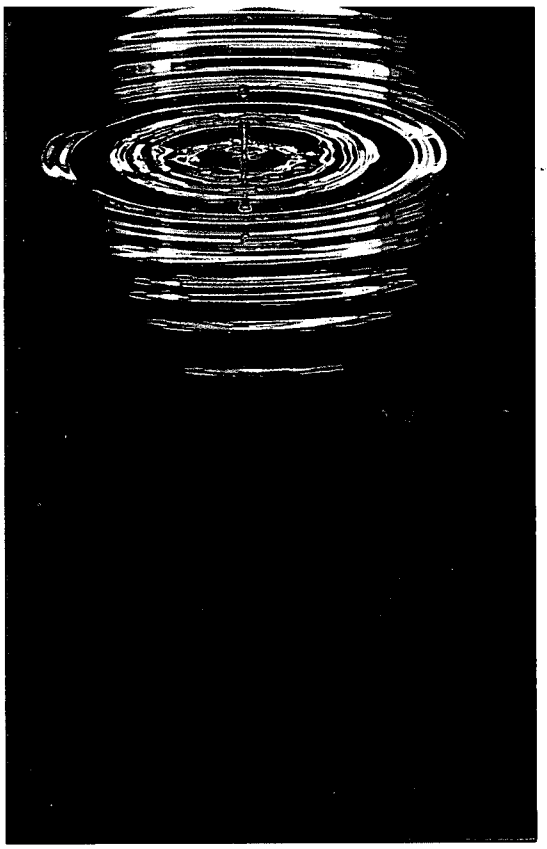

NATIONAL WATER RESEARCH INSTITUTE

Current Research'88

Environment Canada Environnement Canada

CURRENT RESEARCH '88

A SYNOPSIS OF THE 1987-1988 RESEARCH PROGRAM AT THE NATIONAL WATER RESEARCH INSTITUTE

National Water Research Institute
Inland Waters Directorate
Environment Canada

Publication disponible en français sur demande

Detailed information on the research projects at NWRI is available from the Research Branches or the Science Liaison Division. "Reflections 1987-1988", the Executive Director's annual report to the public, and the "NWRI Digest", a quarterly newsletter on the activities of the Institute, are also available upon request. Please contact:

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INTRODUCTION

D. L. Egar
Executive Director
National Water Research Institute

It is with great pleasure that I introduce CURRENT RESEARCH '88, a synopsis of the research activities and publications of the National Water Research Institute (NWRI) during 1987-1988. I hope it will provide our colleagues in the Canadian and international water research communities with a useful overview of our progress in the past year.

Our continuing goal at NWRI is to demonstrate leadership in developing the scientific knowledge and expertise required by Environment Canada to resolve the many important water management issues facing Canada. At present our research strategy emphasizes investigations into the critical ecosystem interactions which control the fate and effects of pollutants, improved understanding of the dynamics of important regional ecosystems, and the development of better aquatic assessment and prediction methodologies.

Research at NWRI is conducted within multidisciplinary project groups, thirteen in total, each of which addresses the science dimension of an emerging or priority water issue. This is our second year of operation within a project-based structure. I believe it has been a successful one of consolidation and reorientation to take better advantage of new working relationships and new opportunities.

In the following pages, Project Chiefs from the three Research Branches summarize the objectives and highlights of their research teams. A comprehensive listing of staff publications is also provided. Their reports are necessarily brief, but I believe they clearly show that the Institute's talented scientists, technicians and support staff are committed to the creation of new knowledge of scientific merit and practical importance.

There is expanding recognition in Canada that the world must quickly adopt a broad philosophy of sustainable development if we are to resolve emerging environmental problems, yet relieve the great poverty that is deepening around the globe. Water is one of the principal pathways by which environmental threats, such as acid rain, climatic change and toxic chemical contamination, impact on society. At the same time, adequate freshwater resources are a key factor in sustainable economic development. Effective water management is thus critical if we are to resolve what the World Commission on Environment and Development has recently termed the "paradox of planetary peril and conditioned hope". Better management can only come with a better scientific knowledge base and we at NWRI look forward to contributing constructively to this common effort.

LAKES RESEARCH BRANCH

R. J. Allan, Director

The Lakes Research Branch conducts applied research to provide effective management options for the conservation and protection of Canada's freshwater lakes. The research program encompasses natural lakes and man-made impoundments throughout Canada as well as the large, freshwater-dominated, upper estuaries of major rivers, particularly the St. Lawrence and Fraser rivers. Although emphasis is on the Laurentian Great Lakes, study sites are located throughout the country.

Research is conducted into important limnological processes and the chemical, biological and physical factors that affect their rates. Emphasis is placed on the sources, fate and effects of pollutants, particularly toxic organic chemicals, as well as on metals, radionuclides and nutrients. The influence of lake trophic state on toxic chemical fate and effects is a major area of interest because of the potential need to integrate existing nutrient control programs with plans to control both future toxic chemical loadings and the effects of previous releases. An important general goal is to quantify the transfer of materials (toxic chemicals, nutrients, sediments, gases) across limnological interfaces such as sediments and water, air and water, and nearshore and offshore water masses. Investigation of the potential for modifying these transfer processes, and their effects, through *in situ* treatment, is also a high priority. Some of the processes being investigated and modelled include:

- assessment of long-term water quality trends;
- external and internal loadings of pollutants;
- sources, transport and movements of water masses and their associated particulate loads;
- partitioning of pollutants between media in the water column;
- partitioning of pollutants between the water and the atmosphere;
- burial of contaminants in bottom sediments;
- sedimentation versus resuspension rates;
- biological mixing of sediments;
- degradation and biological uptake of pollutants;
- food chain transfer by benthic organisms of sediment-associated pollutants;
- evaluation of ecosystem health;
- rehabilitation potential of lakes and reservoirs;
- in-lake restoration methods;
- manipulation of aquatic food chains.

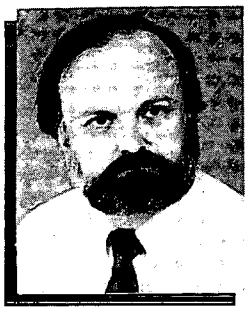
Also included are ecotoxicological assessments of pollutant effects, using techniques such as bioassays, and prediction of pollutant effects by techniques such as quantitative structure activity relationships (QSAR). Comparisons between real and model ecosystem impacts are an important aspect of this activity.

The research studies in the Lakes Research Branch are organized into five multidisciplinary projects: **Nutrient/Contaminant Interactions; Sediment/Water Interactions; Air/Water Interactions; Lakes Restoration** and **Nearshore/Offshore Interactions.**

Our research results are used by national and provincial water management agencies in Canada and by national agencies in other countries involved with water quality protection and conservation. In the Great Lakes, part of the effort from the Branch supports the research and technology transfer needed to develop remedial action plans for the 17 Canadian Areas of Concern. These programs help to fulfill Canada's obligations under the Great Lakes Water Quality Agreement (GLWQA) between Canada and the United States.

NUTRIENT/CONTAMINANT INTERACTIONS PROJECT

J.H. Carey, Project Chief



Introduction

Research and management of the eutrophication issue and the contaminants issue have historically been undertaken separately. Contaminant research has largely focused on environmental pathways of specific chemicals, whereas eutrophication research has focused on the relationship between nutrient inputs and biological productivity as mediated by physical processes. Although the management of both issues is largely based on setting "objectives", nutrient objectives seldom consider the presence of persistent contaminants, while contaminant objectives rarely, if ever, consider the trophic state of the system.

The rationale for the Nutrient/Contaminant Interactions Project is that contaminant dynamics and effects in aquatic systems are directly influenced by trophic state of the system. Therefore, the eutrophication and contaminants issues should not be considered separately. The objective of the project is to characterize and eventually to quantify the critical processes controlling the interaction of nutrients and contaminants in lakes. Although much of the knowledge will be applicable to many lakes, the major focus is on the Great Lakes, where nutrient control programs currently in place could serve unintentionally to increase contaminant concentrations in fish and other biota. A multidisciplinary approach is being employed to examine the general hypothesis that nutrients interact with contaminants by influencing four processes: bioaccumulation, degradation, sedimentation and transport. To avoid the influence of multiple point sources and to provide a wide range in water chemistry, much of the work is being conducted in a series of headwater lakes (within the Great Lakes basin) differing in limnology and receiving only atmospheric inputs of contaminants.

Research Highlights

- Contaminant analyses were completed on zooplankton samples obtained at 28 headwater lakes in eastern Ontario and the results examined for correlations with limnological or water chemistry parameters. An inverse relationship was discovered between the productivity of the lake, as indicated by spring total phosphorus, and the total polychlorinated biphenyl (PCB) concentration in the zooplankton (Figure 1). If applicable, such a relationship will have significant implications for the Great Lakes toxics and eutrophication programs.

- The effect of nutrients on contaminant biodegradation (pentachlorophenol) was investigated in a set of microcosms to which nutrients at different concentrations were continuously supplied. Prior to the addition of the pentachlorophenol (PCP), most of the nutrients were incorporated into the algal fraction. Upon addition, the PCP, which is toxic to algae, caused an immediate reduction in primary productivity. The resulting nutrient release from the dead algae caused an increase in bacterial numbers and a resulting enhanced degradation of PCP.

- There is increasing evidence regarding the importance of reductive processes in the degradation of contaminants. Since eutrophic systems are more prone to anoxia, it follows that reductive processes will be more important in eutrophic systems. A study was conducted on the reductive dehalogenation of organochlorine compounds with reduced hematin, an appropriate model reaction. Differences between the reactivity of aliphatic and aromatic organochlorines were observed. These results suggest that hematin is likely important for the dehalogenation of aliphatic, but not for aromatic organochlorines.

● A collaborative study on the photolytic production of hydrogen peroxide from naturally occurring dissolved organic matter was begun. Considerable site-to-site variation was found in production rates and steady state concentrations of peroxide. Hence, the rates of contaminant degradation via this route are liable to be variable.

● Sedimentation and sediment transport are important factors influencing the fate and distribution of persistent contaminants in lakes and require further study. At present there is no reliable method for integrating sediment fluxes in high current environments characteristic of shallow lakes. Work was begun on the development of a low-cost sediment trap capable of functioning under these conditions. A preliminary design is being evaluated to determine the influence of currents on catch efficiency.

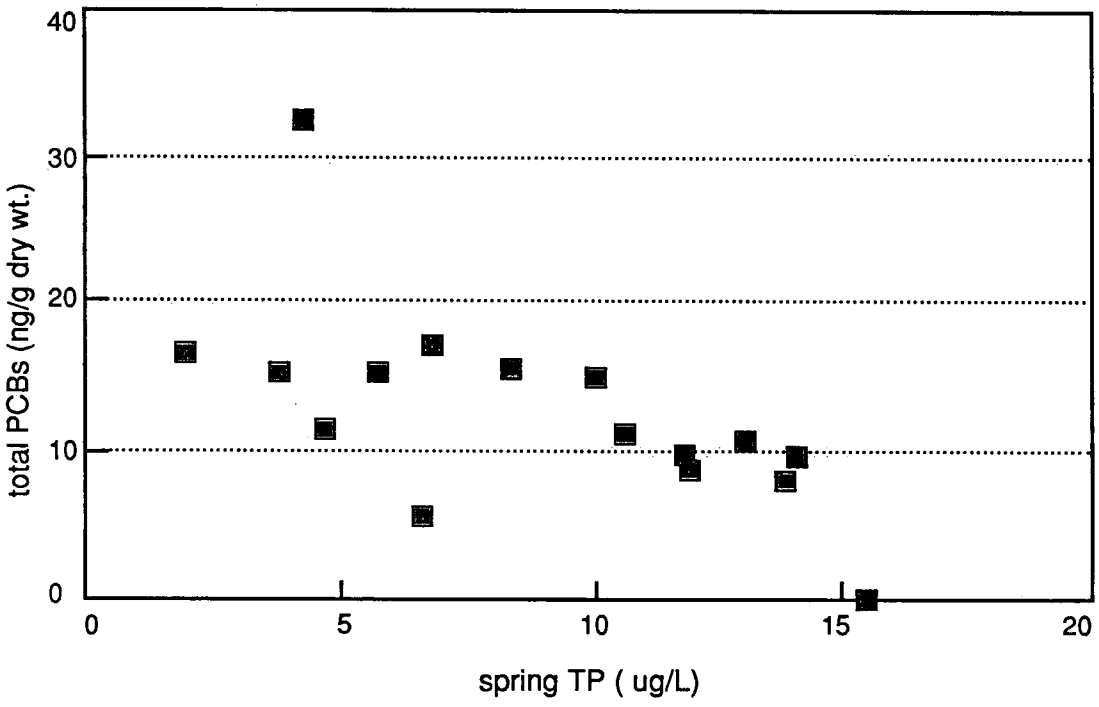
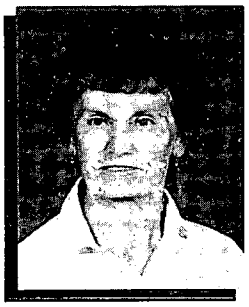


Figure 1. Relationship between spring total phosphorus and zooplankton total PCB concentrations in 28 lakes in Eastern Ontario.

SEDIMENT/WATER INTERACTIONS PROJECT

A. Mudroch, Project Chief



Introduction

Most persistent hydrophobic and toxic organics, metals, radionuclides, and nutrient contaminants are associated with bottom sediments in aquatic environments. Consequently, sediments can serve as an *in situ* source of pollutants which can be recycled into the water column and its food webs. A prerequisite for the development of remedial measures for toxic contaminants in lakes and rivers is an understanding of sediment quality, particularly the quantification of biological and physico-chemical processes affecting the release and availability of sediment-associated contaminants. These pathways and processes are still poorly understood, as are their rates, controlling factors and relative degree of importance.

The objective of the project is to develop sufficient information on the biological, geochemical and sedimentological processes which define the pathways, availability and release of sediment-associated contaminants (Figure 2) in order to propose effective rehabilitation measures for aquatic ecosystems containing polluted sediments, particularly for the Areas of Concern in the Great Lakes.

Research Highlights

- The role of oligochaetes in contaminant mobilization was investigated using three C^{14}-labelled organic compounds: DDE, HCB and PCB (congener 153). Equilibration time was relatively rapid and varied from 6 to 16 days to attain 90 percent of maximum accumulation.

- The potential for terrestrial plants to mobilize contaminants from polluted sediments in confined disposal facilities was studied. Initial analysis has revealed significant differences between plant species commonly found in such facilities.

- The dynamics of fine-grained sediments were studied using artificial tracers at the mouth of the Humber River, Ontario. Silt-sized sediments were initially deposited near the mouth, but physical processes in the lake transported these materials along the western shore of Humber Bay and then into the profoundal zone of Lake Ontario.

- Geotechnical testing of sediment cores in Lake Erie was undertaken to assess the relative intensities of sediment settling, resuspension and transport. Data from the western and eastern basins indicated intensive resuspension and transport while the central basin core showed a history of continuous and regular deposition.

- Resuspension and sedimentation studies in Lake Erie demonstrated that sedimentation was ten times higher in winter than in summer. In addition, sediments collected in sediment traps were richer in PCBs during winter than in summer. The source of these sediments may be the Western Basin.

- The response of Lake St. Clair, a shallow riverine system, to the possible cessation of heavy metal input was examined using mercury as the trend indicator. Concentrations, although decreasing in the upper surface sediments between 1974 and 1985, still indicate continuing inputs of mercury to the lake. Coarse-grained sediments in the upstream river were identified as the probable source of contamination.

- Research continued on the compositional pattern of PAH (polyaromatic hydrocarbon) components in water, sediment and suspended sediments in many locations

across Canada (e.g., the Mackenzie, St. Lawrence and St. Marys rivers, Thunder Bay and Hamilton Harbour). Composition was highly variable and dependent on the site and the nature of the sources.

- Research on the pathways of radionuclide distribution was undertaken adjacent to a radioactive waste management site. Migration of uranium and radium in groundwater entering Lake Ontario was confirmed. Various rainfall samples and receiving environments were also examined following the Chernobyl incident. Four phases of Chernobyl radionuclide deposition reached Canada via westerly and northerly winds.

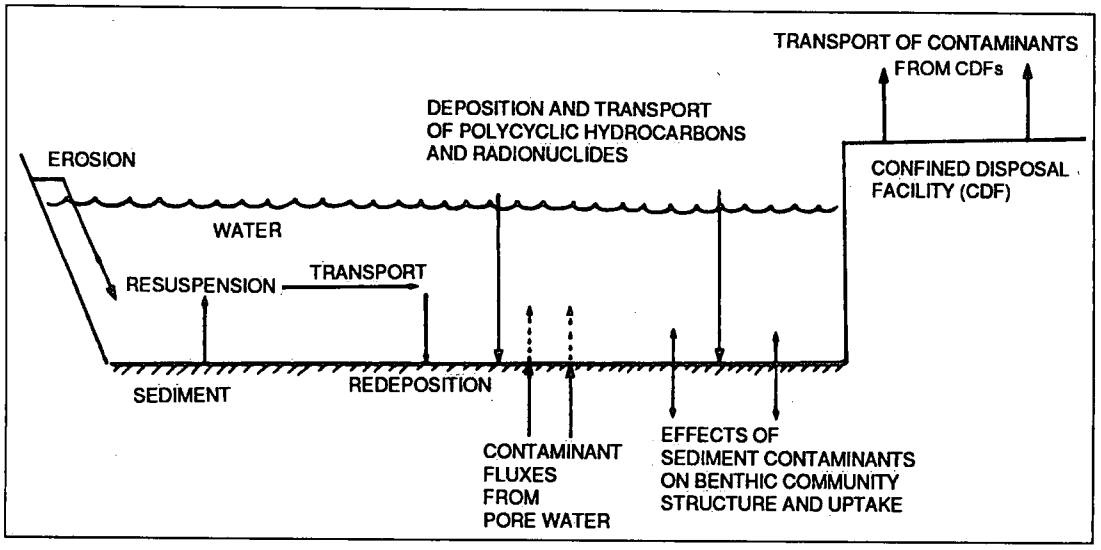
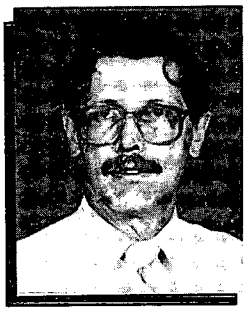


Figure 2. Processes studied within the Sediment/Water Interactions Project.

AIR/WATER INTERACTIONS PROJECT

W.M.J. Strachan, Project Chief



Introduction

Widespread pollution of surface waters occurs in areas of Canada without known point sources for the contaminants involved. Deposition from the atmosphere of many of the same compounds has been established as a major route for the contamination of the Great Lakes and has been highlighted by the Canada-U.S. International Joint Commission (IJC). There is also evidence that an unknown fraction of the contaminants once deposited is revolatilized into the atmosphere. Hence, there is considerable scientific uncertainty over the amount and significance of the net input (or loss) of such substances from the atmosphere to the water.

One of the major goals of this project is to estimate the transfer of toxic chemicals between the atmosphere and the aquatic environment. To do so, concentrations of the chemicals in a variety of land, air and water subcompartments as well as the coefficients for the interface processes are both needed. The former requires extensive data obtained by ongoing monitoring efforts, analysis of samples and field research. The latter, on the other hand, requires complex laboratory experimentation. To date, monitoring has focused on the biota of aquatic systems and has not addressed the question of contaminant concentrations in the basic environmental compartments (sediments, suspended solids, dissolved airborne particulates, vapour state and rain/snow). Laboratory determination of transfer coefficients has only just begun.

The second aspect of air/water interactions addressed by this project is climate change. Climatic fluctuations have had considerable impact on water quality in Canada. Variations in incident energy can substantially alter the structure of lakes and indirectly affect nutrient fluxes, oxygen conditions, chemical budgets and biological productivity. Modelling the effects of energy-budget changes in the recent past on various limnological processes may provide a basis for predicting long-term effects on water quality. Climate change will alter the exchange of materials between the atmosphere and lake surfaces and it is important to quantify the scale of this response.

Research Highlights

- Easily measurable concentrations of organochlorine pesticides, PCBs, chlorobenzenes and PAHs were observed in rain samples collected across southern Canada (Figure 3). Most concentrations were in the parts per trillion range or lower.

- A prototype, all-weather sampler was developed and tested during rain and snowfall events. Through the use of exchange resins, the sampler can isolate samples for organic and inorganic substances, and for metals in wetfall precipitation.

- The use of the bog plant *Sphagnum fuscum* to assess the transport and deposition of arsenic, selenium and cadmium, was evaluated at 37 sites across Canada. Elevated concentrations were observed near major mining and refinery sites (e.g., Flin Flon, Manitoba; Atikokan, Ontario; and Rouyn-Noranda, Quebec). The data base for arsenic was extensive enough to calculate an average background level in the moss of 0.66 mg/kg for areas not affected by these point sources. Near smelters, maximum values up to 31.0 mg/kg were measured.

- The radiological risk for fish and benthic organisms living in or near sediments contaminated with radionuclides was

evaluated. The dose rates at the sediment/water interface were assessed and internal dose rates for biota of different sizes and locations relative to the sediment were calculated. Fish living near the sediment off the Gunnar Mine on Lake Athabasca can receive up to 100 milli-Grays/y (background exposure, 1 mGy/y).

- The transport and fate of radionuclides in Niagara Falls water was investigated. Most radionuclides were transported in suspended sediments which accumulate in the waters off the Niagara bar of Lake Ontario, but a significant fraction was observed in the foam accumulating below the Falls.

- Engineering design and partial construction of a wind-wave flume to measure mass transfer coefficients of volatile organic contaminants were accomplished. The flume will be completely sealed so that water and air concentrations of contaminants can be separately measured and related to wind speed and wave conditions.

- A paleoenvironmental model which relates ostracode species composition in lake sediment cores to climate conditions was refined with the addition of lead-210 dates from three cores in Saskatchewan lakes. The date of influx of Russian thistle pollen found in these cores was also established.

- Evaporation over the lower Great Lakes was reevaluated using a variation of the mass transfer approach in which evaporation is modelled as a function of wind speed and vapour pressure difference between the lake surface and overlying air. The procedure compares favourably with other methods.

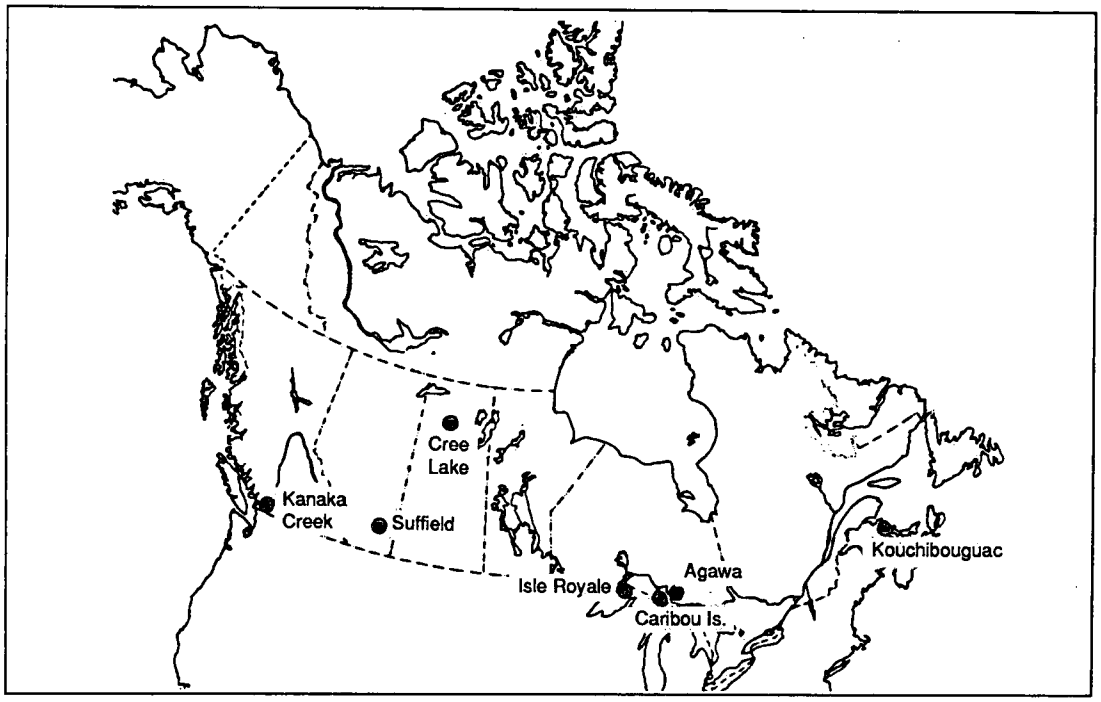
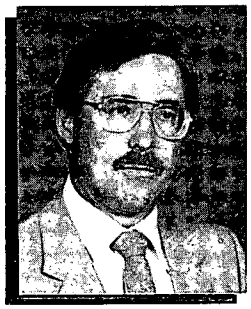


Figure 3. Toxic rain research sampling sites in Canada.

LAKES RESTORATION PROJECT

M.N. Charlton, Project Chief



Introduction

Lakes, reservoirs and embayments in large water bodies do not always respond adequately to pollution controls implemented to attain specific water quality objectives. Such situations can be caused by the presence of contaminated sediments or by continuing input of pollutants from uncontrollable diffuse sources in the drainage basin or from the atmosphere. Other problems for water use can be the invasion of aquatic weeds, siltation and oxygen depletion.

Effective management of such water bodies may require basin-wide land use controls, which can take many years to implement, or they can be tackled directly by *in situ* treatment. The long-term goal of this project is to identify critical geochemical processes that can be manipulated so that *in situ* remedial technologies for the practical restoration of lakes and reservoirs can be devised, evaluated and implemented. Particular emphasis is currently placed on Areas of Concern in the Great Lakes, especially Hamilton Harbour (Figure 4), but several studies are ongoing in western Canada and in smaller lakes in Ontario.

Research Highlights

- Oxygen concentrations and consumption rates in Hamilton Harbour were examined from historical data and were found to be similar to those of today. The rates, however, were 2 to 8 times greater than that required to explain current annual decreases in oxygen. The influx of cool oxygenated water from Lake Ontario may be compensating for the high depletion rates. Incursions of Lake Ontario water into the harbour were documented using instrumentation designed at NWRI for profiling oxygen, conductivity, pH, turbidity and temperature.

- A pilot-scale injection of pure oxygen was conducted in the shallow west end of Hamilton Harbour. The efficiency of oxygen dissolution approached 90 percent for certain equipment configurations. Thus, economical applications of the technique seem feasible.

- Hamilton Harbour suspended sediments were obtained by sediment traps and continuous flow centrifugation for analysis of iron composition. Of the four iron compounds detected, two were naturally occurring forms (Fe^{2+} in chlorite clay and Fe^{3+} in amorphous iron oxides), and two forms were associated with the steel industries (hematite and wustite). The latter two were identified in plumes of Hamilton Harbour outlet water, 0.5 km offshore in Lake Ontario. The sediment trap data confirmed that significant resuspension occurred even in the deepest water of the harbour.

- The distribution of sediment toxicity in Hamilton Harbour was assessed using the *Daphnia magna* bioassay. Highest toxicity was observed in areas nearest the steel industries.

- The sedimentology of Hamilton Harbour was mapped taking into account grab samples, cores and echo sounding transects. Sedimentation since the beginning of industrialization has averaged (3-4 mm/y) at depths greater than 5 m. This is twice the rate suggested in earlier studies.

- The relationship between suspended solids and water clarity was investigated in Cootes Paradise at the west end of Hamilton Harbour. Eighty percent of the suspended solids were mineral silt. At the usual concentrations of 100 mg/L, this resulted in Secchi depths of 20 cm, indicating light penetration too shallow to permit the development of emergent aquatic plants.

● Data confirmed that the lime treatment of Figure Eight Lake in Alberta (to reduce water-column concentrations and sediment releases of phosphorus) was successful. Total phosphorous concentrations were reduced by 50 percent, and significant reductions occurred in summer chlorophyll levels and oxygen depletion rates under ice during winter. Macrophytes were also reduced. Iron analyses by Mossbauer spectrometry indicated that FeS_2 precipitation was inhibited in the past by the presence of copper sulphate, used previously as a remedial technique to control algae.

● An innovative apparatus for differentiating between P released from sediments and from freshly deposited materials was used to assess internal loading at several sites in the Bay of Quinte, Ontario. Rates of P release were as high as 9.3 mg P/m²/d even in well-oxygenated conditions.

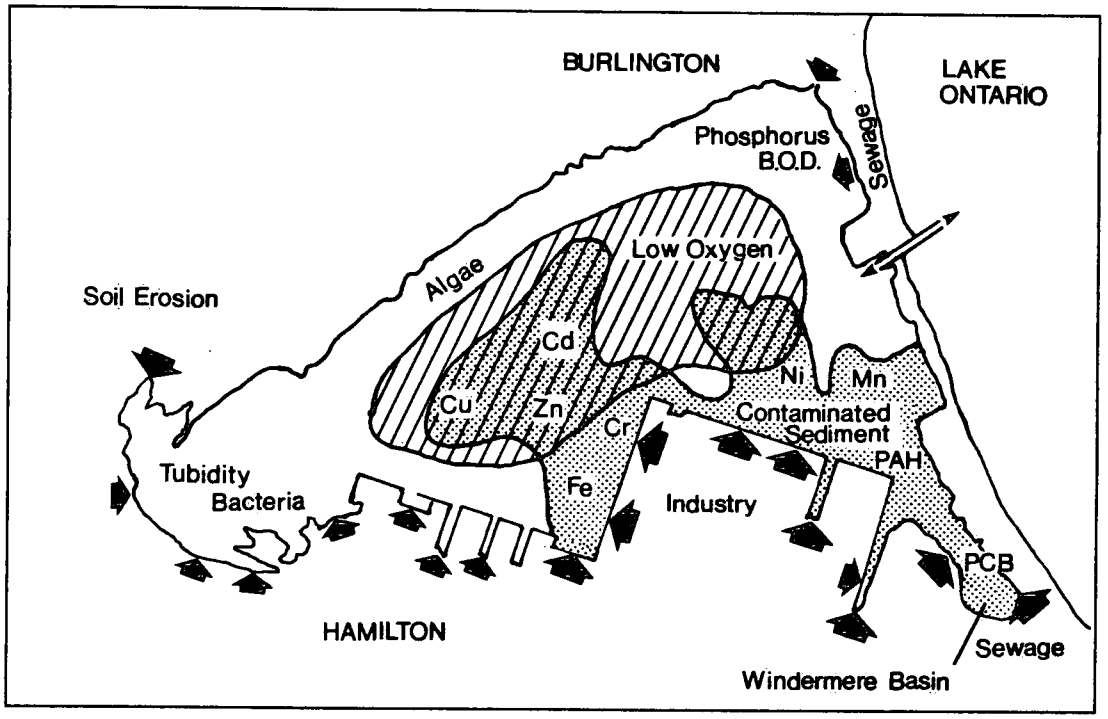


Figure 4. Hamilton Harbour: The pollution effects of industrial discharge, sewage treatment plants and sewer overflows.

NEARSHORE/OFFSHORE INTERACTIONS PROJECT

K.L.E. Kaiser, Project Chief

Introduction

Much of the pollution in lakes occurs when contaminants are released at the shoreline via rivers or industrial discharges. The pathways, fate and effects of these contaminants are complicated by the episodic nature of their interaction with the littoral zone sediments and associated biota within the nearshore zone. The objective of this project is to combine physical, chemical and limnological expertise with chemical and biological expertise to assess the transfer, degradation, adsorption, volatilization, burial, resuspension and biological impacts of contaminants in this important but poorly understood zone. Modelling is a major aspect of the project, which includes both physical hydrodynamics and chemical prediction through quantitative structure activity relationships (QSAR). Research is conducted in the St. Lawrence River, its lakes and estuary, and in the Laurentian Great Lakes Connecting Channels.

Research Highlights

- Volatile halocarbons (VHCs) were proven to be useful for tracking pollutant plumes in lakes and large rivers. The 20 compounds in this group, which are relatively easy to detect, were used to identify contamination sites in the St. Lawrence River from Cornwall to Quebec City. "Microtox" toxicity testing was used to assess the potential effects of these contaminated plumes in the St. Lawrence River and in Lake St. Clair (Figure 5). In the St. Lawrence River, nearly 50 percent of the samples showed low to moderate toxicity.

- A preliminary survey of persistent toxic chemicals such as PCBs, chlorobenzenes, chlorophenols, PAHs and a variety of biocides, was completed for water, suspended sediments, bottom sediments and biota in the upper St. Lawrence estuary.

- Preliminary studies of the distribution and abundance of yeasts in the St. Lawrence River were completed. Yeast densities tend to increase with depth in this system.

- A variety of lake sediments from across Canada were evaluated for their potential to release aluminum. Calculated rates of sediment release were high enough to supply a significant fraction of the dissolved aluminum found in Ontario and Nova Scotian lakes.

- Processes affecting the transport and fate of chlorobenzenes in the Niagara River plume were assessed using field measurements and modelling. The key controlling factors were partition coefficients and the concentration of suspended solids.

- The episodic movement of sediments, via turbulence and horizontal currents, and the resultant effects on contaminant transport were analyzed in Lake St. Clair. A new method to account for general horizontal advection, called the "flux divergence method", has been developed.

- A new version of the TOXFATE model was developed and was applied to simulation and predictive exercises for Lake St. Clair and for the waterfront area of Toronto Harbour in Lake Ontario.

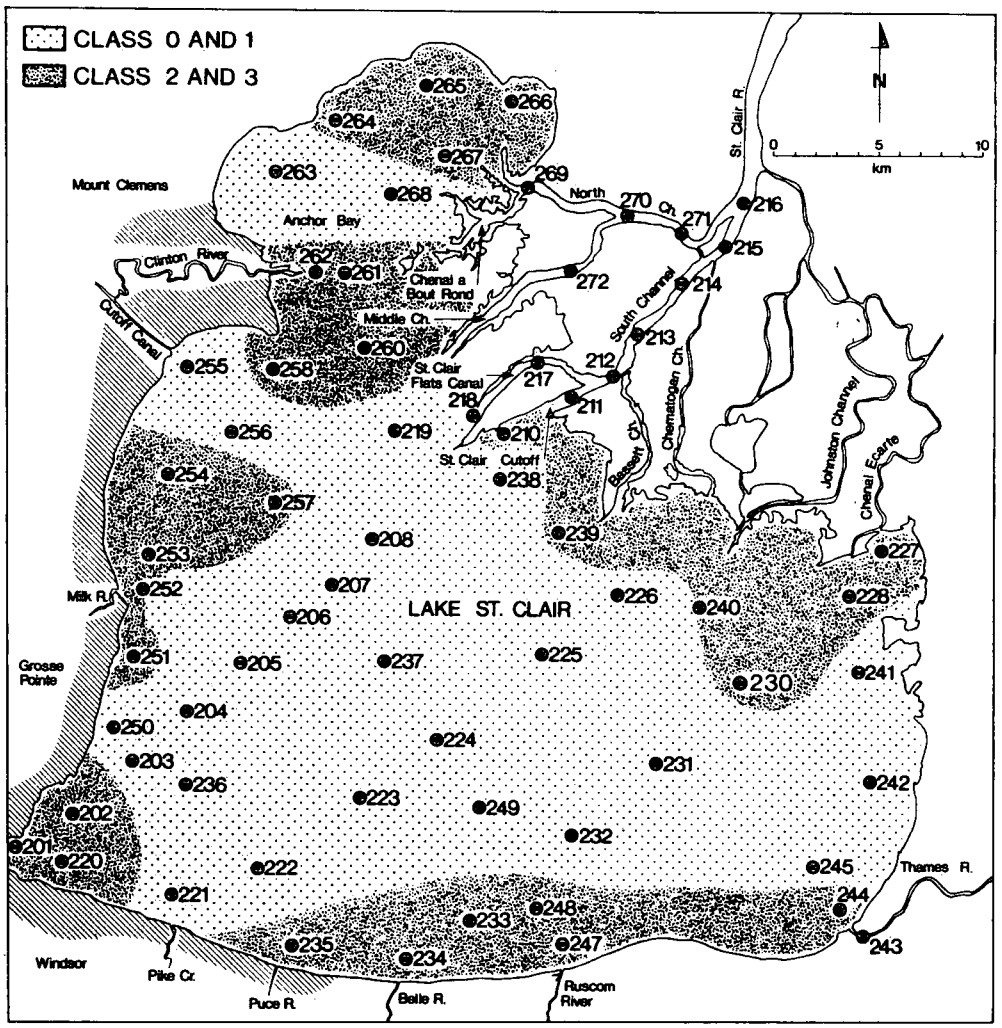


Figure 5. Toxicity survey station numbers in Lake St. Clair and Microtox toxicity test classifications of the lake water indicating the absence (class 0 and 1) and the presence (class 2 and 3) of conditions producing low acute toxicity.

RIVERS RESEARCH BRANCH

E.D. Ongley, Director

The Rivers Research Branch conducts applied research and provides policy advice on a broad range of water resource issues associated with rivers and river basins in Canada. Water resource management in Canada is carried out within the framework of land-water interactions. Rivers receive and integrate the effects of a multitude of anthropogenic activities associated with point sources, such as effluents from urban and industrial activities, and nonpoint sources such as atmospheric deposition, groundwater contamination, agricultural chemicals and urban runoff. Rivers are the primary means by which these impacts are transferred to large lakes and oceans.

The Branch seeks to understand the complex relationships involving physical, biological and chemical interactions in Canadian rivers and drainage systems. This knowledge base is required to meet federal objectives for contemporary and emerging water resource management concerns that have national and international implications.

The branch is structured around five research projects which address contemporary and emerging national priorities: **River Modelling; Contaminants/Pesticides; Long Range Transport of Airborne Pollutants (LRTAP); Ecotoxicology** and **Groundwater Contamination.** While the projects facilitate multidisciplinary research, they also seek to preserve critical mass of disciplinary expertise. Individuals often contribute to more than one project and any one project may provide disciplinary expertise to another project.

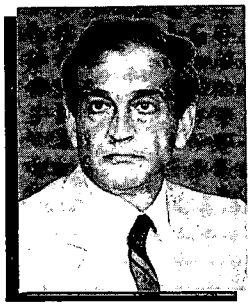
Research and technology transfer activities extend from coast to coast and include such diverse topics as:

- pesticide contamination of groundwater in Prince Edward Island;
- hydrocarbon contamination in Arctic rivers;
- pesticide evaluation;
- acid rain effects and evaluation of mitigation options in Quebec and Atlantic Canada;
- expert systems applications to contaminant pathways in rivers in Ontario and British Columbia;
- water quality monitoring protocols in the Prairie Provinces;
- hydraulic and sediment transport issues across the country;
- ecotoxicological R&D and public health issues nationally and internationally.

Branch scientists serve on a variety of national and international commissions, associations and committees, and participate in national and international policy negotiations. They travel internationally on collaborative and consultative missions for Canadian and international development agencies and scientific organizations. They also serve as editors, conference chairpersons and organizers for a wide range of international activities. Many hold adjunct faculty positions in universities in Canada and abroad. The Branch also seeks opportunities to improve the competitive position of Canadian environmental industries, both through direct R&D transfer and by utilization of international contacts to identify commercial opportunities for Canadian industry.

RIVER MODELLING PROJECT

S. Beltaos, Project Chief



Introduction

The objective of the River Modelling Project is to develop knowledge and expertise, and to provide national leadership, on river flow and basin processes and their interaction with water quality and resource issues. Current emphasis is on runoff processes and transport of contaminants through the land-water interface; hydraulic characteristics of river channels and sediment mobility; transport of fine sediments and associated contaminants in rivers; development of remote sensing capabilities for measuring important river quality parameters; and river ice processes with emphasis on ice jams and frazil ice. Modelling expertise in this project also supports activities in other NWRI Projects. There is extensive interaction with the LRTAP Project for expert systems development of acid rain models.

Research Highlights

- In response to IJC concerns, field investigations were carried out on the nature of non-point source loadings to the Upper Great Lakes Connecting Channels. Non-point sources in Windsor, Sarnia and Sault Ste. Marie were found to produce loadings comparable to point source contributions for chloride, total phosphorus, several heavy metals and various persistent toxic chemicals (PAHs, PCBs and HCB).

- The fate of many contaminants in rivers is largely governed by the hydrodynamic behaviour and transport of fine sediments. Research plans are now in place to address biogeochemical processes, including flocculation, in the laboratory. New equipment has been acquired and existing mathematical models of fine sediment transport critically reevaluated. A two-dimensional version of the MOBED model, nearly completed, will predict changes in channel cross sections and associated bed shear distributions which partly control fine sediment processes.

- Transport studies of chlorinated contaminants in the St. Clair and Detroit rivers have indicated that suspended sediments are the principal pathway for these pollutants. The amount of contaminant transported by the bed load was negligible.

- A mathematical model has been developed and validated to predict the impact of prolonged water level changes on an areal extent of shoreline marshes. Marshland area is related to onshore and offshore slopes, changes in water level, and marsh depth (Figure 6).

- Analysis of unique ice jam configuration measurements was completed. It has been possible to obtain direct field estimates of several theoretical parameters which, in

the past, were either guessed indirectly or unknown. An analysis of ice jam stability when overlain by sheet ice was also carried out and applied to measured data. Laboratory tests on the breaking of ice covers by water surges continued, using SYGICE, a synthetic material developed at NWRI. The results to date confirm theoretical predictions that uncommonly steep surges are required to break an ice cover.

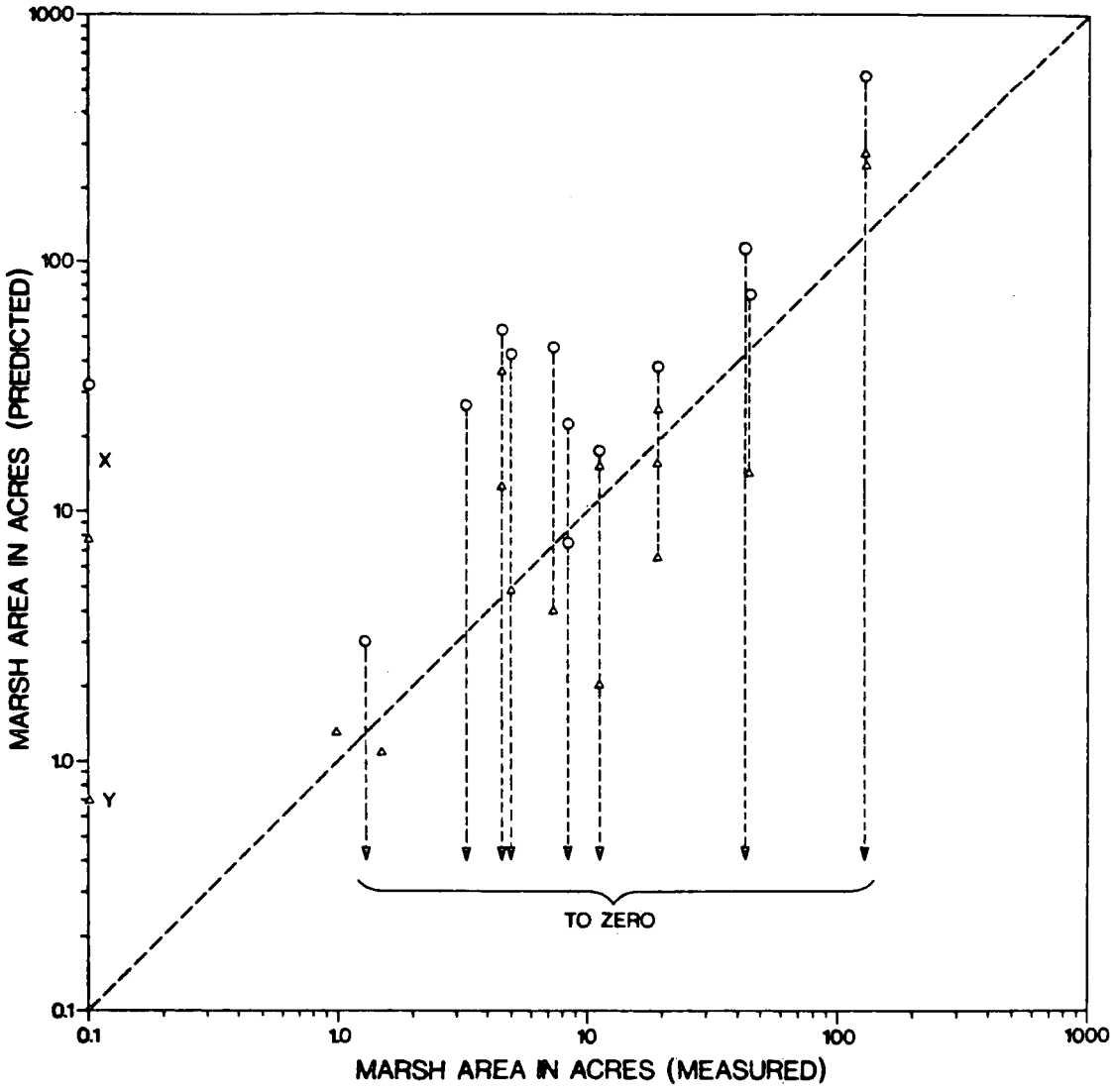
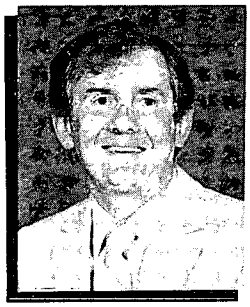


Figure 6. Validation of the geometrical marsh model. Comparison of maximum and minimum marsh area as predicted from the marsh model with actual marsh areas delineated from aerial photos for Georgian Bay/North Channel marshlands. Historical aerial photography obtained between 1935 and 1985 was utilized in conjunction with monthly mean water levels during this interval to effect the model validation.

CONTAMINANTS/PESTICIDES PROJECT

R.J. Maguire, Project Chief



Introduction

The general objective of the Contaminants/ Pesticides Project is to develop knowledge for use by Environment Canada in assessing the hazard posed by toxic chemicals released to Canadian rivers and receiving waters. The hazard of a given chemical to organisms in water or sediment is a function of its concentration, toxicity and persistence. Research is performed in all of these areas and, in conjunction with the Ecotoxicology Project, on the determination of effects of toxic substances on aquatic communities and ecosystems. Research topics are chosen in response to a variety of concerns. These include gaps in the scientific literature, chemicals identified in priority lists for risk assessment (e.g., under the Environmental Contaminants Act, the Pest Control Products Act and, in the future, the Canadian Environmental Protection Act), or in response to regional concerns.

Research Highlights

- Tributyltin (TBT) is an antifouling agent and perhaps the most acutely toxic chemical to aquatic organisms in use. Research in this project was the first anywhere in the world on the occurrence of TBT in water, sediment and fish, and on the chemical and biological degradation and persistence of TBT in water and sediment. TBT was found to be moderately persistent in Canadian waters and present in many locations in Canada at concentrations which could cause chronic toxic effects in sensitive organisms. As a consequence, a limited ban was proposed by Agriculture Canada (under the authority of the Pest Control Products Act) on the use of antifouling paint containing TBT.

- Concentrations of 90 PCB congeners, chlorobenzenes and chlorinated pesticides were determined in the surface microlayer and subsurface water of the Niagara River at Niagara-on-the-Lake. In general the concentration of most chemicals was elevated in the surface microlayer relative to subsurface water, by factors of up to 37. This has implications for sampling protocols and for air/water exchange processes.

- Research into biomonitoring techniques is being carried out on benthic macroinvertebrate community structure as an indicator of ecosystem health in the Yamaska River, Quebec; biochemical response of organisms to known toxicants in the Yamaska River; evaluation of fish bile as a monitoring medium for pesticides with relatively low lipid solubilities; and evaluation of freshwater mussels as biomonitors for pesticides and industrial chemicals. In studies of a pulp mill and a wood preserving plant on the Rainy River and at Thunder Bay, caged leeches were shown effective for monitoring of chlorophenols. Tetraethyllead was produced at one location on the St. Clair River and at another location on the St. Lawrence River. Decreases in alkyllead concentrations in fish and caged clams, but not in sediment downstream of these two sites, have been noted following the cessation of production.

- Deltamethrin, a pyrethroid insecticide, is the most powerful insecticide known. Earlier work on the persistence of deltamethrin in water had not taken into account that sunlight can convert deltamethrin to relatively non-toxic isomers, in addition to degrading it. Deltamethrin, when sprayed on a pond and stream in Prince Edward Island, disappeared quickly from water, with a half-life of about one hour (Figure 7).

- A rapid and sensitive agar plate assay for the microbial toxicity of organic

contaminants has been developed. The method involves the use of a dimethyl sulphoxide-glycerol carrier solvent system to dissolve the test chemicals and the incubation of a seeded agar plate at 30°C to accelerate the bacterial growth rate. Bacterial responses to tripropyllead and trimethyllead could be detected at quantities as low as 200 ng. In addition, an oxygen-uptake toxicity assay was developed for directly assessing the microbial toxicity of Hamilton Harbour sediments, yielding results compatible with the *Daphnia magna* test.

- A high performance liquid chromatography (HPLC) method has been developed for the determination of adenine nucleotides (ATP, ADP and AMP) in studies of stress in algae using the adenylate energy charge ratio technique. Preliminary studies in the Yamaska, St. Lawrence and St. Clair rivers indicate that eutrophic conditions interfere with these analyses.

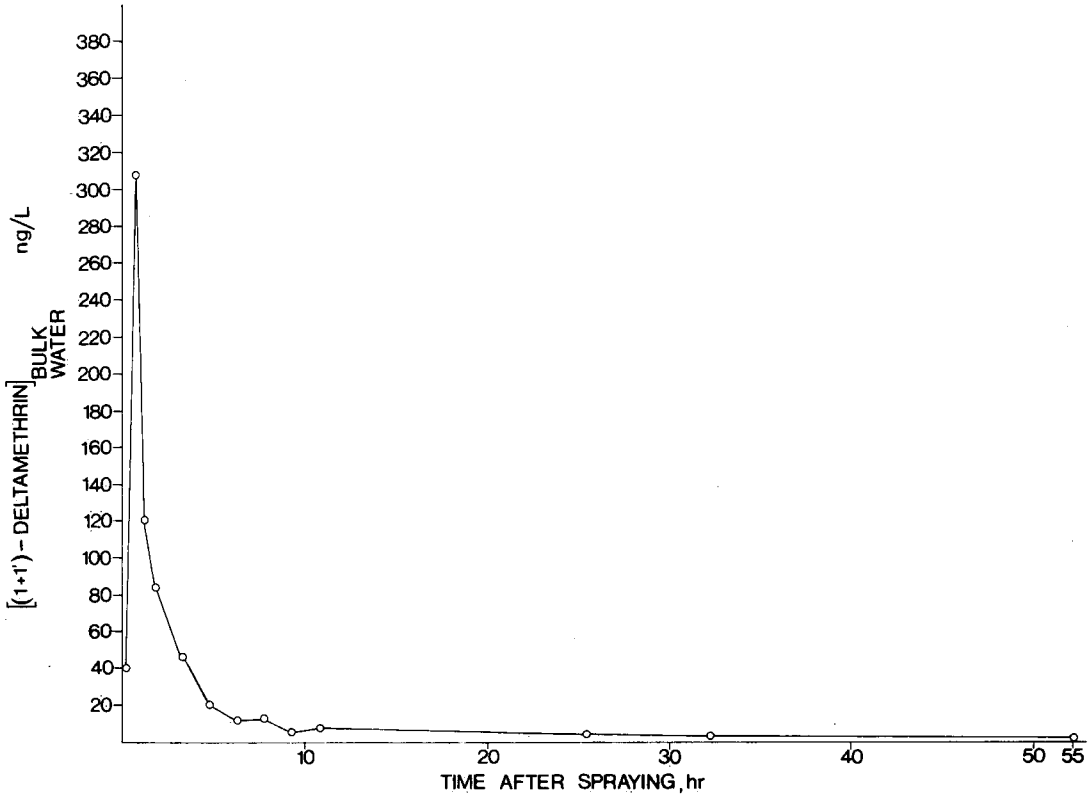


Figure 7. Disappearance of deltamethrin from pond water in P.E.I. following aerial application.

LONG RANGE TRANSPORT OF AIRBORNE POLLUTANTS PROJECT

D.C.L. Lam, Project Chief

Introduction

Current research with the Long Range Transport of Airborne Pollutants (LRTAP) Project is largely in response to the needs of the upcoming national LRTAP "acid rain" assessment due to be completed in early 1990. One area of emphasis has been the completion of studies on sulphur cycling and natural organic acidity. The priority for the Turkey Lakes Watershed Study has been the production of summary interpretations of earlier work and the establishment of a "maintenance" program for the field site. Priority efforts have also been made to complete predictive model development and to apply the models extensively in support of the 1990 assessment. Lastly, research has continued for the development and statistical evaluation of the national LRTAP water quality data base.

Research Highlights

● A 21-paper special review volume on the Turkey Lakes Watershed Study was published (Can. J. Fish. Aquat. Sci. 45, Suppl. 1). It spans the entire range of work that has been conducted, including aquatic chemistry and biology, forestry, and predictive modelling. The processes controlling the hydrological and chemical fluxes associated with spring melt, mass balance studies for ionic species, and aluminum geochemistry were also described at international conferences or in review papers.

● Sulphur isotopic data suggest that large amounts of sulphur are released during summer from biogenic sources such as bogs, marshes and wetlands that cover large areas of Canada. In the first measurement of its kind, large amounts of dimethyl sulphide (DMS) were shown to be produced and released from such ecosystems. Calculations suggest that such sources can contribute up to 20 percent of the airborne sulphur in rural and remote areas of Canada. DMS is rapidly oxidized in the atmosphere by hydroxyl and nitrate ions to sulphur dioxide and methane sulphonic acid (MSA). MSA is thus a marker that can be used to assess the magnitude of the biogenic contribution to the atmospheric sulphur burden. The combined use of the isotopic and MSA data is a potentially powerful tool in acid rain research.

● Dissolved organic matter (DOM) complexes aluminum and thus may protect fish from aluminum toxicity. In cooperation with the Department of Fisheries and Oceans laboratory at St. Andrews, New Brunswick, aluminum-DOM interactions on several Nova Scotian waters are being tested, and, through controlled bioassays, their net effect on salmon alevin survival will be determined.

● Regionalization of acidification impact models may provide a more objective means to assess alternative acid rain control strategies. A prototype expert system, RAISON (regional analysis by intelligent systems on a microcomputer), was developed and shown to improve the performance of individual models (Figure 8). In a formal review of over 100 studies in the U.S. and Canada, a U.S. EPA expert research panel on modelling characterized the RAISON study as a "clear, relevant and realistic" approach. The system provides a highly flexible framework within which a wide variety of geographically based environmental problems can be effectively evaluated. Another version of RAISON has been applied to water quality problems in Malaysia.

● A simple, three-soil-layer model has been developed and verified with runoff data from Mersey River (Nova Scotia) and

Northeast Pond (Newfoundland) watersheds. Simulated data for 15 and 30 years showed satisfactory results when compared with observed hydrographs. Modification of the hydrogeochemistry model was also necessary, particularly in the inclusion of the organic chemistry for the coloured waters of the Mersey River.

- An improved and more acceptable functional relationship between the aquatic and terrestrial regime factors was applied to all the watersheds in the Province of Quebec south of latitude 52°N. The relationship permits evaluation of aquatic resources at risk in the cases where terrestrial data exist, but aquatic data are insufficient. Risk estimates indicate 4.5 percent of the lakes are in critical condition, and an additional 48.5 percent are in a very sensitive and susceptible condition.

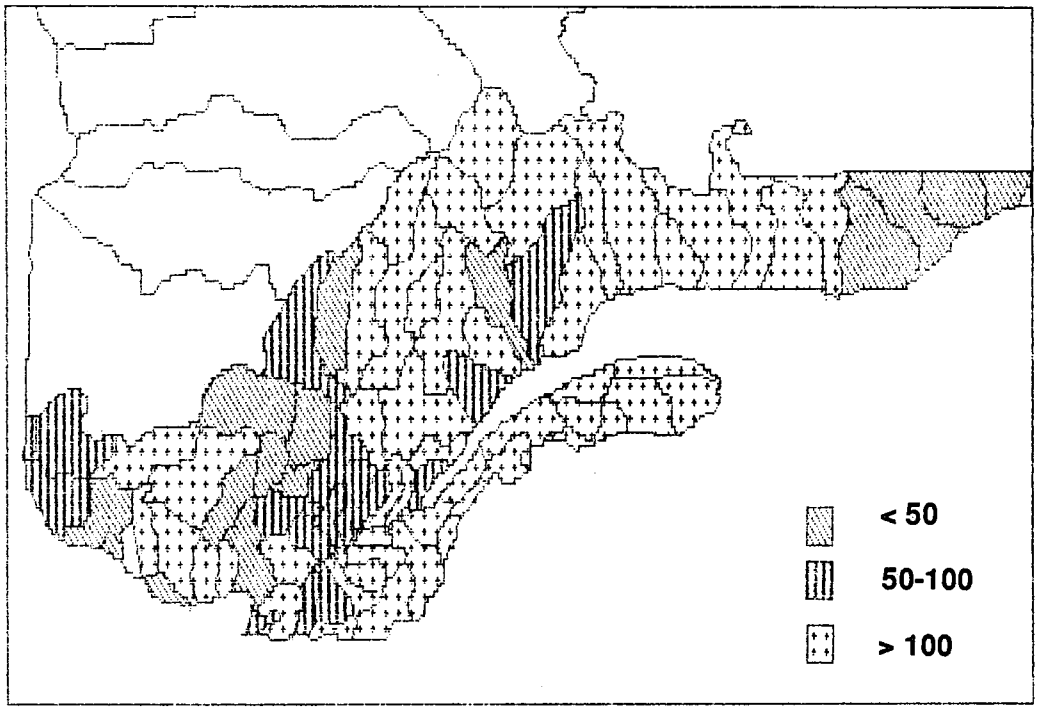
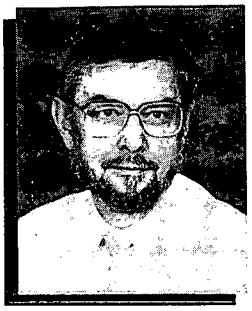


Figure 8. Predicted average acid neutralization capacity (μeq/L) for 91 watersheds in southern Quebec using the RAISON expert system under present loading condition.

ECOTOXICOLOGY PROJECT

B.J. Dutka, Project Chief



Introduction

Ecotoxicological and microbiological tests are among the most important tools for assessing the impact of pollutants on the quality of water, aquatic sediments and biota. These methods permit a determination of the degree of contamination in the environment and the identification of potential ecological impacts. They also provide important insights into a variety of contaminant/biota interactions such as acclimatization; transport rate in fluvial systems; biodegradation, bioaccumulation and food chain effects; growth stimulation or inhibition; and the effects of remedial activities.

The immediate objectives of the Ecotoxicology Project are to improve knowledge of contaminant/biota interactions at the organism and population levels, and to develop a "battery of tests" protocol for chemical stress assessment in freshwater systems. Once this multiple testing protocol has been developed, it will be transferred to lead operational agencies in Environment Canada and to the private sector for implementation in monitoring and regulatory programs.

The expertise in the Ecotoxicology Project is also used in the provision of scientific advice to governments and industries on microbiological problems and on methods for evaluating the ecological significance of toxic contaminants. Staff also contribute to other NWRI projects, such as the LRTAP, Lakes Restoration, and Contaminants/Pesticides projects. Testing protocols developed by the project support the federal government's BIOQUAL initiative, the Ontario government's Municipal and Industrial Strategy for Abatement (MISA) program, a number of regional management initiatives and the future requirements of the Canadian Environmental Protection Act.

Research Highlights

- Sampling of western Canadian rivers and lakes (e.g., Fraser River basin, Saskatchewan River basin and lakes on Indian reserves in northern Manitoba) was completed as part of a study to assess the "battery of tests" approach as well as the effects of organic and ultrapure water extraction of sediments on test responses. These and earlier data from eastern Canadian waters and sediments will be evaluated to select the final core "battery of tests".

- Upon request, a study of Port Hope area sediments was undertaken to ascertain the extent of impact of a local river on Lake Ontario. Generally, the "Area of Concern" for contaminated sediments was greater than had been suspected; a local sewage treatment plant was a factor in sediment contamination. The *Daphnia magna* test was found to be the most sensitive screening test.

- Oxygen injection as a means of improving the water and sediment quality in Hamilton Harbour was evaluated. Acute and chronic toxicant screening tests showed positive effects at stations near the sewage treatment plant outfall. Preliminary microbiological analyses of Hamilton Harbour also indicated no significant effects due to oxygen injection.

- Field and laboratory studies were carried out on key microbial/biogeochemical processes in an acid-stressed lake receiving excessive amounts of atmospheric sulphate and nitrate. Isotopic and diatom evidence indicated microbial sulphate assimilation. This assimilation results in alkalinity generation in anaerobic, organic-rich deeper sediments, thus providing an *in situ* lake rejuvenation process.

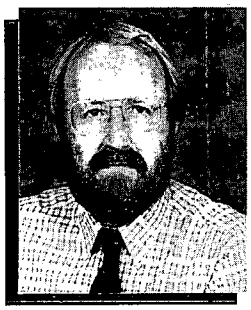
● Development and maintenance of safe potable water supplies require fast and economical assessments of the microbiological quality of the potable water source. With financial support from the Canadian International Development Research Centre (IDRC), coliphage was evaluated as an indicator of the sanitary quality of potable water sources. The objective is to develop a classification system based on coliphage counts and the nature of sanitary services at site.

● Combined with the above study, a variety of simple, inexpensive microbiological water quality assessment techniques for use in potable waters were evaluated. These tests were compared with the bacteriological tests used routinely in Peru, Chile, Brazil, Singapore, Malaysia, Thailand, Morocco and Egypt, and evaluated for their effectiveness, sensitivity, cost, dependence on imported supplies and equipment, and practicality for use in understaffed, underequipped rural laboratories. Results indicated that the use of these tests would provide for safe drinking waters and permit screening of potential sources of potable water for development. This testing protocol will be applied next year to selected areas in northern Canada not served by municipal water supplies.

Figure 9. Beginning ecotoxicological sediment studies near Saint John, New Brunswick.

GROUNDWATER CONTAMINATION PROJECT

R.E. Jackson, Project Chief



Introduction

The Groundwater Contamination Project focuses on the migration and fate of toxic contaminants in groundwater using instrumented field sites, laboratory experiments and mathematical models. The project has three general objectives:

- to understand the physical and chemical controls on contaminant migration and fate in sedimentary rock aquifers, such as liquid industrial wastes in the bedrock of the Niagara region and pesticides in sandstones underlying Prince Edward Island (P.E.I.);
- to develop and/or apply operational tools for hazardous waste site assessment and restoration of outwash aquifers;
- to provide expert advice on groundwater pollution matters of federal concern in Eastern Canada.

Research Highlights

● Cooperative work with the U.S. Geological Survey along the Niagara River frontier is underway to determine the hydraulic properties of the bedrock flow system and the overall groundwater flow pattern. Preliminary results show that groundwater is flowing primarily in the downward direction towards a pervasively low hydraulic head feature at about 120 m depth that is well connected laterally to the Niagara Gorge. Low permeability shales and sandstones in the Clinton group act as aquitards to prevent a significant volume of water from discharging into the Niagara River.

● The freshwater aquifer in the St. Clair River Valley around Sarnia, Ontario, was determined to contain small quantities (i.e., 1 to 10 ppb) of phenol and some volatiles. The results will contribute to the development of a regional model of groundwater flow for Lambton County.

● Research on the hydrogeology of contaminant transport in fractured rocks has centered on the development of a field site at Clarkson, Ontario, and on a methodology for the determination of the aperture distribution of a natural rock fracture using slug tests. The tests were conducted in both open-wellbore and shut-in formats, where up to five successive increases in the volume of injected water were used to investigate fracture aperture heterogeneity.

● Groundwaters of the Gloucester Landfill, situated near the Ottawa International Airport, are contaminated with organic chemicals from incineration of laboratory solvent wastes between 1968 and 1980. NWRI is part of an anticipatory research study to determine optimal methods for aquifer restoration. Studies on laboratory simulation of organic contaminant retardation, on field assessment of organic contaminants in groundwater, and on computer simulation to optimize the configuration for four purge wells for aquifer restoration were completed this year.

● Results of a study on radionuclide transport in a sand aquifer at Chalk River, Ontario, indicate that distribution coefficients for strontium-90 are most strongly affected by spatial variations in the adsorption capacity of the aquifer, as estimated by the specific surface area, rather than by variations in the concentration of competing cations (Figure 10). The adsorption of strontium-90 appears dominated by specific adsorption to Fe/Mn/Al oxide coatings on sand grains rather than by electrostatic adsorption, i.e., by classical cation exchange.

● Studies on the fate of the pesticide aldicarb in the sandstone aquifer of P.E.I.

focuses on migration and fate following application of the chemical to potato crops. High aldicarb values (>5 µg/L) rarely appear, except in conjunction with elevated nitrate concentrations (>10 mg/L). Degradation of fertilizer residues on P.E.I. appears to inhibit the degradation of the pesticide residues and could be avoided by pesticide application following plant emergence in late June, rather than prior to seeding in May. The ratio of aldicarb sulphone to total aldicarb was also found to vary greatly. In the highly oxygenated groundwaters of P.E.I., the ratio is frequently >0.60 compared with 0.40 to 0.48 reported for aldicarb-contaminated groundwaters in the United States.

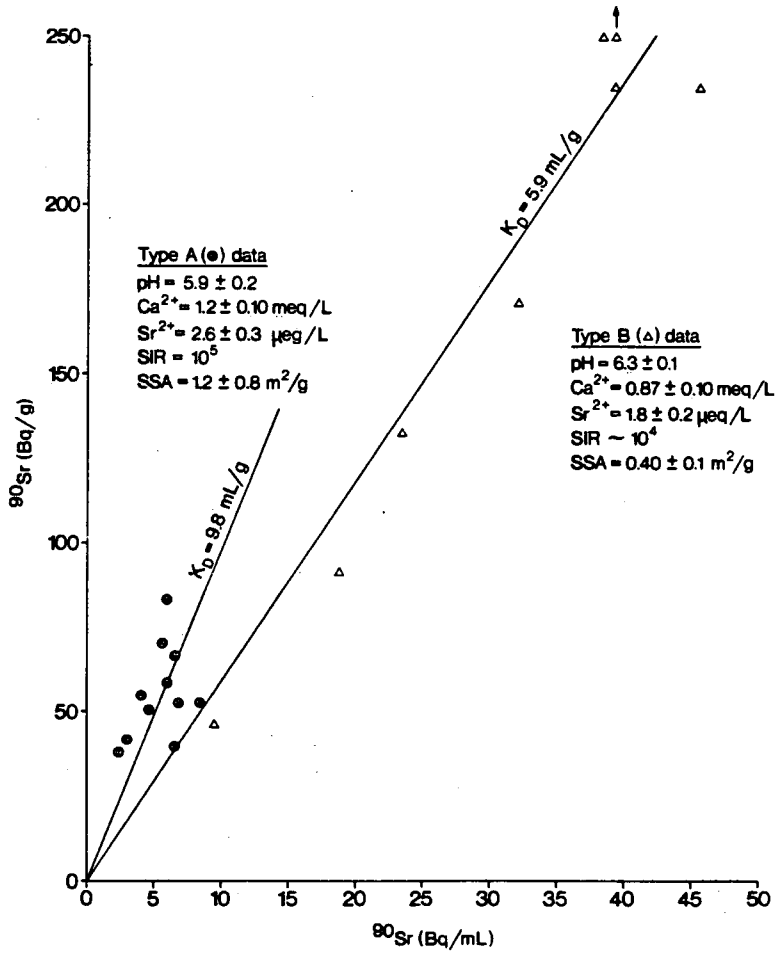
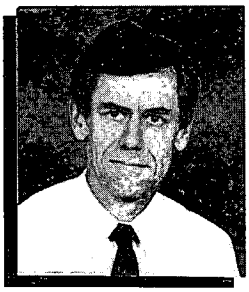


Figure 10. Linear adsorption for ^{90}Sr uptake in two parts of a radioactivity-contaminated aquifer at the Chalk River Laboratories, Ontario. Type A data indicate a geochemical environment in which competition between hydrogen, calcium, stable strontium and radiostrontium ions is greater than with type B data. The linear adsorption partition coefficient K_D is greater for type A data, despite the higher competitive effects, because of the higher specific surface area (SSA) of the aquifer sediments in the type A data. SIR represents the strontium isotope ratio of stable strontium to ^{90}Sr ions.

RESEARCH AND APPLICATIONS BRANCH

J. Lawrence, Director



The Research and Applications Branch conducts mission-oriented basic and applied research in areas of analytical chemistry and hydraulics. It is also responsible for transferring research and technology to the operational sectors of Environment Canada and for providing technical and scientific services such as current meter calibration, sedimentology and geotechnical services, and analytical quality assurance. The work addresses priority issues of the Inland Waters Directorate (IWD) and other agencies of the Department.

New, improved and more cost effective analytical techniques (including laboratory automation) are developed and evaluated for the measurement of priority chemical and biochemical parameters in environmental matrices. The Branch also has lead responsibility for analytical quality assurance for most of Conservation and Protection's chemical monitoring programs. The major recipients for this analytical work include NWRI, the national and regional laboratories of the Water Quality Branch (WQB), the federal-provincial water quality agreements, the LRTAP program, the Prairie Provinces Water Board (PPWB) and the Great Lakes Water Quality Agreement (GLWQA).

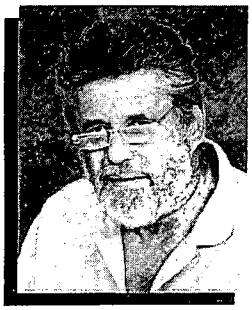
Knowledge of the dynamics of water is sought to provide a framework for the management of water resources and for biology and chemistry research in the aquatic environment. The interfaces between water and the atmosphere, bottom sediments, and shore are studied to explain the mechanisms controlling the transport of pollutants and erosion. Advances are made in river metrology to improve management of that resource. The major clients are the Water Resources Branch, Water Planning and Management Branch, Great Lakes Water Quality Program, Environmental Protection, and the Atmospheric Environment Service.

Universities and private industry are encouraged to make use of the facilities and expertise of the Branch either by collaborative studies with the professional staff or leasing of the facility with or without technical support. The Branch maintains a well-equipped hydraulics laboratory, sedimentology and geotechnical laboratories, and a special clean and hazardous chemicals laboratory, in addition to conventional chemical laboratories. All direct requests from external agencies are cost-recovered, in full or in part, in accordance with the Treasury Board Cost Recovery Policy.

The activities of the Branch are organized into three projects: **Analytical Chemistry**; **Hydraulics**; and **Quality Assurance.**

ANALYTICAL CHEMISTRY PROJECT

I. Sekerka, Project Chief



Introduction

The continuing goal of the Analytical Chemistry Project is to advance knowledge and provide expertise on environmental analytical chemistry. New analytical protocols, instrumentation and methods are essential for the assessment and management of water resources and innovative water pollution research, especially the identification of emerging problems. Both basic and applied, mission-oriented research in environmental analytical chemistry is conducted. New, improved and effective analytical techniques, including laboratory automation, are developed and evaluated for measuring priority chemical parameters. Technology-transfer recipients include other research and operational branches of Environment Canada as well as provincial and private-sector environmental laboratories in Canada and abroad.

The objectives of the project are: 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; to play a lead role in documentation, validation and standardization of analytical methodologies to ensure accuracy and reliability of analytical data; to provide NWRI with sophisticated instrumentation and facilities such as gas chromatography/mass spectrometry (GC/MS) and the Clean and Hazardous Chemical Laboratory; and to transfer developed methods and technologies to the national and regional laboratories of IWD and a wide variety of other "clients" (Figure 11).

Research Highlights

- A fully automated, ion-chromatography method was developed for the measurement of cadmium in water samples at sub-parts per billion (ppb). The detection limit of 0.1 ppb exceeds the existing water quality objective of 0.2 ppb and will substantially improve the capability to provide baseline data on cadmium.

- A comprehensive method for simultaneous determination of 20 chlorophenols and 21 chloroanisoles in fish was developed. This will improve studies on the pathways and degradation of chlorophenol, and on the potential environmental hazard of chloroanisoles in areas such as the Fraser River, British Columbia, where chlorophenols are in heavy use.

- A simple, inexpensive, ion-exchange cartridge suitable for "in-line" preconcentration of ionic species was developed. This permits improved detection limits for the atomic absorption determination of heavy metals (part per trillion range). Its incorporation into inductively-coupled plasma emission spectrometry will permit detection limits that exceed the very low levels of contaminants present in precipitation samples.

- A method for the determination of non-ionic surfactants by supercritical fluid chromatography (SFC) was developed. This is the first quantitative method ever developed for SFC. SFC methods have the potential to provide national and regional water quality laboratories with alternative analytical methods where gas chromatography (GC) and liquid chromatography (LC) are not suitable.

- A working version of a radioimmunoassay (RIA) technique for dioxin detection was achieved. RIA is used to screen large numbers of samples rapidly identifying those that are dioxin-free, and thus eliminating the need for their analysis by other costly time-

consuming techniques. A detection limit of 5 picograms (50 ppt) for TCDD (tetrachlorodibenzo-p-dioxins) was achieved using a lake trout matrix; this is comparable to standard chemical detection methods.

- Improvements to clean up procedures for chromatography, especially for dioxins, were made through development of a first generation of graphite-fibre clean-up columns and an effective process for activating the graphite fibres. The columns are suitable both for GC and LC applications.

- Improved methodologies for organochlorines and PCBs were developed that produce high quality, highly reproducible chromatographs in the dual column, splitless-split injection mode. These methods are a considerable improvement over existing techniques, both in terms of accuracy and precision.

- A validation program for the 24-hour Goulden large sample extractor (GLSE) was completed. This led to acceptance of the GLSE for field use in sampling organic contaminants under the Canada-U.S. Niagara River Toxics Management Plan. The U.S. Environmental Protection Agency and University of Minnesota have also selected GLSE technology for use in a major water quality survey of Green Bay, Wisconsin. Initial steps are being taken to have the GLSE commercially manufactured.

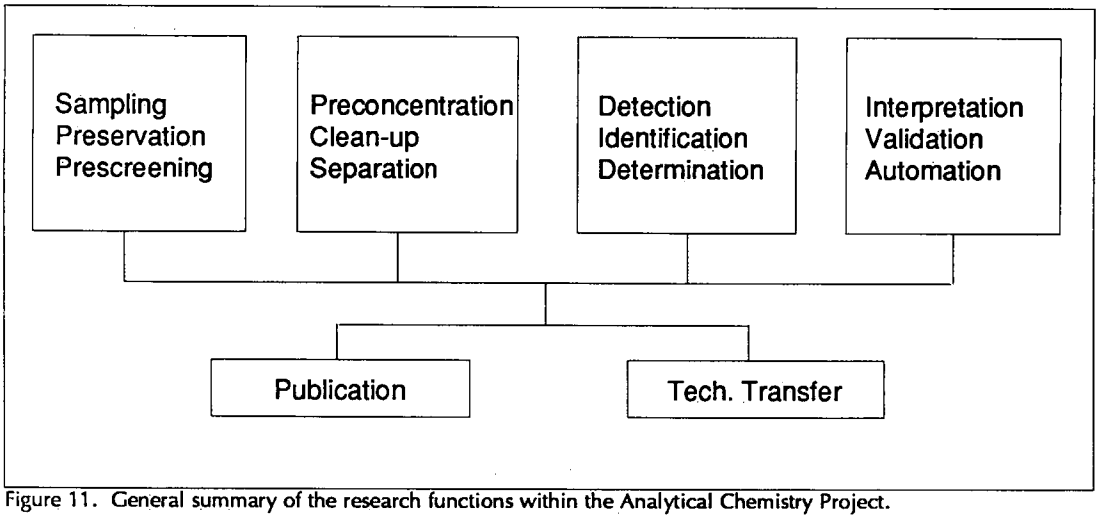


Figure 11. General summary of the research functions within the Analytical Chemistry Project.

HYDRAULICS PROJECT

M. Skafel, Project Chief

Introduction

Research in the Hydraulics Project focuses on the physical dynamics of water and its interaction with air, sediments, shores and man-made structures. Studies on wave mechanics, river flow and sediment transport provide new knowledge for use by water resource managers and engineers in Environment Canada and elsewhere. Special attention is given to understanding hydraulic processes that could lead to structural failure with serious environmental consequences.

Wave mechanics studies create new knowledge on the accurate parameterization of fluxes of mass, momentum, energy and heat across the air/water interface. This work has direct consequences in understanding toxic gas transfer, diffusion of pollutants, wave prediction, lake circulation, seasonal thermocline development, weather forecasting and climatic change. Coastal engineering studies address lake bottom interactions such as the resuspension of cohesive sediments by waves, and develop wave climate prediction techniques to understand sediment resuspension, shoreline evolution and wave-structure interaction. Fluvial engineering research is directed at improved understanding of fluid mechanics and sediment transport in rivers, the development of new and improved techniques for monitoring river processes, and flow-structure interactions.

Research Highlights

- The final phase of WAVES (Water-Air Vertical Exchange Studies) concerning the behaviour, dynamics and effects of deep water wave breaking was completed. This research collaboration with Woods Hole Oceanographic Institution has produced a unique and comprehensive data set for the exploration of wave-turbulence interactions. Although instruments from NWRI and Woods Hole used in WAVES worked on completely different physical principles, excellent agreement was found in responses to both mean flow and turbulence. The NWRI wave-gauge array yielded high resolution, accurate wave directional spectra. Preliminary findings show that downwind spectral densities are quasi-saturated, but that spreading increases linearly with frequency away from the spectral peak, thereby causing the frequency spectra to follow f^{-4} law. At twice the frequency of the peak frequency, a large dip in the directional spectrum appears in the direction of the waves at the peak of the frequency spectrum (Figure 12). The dip may result from the attenuation of short waves caused by the passage of white caps.

- In collaboration with the U.S. Naval Research Laboratory, radar data with continuous azimuthal information has been obtained for the first time from a wave tower. This information, together with simultaneous boundary flux data, promises to be extremely useful for interpreting data from airborne and space-borne microwave radars to infer winds over oceans.

- A large-scale, sealed, recirculating wind tunnel for gas transfer studies was designed and partially constructed. The wind tunnel will excite waves and enhance gas transfer in an existing 32-m flume which is equipped with a closed water recirculation system and hydraulic wave maker. Maximum fluid velocities in air and water will be 22 and 50 cm/s, respectively. Joint experiments will be carried out shortly with the Air/Water Interactions Project to determine the air/water transfer of toxic gases and appropriate surrogates will begin soon using the common pesticide lindane. The flume is equipped with sensitive instrumentation for monitoring wave and boundary layer characteristics and air/water sampling ports.

● Steady-state wave prediction equations (the SMB, JONSWAP and Donelan similarity equations) were evaluated, as were the procedures for applying these contained in the revised U.S. Army Corps of Engineers' Shore Protection Manual. Predictions were compared with measured wave data from Lake Ontario and other sources. All three equations can be used for wave climate predictions and for developing wave forecasts from weather forecasts, but the SMB and Donelan similarity equations provide the best results. The revised procedures in the Shore Protection Manual consistently overpredict both wave height and period.

● Another comparison study of three one-dimensional wave climate prediction models also commenced. Predictions from a proprietary model provided by a consultant, a model used by Public Works Canada, and a model used by Hydraulics Research of Wallingford, U.K. will be compared to measured wave data from lakes Ontario, Erie and St. Clair and from the Gulf of St. Lawrence.

● A literature review on Great Lakes water levels was completed for Public Works Canada, who are developing design guidelines for harbour structures. Public seminars on shore processes and shore protection alternatives in relation to the recent high water levels in the Great Lakes were also held at several locations around the lower Great Lakes.

● Construction began on a physical model of Windermere Basin, the enclosed body of water at the south end of Hamilton Harbour. A partial dredge and filling scheme has been proposed to improve the appearance and environmental characteristics of the basin. The scale model will be used to determine the optimum position of berms, dredge areas and other proposed features under various flow conditions.

● At the request of the Water Resources Branch, IWD, evaluations were completed on their prototype acoustic flow meter for river discharge measurements. Development and evaluation of discharge measurement schemes for the Milk River continued; data on stage-discharge curves for different approach channel conditions were analyzed and weir designs suitable for prototype applications were tested.

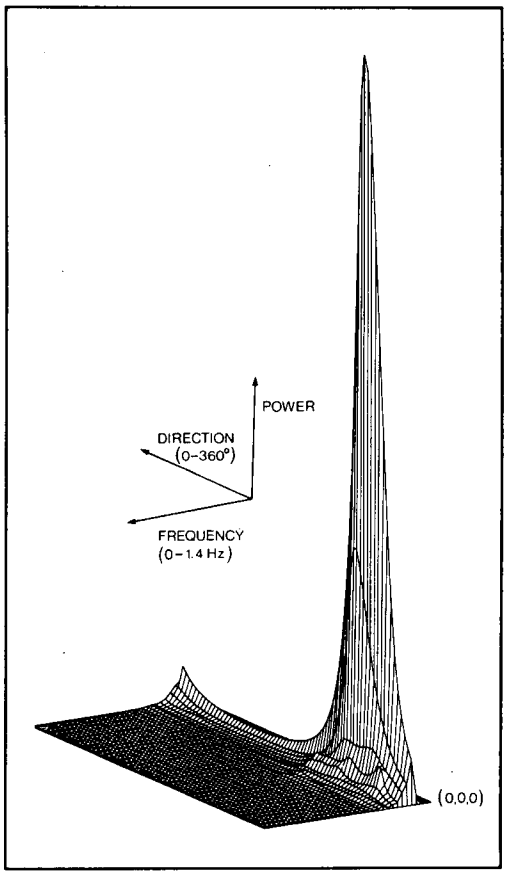
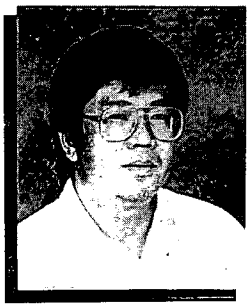


Figure 12. Perspective view of wave directional spectrum.

QUALITY ASSURANCE PROJECT

A.S.Y. Chau, Project Chief



Introduction

The objectives of the Quality Assurance (QA) project are to provide a focal point for coordinated quality assurance programs in Environment Canada and to ensure that analytical data are generally of good and comparable quality. Assurance of data quality enables the Department to provide authoritative, credible, scientific advice on control and remediation strategies derived from the interpretation of scientific data.

Chemical data are essential for decisions on aquatic pollution control. Biased measurements can lead to errors in assessment and in subsequent control actions. In addition, the expense of data collection and interpretation makes the cost of discarding questionable data high. Therefore, data must be suitable, compatible and reliable for the intended use. The long-term goal of the QA Project is to assist with the development of comprehensive analytical quality assurance programs in Canada.

The QA Project plans, coordinates and implements quality assurance and control programs to ensure accuracy, comparability and reliability in analytical data. It develops Certified Reference Materials (water, sediments and biota) for use in quality assurance, analytical method research and environmental assessment studies. Project activities include the development of management plans for quality assurance; advising on field, laboratory and data management quality control procedures; the development of Certified Reference Materials (CRM); and the design and conduct of interlaboratory comparison studies. Studies are conducted for federal, provincial, university and private laboratories producing analytical data for departmental programs. Methodology evaluation and sample preservation are also carried out in support of these studies.

An active program to market the products and expertise of the Project has begun. The first step has been to advertise the availability of the CRMs developed and prepared by the group.

Research Highlights

- The QA program for the binational Upper Great Lakes Connecting Channel Surveillance Program was completed this year. The Quality Management Work Group was generally successful in ensuring the production of quality data for the program. Nine interlaboratory studies were carried out to help participating laboratories identify and correct quality control problems. A set of overall data review reports on interlaboratory performance assessment and a final report with recommendations relevant to future multi-agency, international surveillance programs were also produced.

- Two large interlaboratory QA studies were finalized for the Great Lakes Water Quality (GLWQ) Surveillance Program. These addressed organics in ampules and sediments, and total P in sewage effluent. Two other QA studies on total P in water and total metals in sediments were initiated.

- Activities continued for three national QA programs: the Federal/Provincial Agreement QA program, the Prairie Provinces Water Board QA program, and the Long Range Transport of Airborne Pollutants (LRTAP) program. For the first two programs,

monthly interlaboratory QA studies, six data summaries and six final reports were sent to participants. In addition, the Prairie Provinces Water Board received a large, integrated report on laboratory performance for the year. For the LRTAP program, three large QA studies for major ions and nutrients were designed and conducted. Computer programs were also developed to provide information on laboratory performance and data quality (Figure 13).

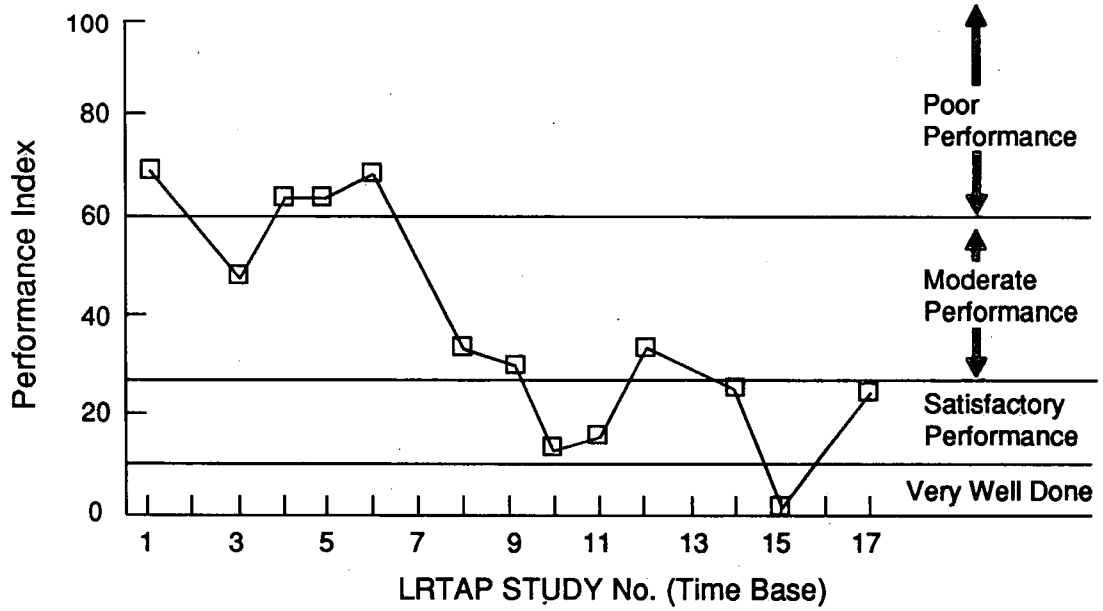
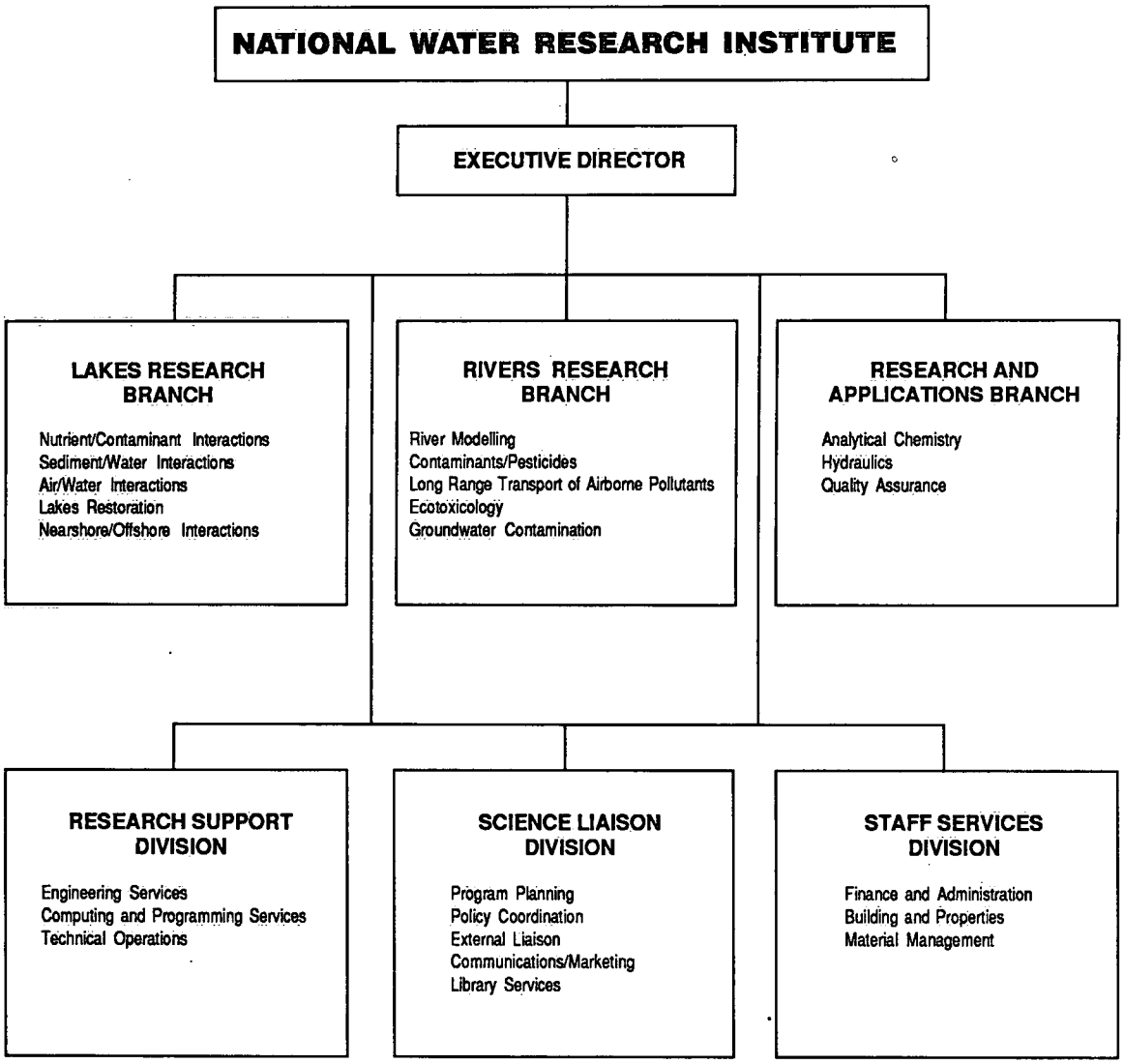


Figure 13. Impact of external QA studies on laboratory performance in the national LRTAP program.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Forester, R.M., **L.D. Delorme** and T.A. Ager. 1988. A lacustrine record of late-Holocene climate change from south-central Alaska: a collection of invited papers by the 'Palim' climate group to be published as an American Geophysical Union Monograph. In press.

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PUBLICATIONS

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PUBLICATIONS

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PUBLICATIONS

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PUBLICATIONS

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