in western Canada frequently result in the need for restoration techniques such as aeration, dredging, lime addition, and mechanical and chemical weed control to maintain water quality. Several provincial agencies have adopted restoration methodologies developed by NWRI and continue to rely on institute expertise to recommend management options for specific small lake problems.

The need for research on the impact and efficacy of restoration techniques is evident in the uncertainty relating to the rehabilitation of Hamilton Harbour. Dredging of the contaminated sediments to improve water quality has been advanced as a management option, but the dredged material is so contaminated that it must be treated as a hazardous waste. Anoxia in the hypolimnion of the harbour is one of the major limiting factors for a successful warm water fishery and yet according to computer modelling of all relevant processes, shore-based actions can only improve hypolimnetic oxygen conditions to a small extent.

Federal expertise on small lake restoration techniques resides at NWRI. The Institute reacts to provincial and industrial requests for assistance in addition to contributing to restoration efforts in federal waterways such as the Trent-Severn-Rideau corridor and the harbours of the Great Lakes. Research is undertaken to solve specific problems and to keep abreast of technological advances.

PROJECT OBJECTIVES:

To contribute to the restoration of Canada's lakes and harbours by: assessing the impact and efficacy of aquatic plant control technologies; developing expertise in long-term aquatic plant management; assessing lime addition as an in-lake nutrient reduction technology and winter aeration/destratification as an aid to fishery management in small prairie lakes; and providing advice to federal and provincial departments and the private sector on lake restoration techniques.

CURRENT ACTIVITIES:

1. Aquatic Plant Control

Laboratory bioassays will attempt to determine if the sediments from 25 sites in Lake Scugog and the surrounding Trent Canal lakes are inhibitory. Sediment characteristics will be examined for possible relationships with growth. The geographical extent of the moth larva found feeding on milfoil will be determined. An assessment of feeding damage will help in estimating the potential for biocontrol.

2. Lime Addition Assessment

Cooperate with the University of Alberta and the Alberta Ministry of Environment in a lake restoration project which involves lime addition for nutrient control and winter aeration for destratification and fishery management.

3. Lake Trout Habitat Destruction

Determine the habitat parameters which appear to characterize successful lake trout spawning sites; determine factors which appear to have degraded historic sites of lake trout spawning; and determine habitat characteristics which may influence parts of the food-web structure upon which lake trout are dependent.

PROJECT CONTACTS:

MANAGER:	J. Barica	336-4785
PROJECT LIAISON SCIENTIST:	S. Painter	336-4789

STUDY LEADERS	PROJECT COMPONENT	TELEPHONE #
S. Painter	Macrophytes - control	336-4789
T. Murphy	Lake restoration - dredging, aeration, liming	4602
P.G. Sly	Lake trout habitat	4625

AQUATIC EFFECTS OF CLIMATE CHANGE

SYNOPSIS:

This project examines the effect of climate on the water quality responses of Canadian Lakes. Analyses are conducted for a climatological time frame on Lake Erie and Lake Ontario in the Great Lakes region. Biological proxy data is used to reconstruct paleoclimatic conditions for selected Canadian Prairie lakes, as well as to examine the relationship between climate and water quality of these lakes though time.

ISSUE AND RATIONALE:

Climatic variations of the surface energy balance and the lake thermal structure can substantially alter nutrient fluxes, oxygen conditions, primary production and chemical budgets of large water bodies such as the Great Lakes. Combining longterm series of hydrometeorological data with heat balance models and thermodynamic computations may lead to accurate predictions of these climate-lake responses.

Large water bodies such as Lake Erie and Lake Ontario influence the surrounding land mass by moderating temperature and precipitation. Accurate specification of the energy balance of such large lakes with improved formulation of mechanisms at the air water interface may improve the physical basis for regional climate models.

One of the major objectives of the Canadian Climate Program is to develop a coupled atmosphere ocean circulation model for climatic time scales. Development and verification of the air-water exchange component of the model is handicapped by deficiency of oceanic data but can be accomplished by recourse to the extensive data base available for the Great Lakes.

Prairie regions have been susceptible to drought conditions which has implications to the viability of agriculture. Paleoclimatic analysis provides an insight into the history of climatic variability in the region and the consequent water quality changes. The study has potential to improve the predictive capabilities in hydrometeorology and agrometeorology of the Prairie region.

PROJECT OBJECTIVES:

The objectives of the NWRI Climate Change Program are to model the climate-induced variations of air-water exchanges, thermal structure and climate-water quality responses of natural water bodies and to evaluate the relationship between climate, water quality and lake ecology using proxy data.

CURRENT ACTIVITIES:

Great Lakes

1. Development of a climatological (30 year) data base of hydrometeorological and limnological parameters for the Lake Erie and Lake Ontario (1950-1983).

2. Development of an improved lake heat balance model and establishment of long-term heat storage budgets.

3. Computer simulation of lake surface water temperatures.

4. Establishment of baseline statistics for the overall thermal stratification cycle in response to weather variations.

5. Simulation of longterm water quality responses to weather.

Prairies

To evaluate the relationship between climate and water quality using biological proxy data.

1. To characterize fossil benthic shelled invertebrates found in shallow lakes.

2. To interpret chemical, physical and climatic variables for these shallow lakes by means of fossil benthic shelled invertebrates.

3. To evaluate the general use of shelled invertebrates as paleolimnological and paleoclimatic indicators.

PROJECT CONTACTS:

MANAGER:	J. Barica	336-4785
PROJECT LIAISON SCIENTIST:	B. Schertzer	336-4915

STUDY LEADERS	PROJECT COMPONENT	TELEPHONE #
D. Delorme	Paleoclimatology, paleolimnology	336-4788
W.M. Schertzer	Air sea interaction, energy balance of lakes, water quality monitoring	4915

REQUESTED HYDRAULICS STUDIES

SYNOPSIS:

Research expertise can address specific problems efficiently and quickly. Water managers obtain direct response from the research team to resolve technical problems either through advice, technical analysis, or experimentation and modelling. Managers outside the Inland Waters Directorate are included.

ISSUE AND RATIONALE:

Water managers who have identified specific problems do not always have the expertise or the equipment to resolve them. Response to direct requests fulfills two needs. The first is that the particular problem at hand is addressed efficiently and effectively. The second is that the scientific staff are made aware of developing practical problems and, consequently, the design of the research programs will more likely address recurring problems.

Because the projects are client-oriented they are unrelated to one another. However, projects to solve particular problems also provide a door for other research results which may be of interest to the client.

On a broader front there are occasionally demands from industry which are not closely related to IWD concerns. Where NWRI can respond by making equipment available it does so. All direct requests from outside IWD are cost recovered, either in full or in part, in accord with the Cost Recovery Policy.

PROJECT OBJECTIVES:

To respond to client requests consistent with longer term strategic research.

To develop policies and programs to increase the use of laboratories where equipment installed is not readily available elsewhere, particularly in the private sector.

To communicate research results to clients and to Canadian water managers where the subject matter warrants.

RESEARCH PROGRAM:

With direct requests there is no program as such. There is, however, a policy of responding positively wherever possible to direct requests for specific assistance. For clients outside the DOE there is full or partial cost recovery.

There is a long-standing NWRI agreement with Small Craft Harbours Branch of F&O to provide expert hydraulics and hydrology advice and, on occasion, to undertake physical model analysis for new developments. There are also long term client relationships with the Water Survey of Canada and Quebec Hydro to calibrate and test current meters in the Hydraulics Laboratory.

CURRENT ACTIVITIES:

PILP and Consulting

To identify potentially marketable NWRI instruments to the PILP program, three studies with the private sector are underway:

a) With MONITEQ to complete field tests of a new Multiband Transmissometer.
b) With QUESTA Design and Engineering, to provide advice for the construction of a commercial prototype of an optically-triggered, lightweight core sampler.
c) With METREX Instruments, to evaluate a prototype Solid State Temperature Logger.

Mathematical Modelling of the St. Mary's River

A new model to predict the impact of dredging on the flow and sediment depositional patterns in the St. Mary's River system, as requested by the Water Resources Branch, Ontario, will be developed.

River Flow Measurement Alternatives

To evaluate alternative systems of discharge measurement and to devise solutions where conventional techniques are unsatisfactory, a working laboratory model for a magnetic flow- measuring device will be tested. That and other weir solutions will be examined with respect to the Milk River flow measurement at the Eastern Crossing.

Waterford River Basin

A final report will be completed on the impacts of urbanization on water quality and quantity in the basin and installation of the hydrologic model will proceed. IWD Atlantic will provide data to set up and verify the model.

Applied Shore Studies

Laboratory tests to obtain reliable estimates for wave and current forces on submerged pipelines will be completed and a report provided to the energy program and clients. The effects on the shore of the developments at Goderich Harbour will be monitored and assessed, with the results going to DPW and EPS.

Frazil Ice Recorder

A prototype instrument to monitor frazil ice concentrations in rivers over long time periods is completed and should be installed in the Nashwak River, N.B., in response to a request of the Government of New Brunswick and the Atlantic Region, IWD.

Future Great Lakes Water Levels

In an attempt to summarize present knowledge on Great Lakes Water Levels over the next 5 to 50 years, contacts will be made with various authorities and existing literature and reports will be reviewed and reported.

Evaluation of Water Level Measuring Instrumentation

To establish performance and limitations of data acquisition equipment used for water quantity monitoring, tests will be undertaken on DCP's, pressure transducers, float type water level recorders, gas bubble type water level recorder, STACOM, and Winnipeg pressure-type water level recorders.

PROJECT CONTACTS:

MANAGER:	T.M. Dick	336-4738
PROJECT LIAISON SCIENTIST:	M.G. Skafel	336-4736

STUDY LEADERS	PROJECT COMPONENT	TELEPHONE #
Y.L. Lau	Technology Transfer	336-4897
B.G. Krishnappan	St. Mary's River	4766
P. Engel/Y.L. Lau	Milk River, Alberta	4737
P. Engel	Meter Rotor Development	4737
J. Marsalek	Waterford River Basin	4899
M.G. Skafel	Applied Shore Studies (pipeline forces)	4736
J. Ford	Frazil Ice Recorder	4890
C. Bishop	Future Great Lakes Water Levels	4886
P. Engel	Water Level Instrumentation	4737