Environment Canada

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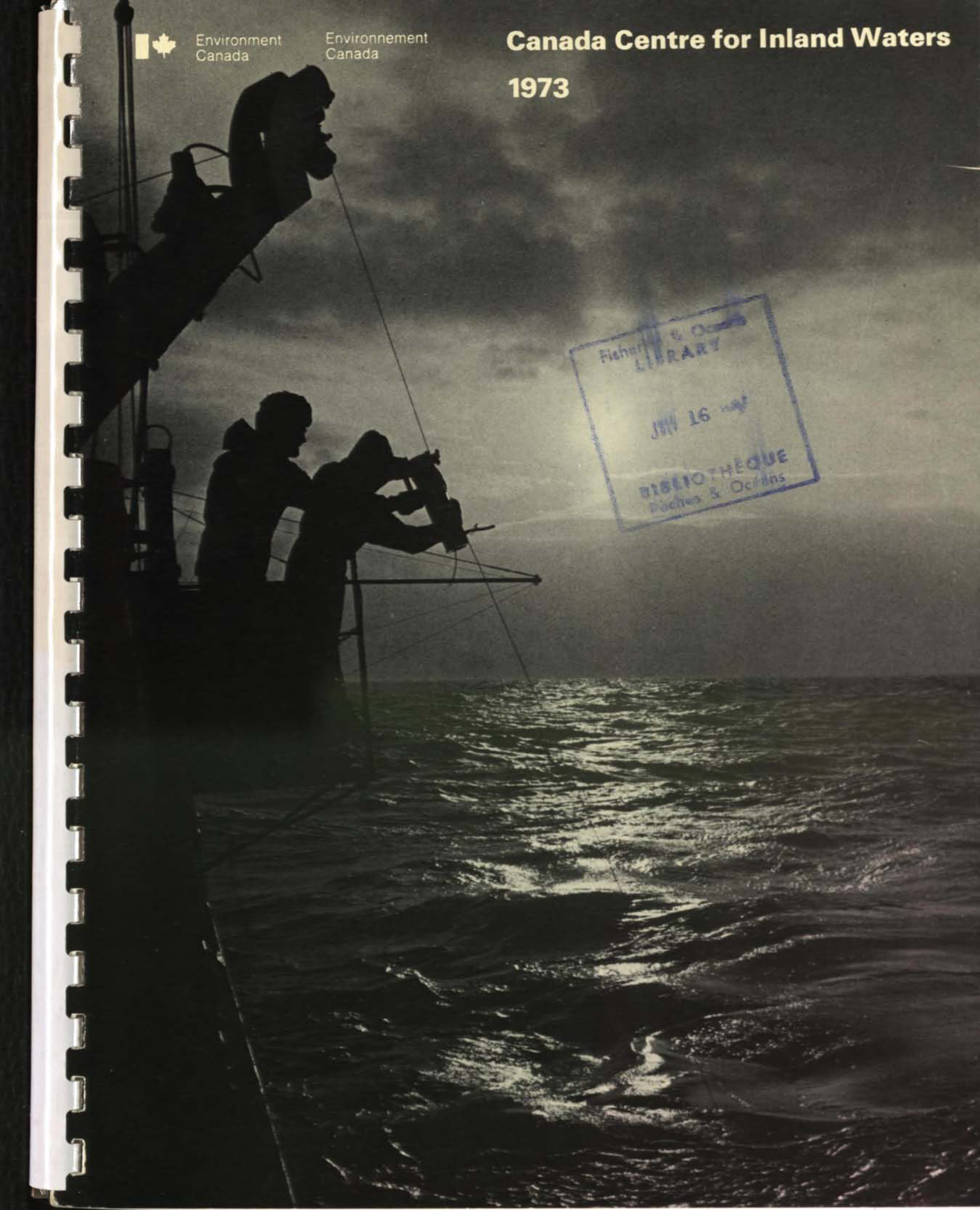
Canada Centre for Inland Waters

1973



CANADA CENTRE FOR INLAND WATERS – 1973

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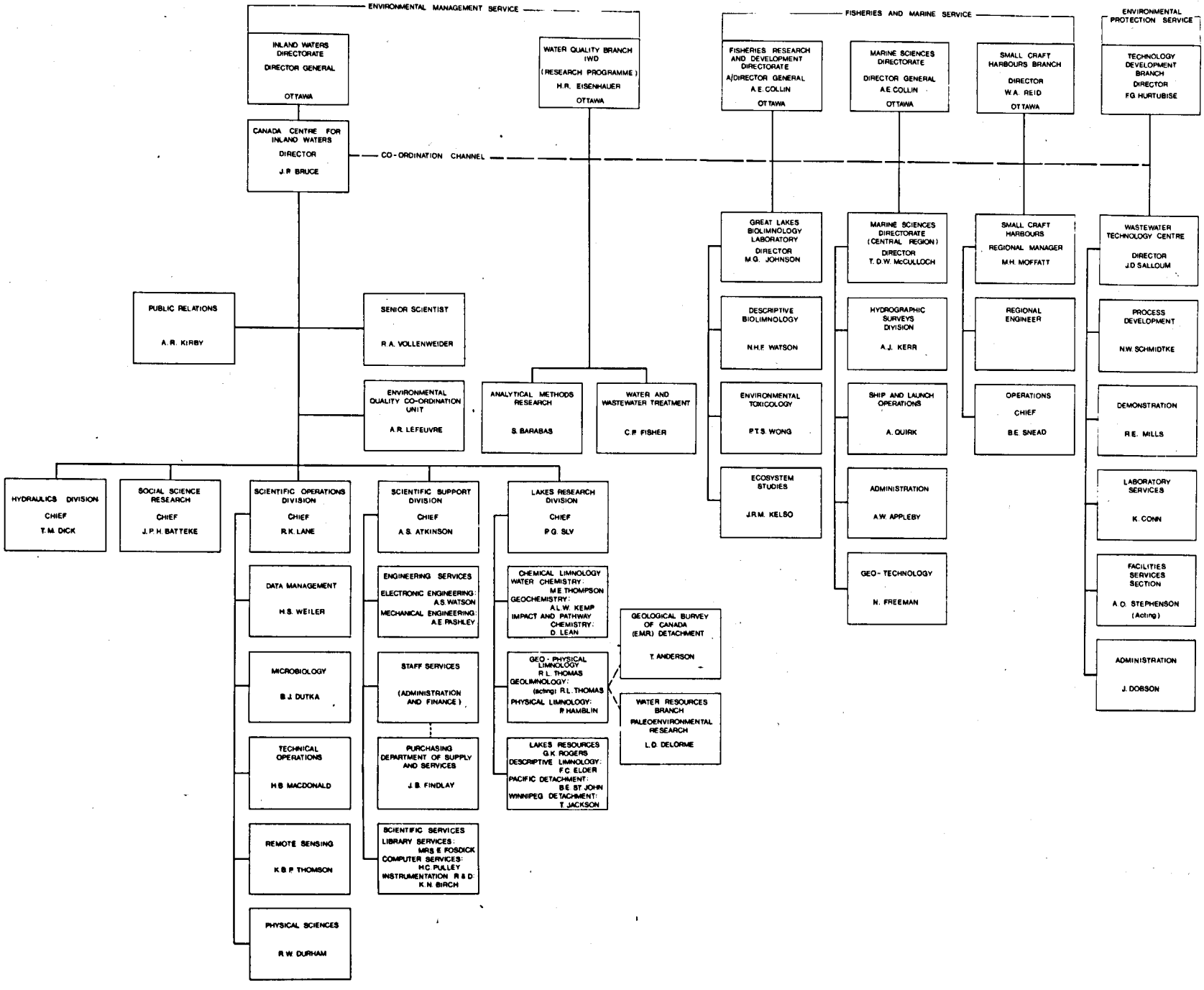
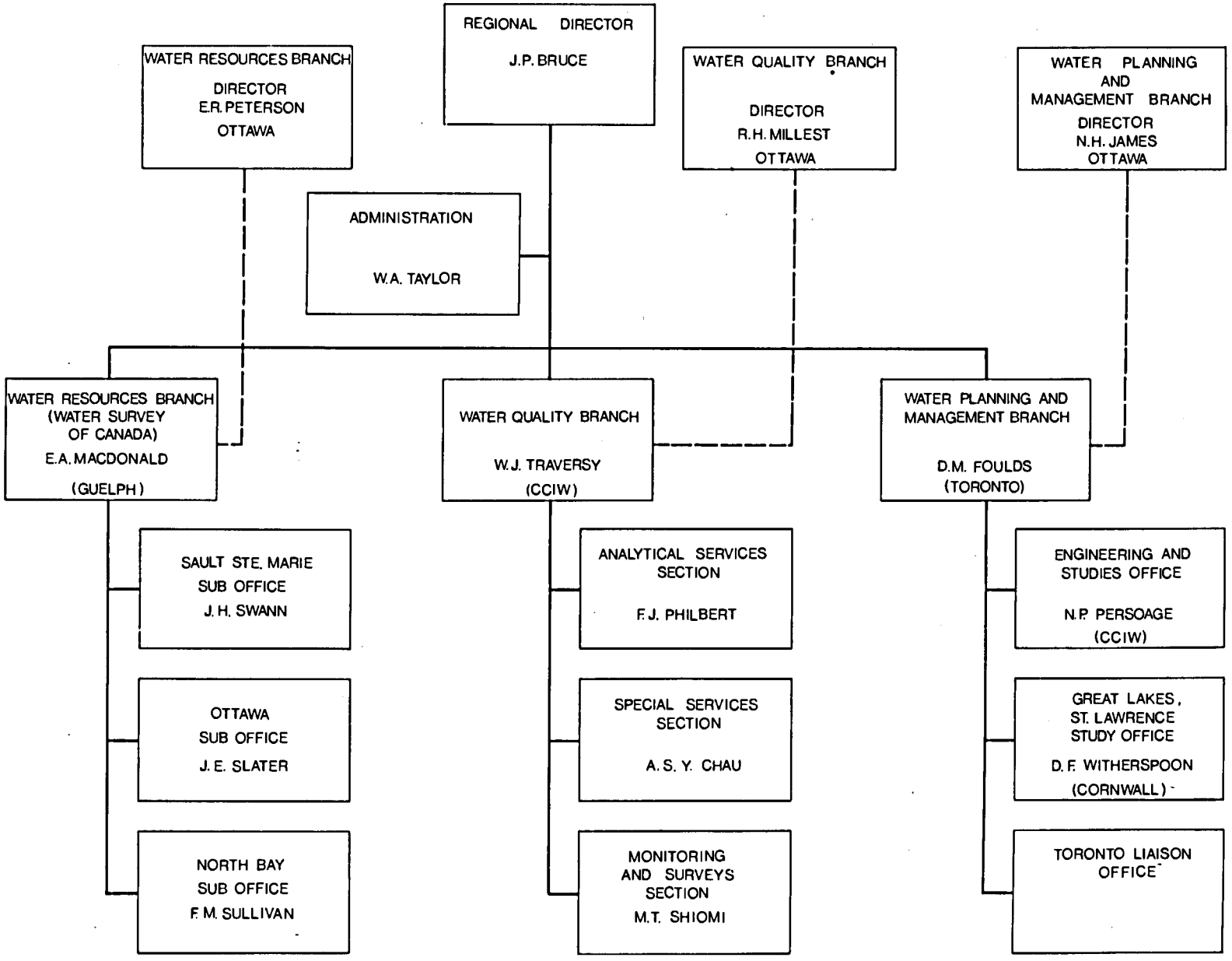


CCIW Organization, December 31, 1973.



Inland Waters Directorate, Ontario Region, December 31, 1973.

Highlights in Review

IMPLEMENTATION OF GREAT LAKES WATER QUALITY AGREEMENT

A major share of activities were directed towards implementation of programs required by the Canada-U.S. Agreement signed in 1972. More than a score of staff members participated in work of IJC Boards, Committees and Reference Groups established under the Agreement. Specific major research and monitoring projects undertaken or started in 1973 included:

(1) Lake Superior base-line water and sediment data collection through 8 major ship cruises,
(2) initial evaluation in Lake Superior of impact and dispersal of a major industrial effluent source (from a pulp and paper mill),
(3) surveillance programs of Lower Great Lakes and interconnecting channels, jointly with Ontario and U.S. agencies, to assess impact of major pollution control measures now being implemented,
(4) initial assessment of priorities and plans to control pollution from land drainage sources, based on available knowledge, and design of definitive study program,
(5) development of research program (mainly by contract) on methods of minimizing environmental impact of disposal of polluted dredged sediments,
(6) physical, chemical and biological projects undertaken to provide a sound scientific basis for water quality objectives for waste heat and radioactivity, and for some of the toxic substances listed in the Agreement, and
(7) special studies of distribution and sources of asbestos-like fibres in Lake Superior water and sediments, in view of the public health concern raised over the high concentrations observed in the Duluth area.

CANADA-ONTARIO AGREEMENT ON GREAT LAKES WATER QUALITY

This domestic Agreement, designed to ensure that Canada meets its municipal waste treatment obligations under the international water quality Agreement, also required substantial efforts of CCIW staff members for Board and Committee activities. It involved EPS, Water Quality Branch, and Hydraulics Lab staff in research projects designed to minimize costs and improve efficiency of the estimated $500 million Canadian sewage treatment program. The year saw completion of most of the studies on phosphorus removal techniques done by contractors, by Ontario MOE and by EPS at CCIW. The most valuable results were presented at two phosphorus removal design seminars, the first for consulting engineers who are designing the facilities required to be completed under the international Agreement between 1973 and 1975. The second was specifically for municipal officials to give them background information on the need for the program, the technical methods available, and the likely costs. Both in-house and contracted programs under this Agreement are now being concentrated on land disposal of sewage sludges and on methods for reducing pollution from storm and combined sewer systems.

HIGH WATER ON THE GREAT LAKES

High water in the Great Lakes system and related shore erosion problems involved intensive efforts on the part of Inland Waters and Marine Sciences staff. Lake Ontario was close to record levels in the spring, and Erie, St. Clair, and Huron all equalled or exceeded previous highest levels in the past 100 years. Severe spring storms caused extensive flooding and erosion damage. At a major press briefing held at the Centre on March 15th, 2 new pamphlets were released ("What You Always Wanted to Know About Great Lakes Levels – and Didn't Know Whom to Ask" and "Shore Erosion – Cause and Cure") and 2 new Environment Canada prediction services announced, 6-month lake level forecasts and a storm surge advisory service by Atmospheric Environment Service.

IWD Regional staff at Cornwall and CCIW continued to provide extensive technical support to IJC Boards of Control for Lake Ontario and Lake Superior to ensure that discharges from these lakes were made in a way that would minimize shore property damage and other economic losses. A new operating plan was developed for Lake Superior and recommended to Canada and the U.S.A. by IJC. The International Great Lakes Levels Board study for the IJC, initiated in 1964, of the feasibility of greater control of levels, was largely completed at year end. Some aspects of the study will require further work and take into account implications of record high water supplies in 1973.

SHORE PROPERTY DAMAGE – GREAT LAKES

Because of extensive property damage due to shore erosion and flooding, a rapid intensification of shore property surveys and shore erosion studies was undertaken

by MSD and IWD staff at CCIW. In response to requests from the Minister's office, a report was prepared on CCIW work on the past 4 years on this subject. This report was tabled in the House of Commons, March 23rd. In addition, an inter-departmental task force was formed (co-ordination by CCIW) which produced a report summarizing available data on shore erosion and flooding in the whole Great Lakes – St. Lawrence System. At the same time, agreement was reached with the Ontario Ministry of Natural Resources for a special intensive survey of 1973 shore property damage, uses and ownership, erosion rates, and erosion and flood protection needs. CCIW efforts of MSD and IWD, and Department of Public Works activities on this joint $700,000 program with Ontario, are coordinated by a federal task force led by T.D.W. McCulloch, Regional Director, MSD. Federal-provincial liaison is the responsibility of J.P. Bruce, CCIW, and W.A. Giles, OMNR. A major report and Coastal Zone Atlas will be completed by mid-1974.

MAJOR FIELD PROJECTS

Hydrographic Surveys – Arctic

Hydrographic Surveys in the Arctic were emphasized. The Ministry of Transport light icebreaker "NARWHAL" was again used in James Bay, completing the navigable corridor into Fort George. CCGS "N.B. MACLEAN" was also used for a short reconnaissance survey in Chesterfield Inlet. Farther north, the Polar Shelf Project team surveyed Norwegian Bay and hydrographers from Central Region participated in two icebreaker probes aboard "JOHN A. MACDONALD" to Victoria Strait and "LOUIS ST. LAURENT" to the Ringnes Islands.

Hydrographic Surveys – Lake Winnipeg

A major hydrographic survey of Lake Winnipeg, which is planned to extend over five years, was initiated. This survey used a Mini-fix positioning system and Bertram launches.

Research and Development – Marine Sciences Directorate

A pilot project for a major tidal current study in the lower St. Lawrence was carried out by the Research and Development Division using C.C.G.S. "PORTE DAUPHINE". Summer and winter physical oceanographic measurements were undertaken in James Bay in support of an oceanic impact assessment of the James Bay Power Development. Scientific contracts were let: (1) to develop operational techniques for storm surge forecasting on the Great Lakes and (2) to analyze and interpret the physical oceanographic measurements on James Bay.

IWD Projects Outside Great Lakes Basin

Establishment of a Pacific Region detachment based in Vancouver resulted in special studies of sediments and geochemistry of Babine Lake and development of a regional limnology program for British Columbia lakes. Steps were taken to strengthen the Western Region detachment based at the Freshwater Institute, Winnipeg. Staff participated in planning for a federal-provincial study of Lake Winnipeg. In addition, staff from Burlington undertook special projects on Lake Memphremagog, Quebec, on hydraulic design of major culverts on the Mackenzie Highway to minimize hazards to fish movement, and on evaluation of sonic measurements for bed gravel transport measurements on the Vedder River, B.C.

EPS Wastewater Treatment Technology Development

Field projects continued on mine wastes in New Brunswick and land disposal of sludge in British Columbia, as well as a number of projects in Ontario.

HYDRAULIC LABORATORY DEVELOPMENT

The new national towing tank facility for calibration of current meters was commissioned in March to replace the former outdoor facility in Calgary. More than 400 meters of 20 different types have now been calibrated. Sediment flumes and cold room facilities for ice hydraulics have been completed, and the major wind/wave flume will be completed early in 1974. Projects on reaeration of streams, waste heat diffusion in rivers and lakes, and combined and storm sewer sampling techniques for mathematical modelling of urban flows and water quality were carried out.

FISHERIES PROGRAM COORDINATION

Strategic planning meetings between Fisheries and Marine Service personnel and Fisheries Management and Research managers of Ontario Ministry of Natural Resources, together with closer working relationships between OMNR field stations and GLBL staff, should lead to a well-coordinated fisheries program on the Great Lakes.

TOXIC SUBSTANCE RESEARCH

IWD and FRD components of CCIW further developed their capability for a comprehensive program of research on environmental contaminants. The program ranges from assessments of uses of toxic materials in the Canadian economy and the social costs associated with these uses, chemical analytical methods development, research on pathways and behaviour of such substances by themselves and in combination, and effects of toxic substances on biotic communities. Among important developments were a better understanding of the role of natural chelating substances in water systems, demonstration of the methylation of lead to highly toxic forms in the environment, and a more complete knowledge of the compounds identified as PCB's in water, sediments, and fish (see page 1, item 5).

RESEARCH REPORTS AND CONFERENCES

About 120 papers by CCIW staff were published in journals and departmental publications during the year (Appendix B). For the second year in a row a CCIW staff member won the Chandler-Misener Award for the best paper published in the proceedings of the International Association for Great Lakes Research. This year's winner was Dr. T.J. Simons for his work on mathematical modelling of lake circulation. Staff scientists also presented 196 papers at a number of international and national conferences (Appendix B). Three major conferences were held at CCIW with a total attendance of over 1000. The American Water Resources Associates Symposium on Remote Sensing of Water Resources; the IJC Research Advisory Board's Symposium on Viruses in the Environment and Their Potential Hazard, and the Chemical Institute of Canada's Symposium on Water Quality Parameters – Their Selection, Measurement, and Monitoring. CCIW staff also organized a workshop on land drainage effects on water quality held at the University of Guelph.

NEW RESEARCH VESSELS

Two minor research vessels were acquired – "ADVENT", a fast cutter, 77 feet in length, and "HILDUR", 106 feet in length. "HILDUR", which had originally been built as a research vessel in Norway, was purchased from the estate of the late T.E. Eaton.

OIL SPILL STUDIES

With leadership from the Centre of Spill Technology (COST-EPS) at CCIW, programs on oil spill clean-up technology were accelerated in EPS, F&MS, and IWD. CCIW staff contributed major portions of new departmental guidelines on uses of dispersants and chemical oil herders. Critical evaluation of available remote sensing techniques for spill detection was initiated, and studies of emulsification and mixing of oil in flowing waters carried out. Field evaluations of various clean-up devices, including DIP (Dynamic Inclined Plane) were carried out.

BAY OF QUINTE PROGRAM

FRD and IWD components conducted an active program on the Bay of Quinte in collaboration with Ontario agencies. This mostly enclosed bay is, in many ways, as euthrophic as Central Lake Erie, and impact of nutrient control measures being implemented between 1973 and 1975 should be easier to assess than for a large lake. Special "limno corrals" were installed to assess nutrient cycling in such a system, and to permit enrichment experiments to be conducted. Work will continue for several years.

ENGINEERING AND COMPUTER SERVICES

In support of the programs at CCIW in 1973, more than 60 major data-acquisition systems were provided by Engineering Services, which also maintained and calibrated many existing common instruments valued at about $2 million. Although much of this maintenance work is provided under contract by Canadian industry, the administration of the contracts is done by Engineering. An Instrumentation Research and Development unit was started this year, with initial emphasis on developing an underwater monitoring system to measure in situ such parameters as pH, D.O., EH, conductance and light scattering index. A CDC 3170 computer system was installed this year, complete with new "MASTER" operating system, resulting in faster and more complete service to CCIW users.

PUBLIC RELATIONS

One emphasis of 1973's expanded public relations programme was explaining Great Lakes levels fluctuations and regulation efforts. As well as publishing the booklet and folder mentioned on page 1, the Centre began monthly issue of a press release to accompany the new levels forecast service. Production of a short film on this subject was also begun. A film on the Centre and its work was produced, and this became an important part of a new series of monthly public visit programmes which began in the autumn.

INTERNATIONAL INVOLVEMENT

As CCIW programs become better known, the trickle of foreign visitors has become a small torrent. CCIW was designated as lead institute for North American contributions to OECD's measurement program on lake eutrophication, and Senior Scientist R.A. Vollenweider was made chairman of the technical committee for the whole program. Staff members participated in many OECD committees and activities. At the request of the World Health Organization, CCIW has agreed to prepare under contract, an extensive "Guide to Water Quality Management."

Faits Saillants

MISE EN APPLICATION DE L'ACCORD RELATIF A LA QUALITÉ DE L'EAU DES GRANDS LACS

Les efforts ont porté en grande partie sur la mise en application des programmes élaborés dans le cadre de l'Accord signé par le Canada et les États-Unis en 1972. Plus d'une vingtaine de membres du personnel ont participé aux travaux des conseils, comités, et groupes d'étude de la Commission mixte internationale, créés en vertu de cet Accord. Parmi les principaux projets de recherche et de contrôle entrepris en 1973, citons:

1) le recueil de données sur les eaux de surface et les sédiments du lac Supérieur par 8 navires;
2) une première évaluation, pour ce même lac, des effets des effluents provenant d'une source industrielle importante de pollution (en l'occurrence, une usine de pâte à papier), et de leur dispersion;
3) des programmes de surveillance des Grands lacs inférieurs ainsi que des canaux les reliant, en collaboration avec des organismes ontariens et américains, pour évaluer l'efficacité des mesures de lutte contre la pollution actuellement appliquées;
4) une première appréciation des priorités et des plans de lutte contre la pollution provenant du drainage des terrains, sur la base de connaissances déjà acquises, suivie d'un programme définitif d'étude;
5) un programme de recherches (effectuées surtout par contrat) sur les moyens de réduire les effets nuisibles pour l'environnement de l'évacuation par dragage des dépôts pollués;
6) des études physiques, chimiques, et biologiques devant fournir une base scientifique solide pour les objectifs de qualité de l'eau, sur les plans de la chaleur résiduelle et de la radioactivité, ainsi que pour certaines substances toxiques mentionnées dans l'Accord;
7) des études ayant trait à la répartition et à l'origine des fibres de type amiante dans l'eau et les sédiments du lac Superieur, en raison de l'accumulation de ces fibres dans la région de Duluth, accumulation jugée dangereuse pour la santé de la population.

L'ACCORD CANADA-ONTARIO SUR LA QUALITÉ DE L'EAU DES GRANDS LACS

Cet Accord interne, ayant pour but d'assurer la réalisation par le Canada des travaux d'épuration des eaux exigés par l'Accord international, a été à l'ordre du jour de bien des réunions du conseil et des comités du Centre canadien des eaux intérieures (CCIW). La Direction de la qualité de l'eau et le laboratoire d'hydraulique du Service de la protection de l'environnement ont participé aux efforts de réduction des frais et d'amélioration du programme canadien de traitement des eaux d'égout, dont on estime le coût à 500 millions de dollars. La plupart des études sur les techniques d'élimination du phosphore effectuées par des entrepreneurs, par le ministère de l'Environnement de l'Ontario, et par le Service de la Protection de l'environnement du Centre canadien des eaux intérieures ont été achevées cette année. Les résultats les plus intéressants de ces études ont été présentés lors de deux séminaires sur les techniques d'élimination du phosphore; le premier séminaire a réuni les ingénieurs-conseils chargés de concevoir les installations de traitement devant être terminées, en vertu de l'Accord, entre 1973 et 1975. Lors du deuxième séminaire réservé, lui, aux fonctionnaires municipaux, ceux-ci reçurent des renseignements sur la nécessité de ce genre de programme et les méthodes techniques disponibles, et une estimation des frais. Les programmes établis au sein de la direction ou à l'extérieur, en vertu de cet Accord, portent surtout sur l'évacuation sur les terres riveraines des boues résiduelles et sur les méthodes de réduction de la pollution causée par les réseaux d'égouts pluviaux et mixtes.

LES HAUTES EAUX DANS LES GRANDS LACS

Les hautes eaux dans le réseau des Grands Lacs et l'érosion des terres en bordure de ces lacs ont posé bien des problèmes au personnel des eaux intérieures et des sciences de la mer. Le lac Ontario a en effet presque atteint son niveau record au printemps, et les lacs Érié, Saint-Clair, et Huron ont tous atteint ou dépassé leur niveau record du siècle. Au printemps, les violents orages ont provoqué de fortes inondations et une érosion intense du rivage. Lors d'une importante conférence de presse tenue le 15 mars au Centre, on a présenté deux brochures intitulées respectivement: «Ce que vous avez toujours voulu savoir au sujet du niveau de l'eau des Grands Lacs—sans savoir à qui vous adresser» et «L'Érosion des rivages—cause et remède»; deux nouveaux services de prévision(s) d'Environnement Canada ont indiqué les niveaux probables des lacs pour les six mois suivants, et enfin, le Service de l'environnement atmosphérique a prévu les houles sur ces mêmes lacs et donné des conseils à ce sujet.

Le personnel régional de la Direction des eaux intérieures à Cornwall, et le CCIW ont continué d'apporter un concours technique intensif aux conseils de contrôle de la Commission mixte, pour assurer que l'évacuation des effluents des lacs Ontario et Supérieur s'effectue de manière

à réduire les dégâts sur les terrains riverains et autres pertes financières. La Commission a mis sur pied pour le lac Supérieur un nouveau programme qu'elle a recommandé aux gouvernements canadien et américain. A la fin de l'année, l'étude de faisabilité d'un contrôle accru des niveaux des lacs, entreprise en 1964 par le Bureau international du niveau des Grands lacs (IGLLB), pour le compte de la Commission, était terminée en grande partie. Le Conseil devra cependant se pencher plus avant sur certains aspects de cette étude et tenir compte des niveaux records des Grands lacs en 1973 et de l'afflux d'eau qui en a résulté.

TERRAINS RIVERAINS ENDOMMAGÉS—GRANDS LACS

Devant l'étendue des dégâts dus à l'érosion du rivage et aux inondations, le personnel de la Direction des sciences de la mer et celui de la Direction des eaux intérieures du CCIW ont hâté leurs enquêtes sur les terrains riverains ainsi que les études sur l'érosion des rives. En réponse à la demande du Ministre, le CCIW a rédigé un rapport sur les travaux des quatre dernières années dans ce domaine. Ce rapport a été déposé aux Communes le 23 mars. Un groupe interministériel d'étude, dont la coordination est assurée par le CCIW, a présenté, par ailleurs, un rapport résumant toutes les données disponibles sur l'érosion des rives et les inondations dans l'ensemble du réseau Grands lacs — Saint-Laurent. On a convenu, dans le même temps, avec le ministère des Ressources naturelles de l'Ontario, d'entreprendre une enquête spéciale, approfondie, portant sur les dégâts causés en 1973 aux terrains riverains, sur leur emploi et leurs propriétaires, sur les taux d'érosion, ainsi que sur la protection contre l'érosion et les inondations. Les travaux de la Direction des sciences de la mer et de la Direction des eaux intérieures du CCIW, ainsi que ceux du ministère des Travaux publics effectués conjointement avec l'Ontario, dans le cadre de ce programme de $700,000, sont coordonnés par un groupe fédéral d'experts, à la tête duquel se trouve M. T.D.W. McCulloch, directeur régional des sciences de la mer. La liaison entre les gouvernements fédéral et provincial est assurée par M. J.P. Bruce, du CCIW, et M. W.A. Giles pour le ministère des Ressources naturelles de l'Ontario. On présentera, vers le milieu de l'année 1974, un rapport détaillé ainsi qu'un atlas de la zone côtière.

PRINCIPAUX PROJETS

Études hydrographiques dans l'Arctique

Intensification des études hydrographiques dans l'Arctique. Le brise-glace léger «NARWHAL» du ministère des Transports, de nouveau utilisé à la Baie James, a tracé le corridor navigable menant à Fort George. Bref voyage de reconnaissance effectué par le CCGS «N.B. MACLEAN» dans le Chesterfield Inlet. Plus au Nord, l'équipe chargée du projet «Polar Shelf» a parcouru la Baie norvégienne, tandis que des hydrographes de la région centrale participaient à deux trajets de recueil de données, l'un dans le détroit de Victoria, à bord du «JOHN A. MACDONALD», et l'autre vers les îles Ringnes, à bord du «LOUIS ST. LAURENT».

Études hydrographiques du lac Winnipeg

On a entrepris une étude hydrographique poussée du lac Winnipeg, devant durer cinq ans et au cours de laquelle on utilisera le système de positionnement Mini-fix et des chaloupes Bertram.

Recherche et développement—Direction des sciences de la mer

Le personnel de la Division de la recherche et du développement a réalisé un projet-pilote en vue d'une étude poussée des courants dans le bas Saint-Laurent, sur le CCGS «PORTE DAUPHINE». A la Baie James, prise de mesure océanographiques en été et hiver, pour évaluer les effets sur le plan maritime de la mise en valeur de cette région. On a confié par contrat à des organismes (1) l'élaboration de techniques de prévision des houles sur les Grands lacs, et (2) l'analyse et l'interprétation des mesures océanographiques à la Baie James.

Autres projets de la Direction des eaux intérieures

La création d'un service sur la Côte du Pacifique, à Vancouver, a permis d'étudier les sédiments et les aspects géochimiques du lac Babine, et de mettre sur pied un programme de limnologie pour les lacs de Colombie-Britannique. On a, par ailleurs, augmenté le personnel du service de la région de l'Ouest, installé au Freshwater Institute de Winnipeg. Ce service a participé à l'organisation d'une étude fédérale-provinciale du lac Winnipeg. Des spécialistes de Burlington ont, quant à eux, entrepris la réalisation de projets spéciaux concernant le lac Memphremagog, au Québec; la conception, sur le plan hydraulique, de grands ponceaux le long de l'autoroute Mackenzie, pour éviter d'entraver le mouvement des poissons, et l'évaluation des mesures par écho-son qui permettront de mesurer le charriage du gravier dans le lit de la rivière Vedder, en Colombie-Britannique.

MISE AU POINT PAR LE SERVICE DE LA PROTECTION DE L'ENVIRONNEMENT D'UNE TECHNIQUE DE TRAITEMENT DES EAUX USÉES

Les projets de traitement des eaux résiduaires des mines au Nouveau-Brunswick et de décharge des boues sur les terres en Colombie-Britannique, ainsi qu'un certain nombre de projets en Ontario, sont en cours de réalisation.

CRÉATION D'UN LABORATOIRE DE RECHERCHES HYDRAULIQUES

La nouvelle remorque-citerne, qui est utilisée à l'échelle nationale pour le calibrage des compteurs actuels, a été commandée en mars dernier; ce réservoir remplace l'ancienne installation à ciel ouvert de Calgary. Plus de 400 compteurs de 20 modèles différents ont maintenant été calibrés. L'installation de canaux de dépôt et de chambres froides pour les eaux glacées a été achevée, et l'aménage-

ment principal de canaux destinés à l'étude de la vitesse des vents et du mouvement des vagues sera terminé au début de 1974. En outre, certains projets portant sur la réaération des cours d'eau et la diffusion des chaleurs perdues dans les rivières et les lacs ont été mis en œuvre. Il convient également de signaler la mise au point de techniques d'échantillonnage combinées et de techniques d'échantillonnage dans les égouts d'eaux pluviales, qui ont permis d'établir un modèle mathématique de l'évacuation des eaux urbaines et de la qualité de l'eau.

COORDINATION DU PROGRAMME SUR LES PÊCHES

Les réunions de planification stratégique entre le personnel du Service des pêches et des sciences de la mer et les directeurs de la gestion et des recherches sur les pêcheries du ministère ontarien des Ressources naturelles (OMNR), ainsi que les étroites relations de travail qu'ont entretenu les stations de l'OMNR établies sur place et le personnel du GLBL, devraient donner lieu à une coordination efficace du programme relatif à la pêche sur les Grands lacs.

RECHERCHES SUR LES SUBSTANCES TOXIQUES

La Direction générale des eaux intérieures (IWD) et la Direction des recherches sur les pêches (FRD), qui travaillent de concert avec le Centre canadien des eaux intérieures (CCIW), se sont doté des moyens nécessaires pour établir un programme global de recherches sur les contaminants de l'environnement. Le programme porte sur l'utilisation estimative des substances toxiques au niveau de l'économie canadienne et des coûts que cela représente sur le plan social, le perfectionnement des méthodes d'analyse chimique, les recherches sur les déplacements et le comportement de ces substances, considérées isolément ou combinées à d'autres substances, ainsi que les effets des substances toxiques sur les milieux biotiques. Parmi les principaux résultats obtenus jusqu'à présent, citons notamment: une meilleure compréhension des phénomènes que produisent les substances naturelles «chelatantes» dans les réseaux de canalisation, une confirmation que la méthylation du plomb donne liau à un coefficient élevé de toxicité dans l'environnement, ainsi qu'une connaissance plus approfondie des éléments appelés PCB, que l'on retrouve dans l'eau, dans les sédiments et dans l'organisme des poissons (voir page 4, item 5).

RAPPORTS DE RECHERCHES ET CONFÉRENCES

Au cours de l'année, environ 120 rapports préparés par le personnel du CCIW ont été publiés dans les revues et bulletins du Ministère (Annexe B). Pour la deuxième année consécutive, un employé du Centre a remporté le prix Chandler-Misener pour le rapport le plus intéressant paru dans le Journal de l'Association internationale de recherches dans les Grands lacs. Le Prix a été décerné cette année au Dr. T. J. Simons pour ses travaux sur l'établissement d'un modèle mathématique de l'écoulement de l'eau des lacs. Des scientifiques du Centre ont également présenté 196 rapports à certaines conférences nationales et internationales (Annexe B). Le CCIW a organisé trois importantes conférences qui ont attiré plus de 1000 personnes au total. Il s'agit du American Water Resources Associates Symposium on Remote Sensing of Water Resources (Symposium américain sur la détection à distance des ressources en eau), du Symposium du Conseil consultatif de recherche de la Commission mixte internationale où il a été question de la présence de virus dans l'environnement et leurs effets nocifs éventuels, et enfin du Symposium du Chemical Institute of Canada sur les paramètres de la qualité des eaux—leur choix, leur mesure et leur contrôle. Le personnel du CCIW a en outre organisé un atelier de travail à l'Université de Guelph, où les participants ont analysé les effets du drainage des terres sur la qualité de l'eau.

NOUVEAUX NAVIRES DE RECHERCHES

On a fait l'acquisition de deux petits navires de recherche, le «ADVENT» et le «HILDUR», qui mesurent respectivement 77 et 116 pieds de longueur. Le premier est un cotre de grande vitesse, et le deuxième, qui a été construit en Norvège pour les fonctions qu'il remplit actuellement, a été vendu par les héritiers de feu. T. E. Eaton.

ÉTUDES SUR LE DÉVERSEMENT D'HYDROCARBURES

Sous la direction du Centre technologique de détection des hydrocarbures (COST-EPS) au CCIW, le Service de la protection de l'environnement (EPS), le Service des pêches et des sciences de la mer (F&MS) et la Direction générale des eaux intérieures (IWD) ont accéléré la mise en œuvre des programmes sur les techniques d'épuration des eaux polluées par les hydrocarbures. Le personnel du CCIW a contribué à l'établissement de la plupart des lignes de conduite ministérielles sur l'utilisation des dispersifs et des agents de regroupement chimique des hydrocarbures. Les travaux entrepris comportaient une analyse critique des techniques actuelles de détection à distance des nappes d'hydrocarbures, des études sur l'émulsification et le mélange d'hydrocarbures dans les eaux vives, ainsi que des évaluations sur place des divers dispositifs d'épuration, dont le DIP (plan incliné dymamique).

PROGRAMME DE LA BAIE DE QUINTE

De concert avec des organismes ontariens, la Direction des recherches sur les pêches (FRD) et la Direction générale des eaux intérieures (IWD) ont entrepris un programme dynamique dans la baie de Quinte dont les eaux, presque entièrement entourées de terres, sont, à plusieurs égards, aussi eutrophes que celles de la partie centrale du lac Érié. Les dimensions restreintes de la baie, comparativement à la superficie d'un grand lac, devraient permettre d'évaluer plus

facilement l'efficacité des mesures de contrôle au moyen de substances nutritives, mises en œuvre entre 1973 et 1975. Des bancs de limnées d'un type particulier ont été déposés dans les eaux, en vue d'analyser le cycle nutritif dans ce bassin, et d'entreprendre des expériences d'enrichissement. Les travaux se poursuivront pendant plusieurs années.

SERVICES TECHNIQUES ET INFORMATIQUES

Pour appuyer les programmes mis en œuvre au CCIW en 1973, les services techniques ont fourni plus de 60 systèmes principaux de prise de données et ont assuré l'entretien et le calibrage d'un grand nombre d'instruments courants, évalués à plus de 2 millions de dollars. Bien que l'industrie canadienne assure la majeure partie de ces travaux d'entretien par voie de contrat, l'administration de ces contrats incombe aux services techniques. Une unité de recherche et de perfectionnement dans le domaine des instruments a été créée cette année, en vue de mettre au point un système de contrôle sous-marin permettant de mesurer sur place des paramètres tels que le pH, la teneur en oxygène dissous, l'oxydo-réduction, ainsi que les coefficients de conductivité et de dispersion de la lumière. Un système d'ordinateurs CDC 3170, installé cette année et comprenant le nouveau système d'exploitation «MASTER», permet de dispenser aux utilisateurs du CCIW des services plus rapides et plus complets.

RELATIONS PUBLIQUES

Le programme de relations publiques, dont les cadres ont été élargis cette année, visait entre autres à expliquer les fluctuations de niveaux dans les Grands lacs, ainsi que les efforts déployés en vue de les régulariser. Outre la parution de la brochure et du dépliant mentionnés à la page 4, le Centre a commencé à publier un communiqué mensuel qui vient s'ajouter au nouveau service de prévision des niveaux d'eau. Un court métrage portant sur ce sujet est en voie de réalisation. De plus, un film consacré au Centre et à ses activités a joué un rôle important dans l'organisation de nouveaux programmes de visites publiques mensuelles, qui ont débuté à l'automne.

PARTICIPATION À L'ÉCHELLE INTERNATIONALE

À mesure que les programmes du CCIW deviennent plus connus, le nombre des visiteurs étrangers s'accroît en conséquences, et le Centre a été désigné comme l'institut nord-américain qui a le plus contribué au programme de mesures de l'OCDE sur l'eutrophisation des lacs. Le réputé scientifique R. A. Vollenweider a été nommé président du comité technique pour l'ensemble du programme. Les membres du personnel ont participé aux travaux de plusieurs comités et programmes de l'OCDE. À la demande de l'Organisation mondiale de la santé, le CCIW a consenti à préparer à contrat un ouvrage d'envergure qui s'intitulera «Guide to Water Quality Management» (guide destiné à la gestion de la qualité des eaux).

Environmental Management Service

Inland Waters Directorate—National Research

HYDRAULICS DIVISION

COMMISSION

The Hydraulics Division is responsible for the inception and implementation of a service and research program in hydraulics which is national in scope.

A national calibration service for hydrometric instruments, particularly current meters of all types is provided. Other types of testing may also be undertaken. Tests of a calibration nature are done to suit the user's specifications.

Research studies and tests are undertaken directly in the Divisional laboratory or indirectly by contract. Subjects of study are basic fluid dynamics, mobile boundary hydraulics, density currents, ice and cold weather hydraulics, wave dynamics erosion, coastal engineering and urban hydraulics. The aims are to bring about by systematic experiments a thorough understanding of natural hydraulics processes to provide estimates of the changes in regime caused by land and water developments and to seek the most efficacious practices and design methods which will mitigate undesirable environmental changes.

LABORATORY DEVELOPMENT

A sensibly large portion of the Divisional effort was devoted to the preparation of specifications, supervision of contractors and expedition of deliveries for the acquisition of major equipment in the Hydraulics Laboratory. A recitation of the various design decisions, problems, compromises and crises is not interesting in retrospect but it may be useful to summarize here the specifications of equipment operating or almost ready by December 1973.

1. Towing Tank and Carriage

Tank: Interior length 122 m
Interior width 5 m
Interior depth 3 m

Carriage: The carriage is a semi-automatic remote controlled unit installed by Westinghouse Canada Ltd. Speeds are controlled well within the specified limit of ±1% and there are three speed ranges:

0.5 – 6.0 cm/s
5 – 60.0 cm/s
50 – 600.0 cm/s

2. 1m Tilting Flume

This is a basic flume with glass walls. Maximum discharge is about 0.80/m^3/s. The dimensions are:

Width	1.0 m
Overall length	25.91 m
Wall height	0.76 m
Slope	Infinitely variable from 0 to 5%

3. 2m Flume

This flume is still undergoing final adjustments. It was designed primarily for sediment research and forms part of an integrated system described below.

Flume: The flume is a steel and aluminum structure with glass walls. Maximum discharge is about 0.80 m^3/s. The dimensions are:

Width	2.0 m
Overall length	22.8 m
Wall height	0.76 m
Slope	Infinitely variable from −1% to +1%

Sediment Feed: This is still under development but consists of a hopper, a supply system and sediment release mechanism. The basic dimensions are:

Hopper storage	9 m^3
Maximum feed rate	3.25 kg/sec (sand)
Accuracy of feed rate	about ±1%

Sediment Traps: Sediment leaving the flume is trapped in three stilling basins which can be elevated to remove and measure sediment. During the experimental set-up period, all sediment may be diverted to two of the traps, leaving the third central trap for the collection of material during the experimental stage. Basic dimensions are as follows:

Number of traps: 3

Overall dimensions of each trap:	
Length	10.98 m
Width	1.52 m
Height	2.13 m

The useful accumulation of sediment in each trap is about 2.8 m^3 for fine sediment.

Sediment Processing: A miniature granular material processing and conveying system has been installed. It consists of a fluidized bed dryer, a storage bin, a sieving system, an elevating and screw conveyor system which

can be used to reload the flume or to supply the hopper. The system can also be used to supply material for other parts of the laboratory.

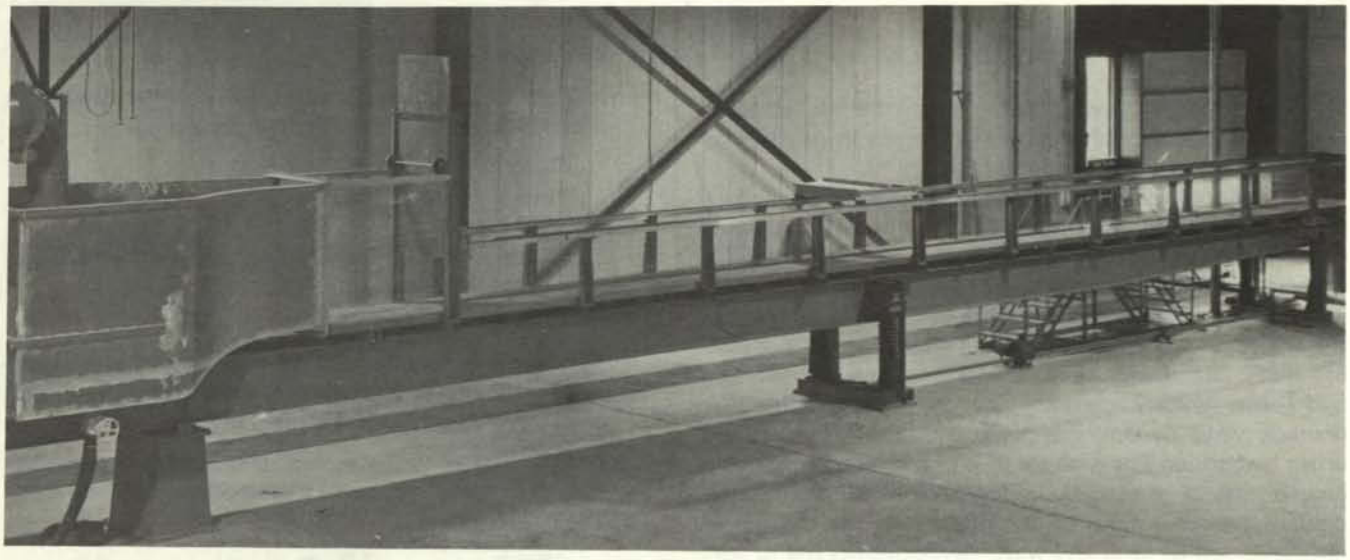
4. **Environmental Rooms**

These rooms were virtually completed by the end of 1973 and were in the testing stage in December. There are in total three rooms contained within a structure 18.3 m long by 6.1 m wide.

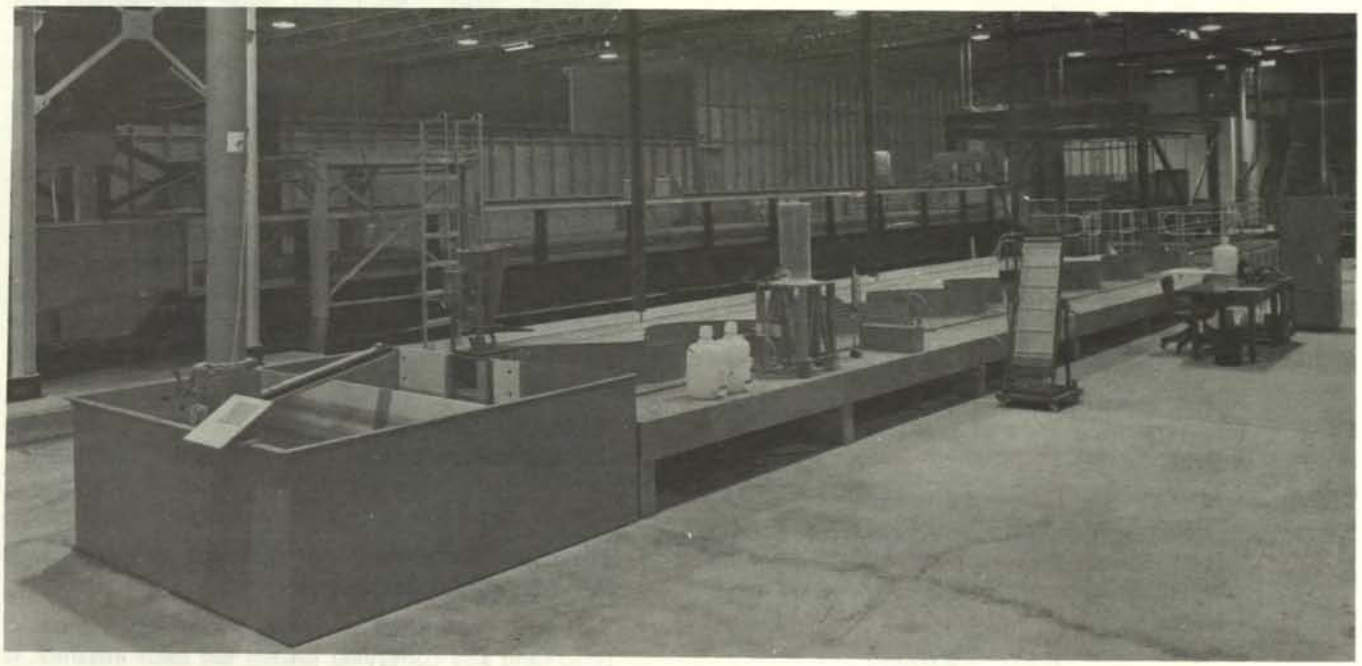
In Room B, designed for cold-weather testing of instruments, the specifications and dimensions are:

Length	6.1 m
Width	3.65 m
Height	2.43 m
Minimum temperature	−30°C
Temperature control limits	± 1°C
Temperature uniformity	± 2°C

Room A and Antechamber: The remainder of the total



View of tilting flume, 1-metre wide, in the Hydraulics Laboratory. Maximum slope is 5%.



View of inclined plane with meandering channel. Behind, the 2-metre wide tilting flume for sediment studies can be seen. Beyond that the wind tunnel for the wind/wave flume under construction is shown.

space is given over to a large rectangular room with a smaller attached antechamber. The whole space, however, is specified to meet the following:

Minimum temperature	−30°C
Temperature control limits	± 0.5°C
Temperature uniformity	± 1°C or better

Separate systems and controls are used for these two main areas. Air is circulated through the roof panels to avoid any local air jets. The cooling units always operate at full capacity, no shutdown is needed for defrosting and temperature control is obtained by adding heat to the cooled air supply. These rooms provide a unique testing facility for ice and cold weather research.

5. **Wind/Wave Flume**

Work began this year to install the wind tunnel, its fan, the circulating pumps, control room, data acquisition and control equipment, the programmable wave machine and the wave absorbing beaches. When complete, this flume will provide a unique experimental facility for work in coastal engineering, lake and reservoir problems, wave run-up, overtopping, forces on structures and optimum coastal protection designs. Basic studies on air water interactions will also be possible. When completed, the flume will have the following basic specifications. All should be ready by no later than July 1974.

The facility consists of a contrete flume with hammerhead beach. It will be enclosed by a wind tunnel and is intended for study of wind generated waves and their interaction with structures.

Description:		
	Width	4.5 m
	Height of side walls	1.48 m
	Gross lengths	83.25 m
	Hammerhead beach	13.70 x 19.2 m
	Maximum water depth	1.25 m
	Minimum water depth	0.60 m

Equipment for 1973/74:

Wave generator — a hydraulically driven piston which can generate uniform as well as random waves
- — frequency range — .125 cps — 3.33 cps
- — maximum stroke 0.7 m
- — a solitary wave can also be generated

Water recirculating system — water can be recirculated in the flume in either direction of a reversible, axial pump
- — maximum flow rate 0.85 m^3/s
- — maximum current velocity in the flume
  15 cm/sec (for depth 1.25 m)
  30 cm/sec (for depth 0.6 m)

Wind tunnel — a closed circuit of timber structure width 4.5 m; height of the ceiling above the top of flume side walls — 1.55 m.
- — air velocity range 15.2 cm/s — 15.2 m/s
- — accuracy of velocity control — plus or minus 1%
- — the velocity profile can be controlled at entry.

HYDROMETRY UNIT

In January, the towing carriage was turned over to the Division for operations and after some early minor adjustments, the carriage has been running steadily and reliably throughout the year. The first meters were calibrated on February 27, 1973 and since then a total of 400 meters have been calibrated ranging from simple impulse meters such as OTT or Gurley Price to more elaborate types such as Geodyne. The Unit designed and supervised the construction of a Great Lakes Water Levels display. This demonstration model shows the Great Lakes in their hydraulic aspect and correctly indicates relative surface areas, relative mean depth, stage discharge curves and flood routing through the system.

Hydraulic model studies of culverts to establish modifications to permit the passage of migrating fish were undertaken on behalf of the Hydraulic Design Assessment Committee of the Environmental Working Group on the Mackenzie Highway. The tests were done in the 1m flume and the results are expected to provide the data essential for engineering modifications to culverts where fish migration must take place under a wide range of conditions, it was essential to seek a virtually universally applicable solution.

TECHNICAL SERVICES UNIT

The Technical Services Unit is responsible for providing assistance to scientists and engineers of the Hydraulics Division with their projects. Duties range from design and construction of experiments to field and laboratory tests and measurements and subsequent analysis. A "light" machine shop provides repairs to current meters and to construct specialized small parts for experiments. The Unit also contracts work to local industry and co-ordinates work with the central machine shop at the Centre. At the latter portion of the year, carpentry requirements were such that it was decided to hire a full time carpenter so that there would be less danger to inexperienced technicians and to ensure quality of work in wooden structures.

Electronic maintenance of equipment is also provided and liaison and co-ordination with other specialized electronic groups at CCIW maintained.

During the year, the workload exceeded the available permanent manpower and the Unit added temporary technicians by contractual arrangements through technical manpower service companies.

RESEARCH ACTIVITIES

A systematic experimental study of the rate of reaeration of flowing water and the hydraulic parameters which control the reaeration was completed and a report prepared. For this study a special flume was designed and constructed.

The flume was designed by the Scientific Support Division. Its basic design specifications are as follows:

Length	31 m
Width	61 cm
Recirculating maximum flow	.028 m^3/s

The reaeration tests established that the reaeration coefficient k_2 for an open-channel flow, defined as the oxygen absorption rate divided by the oxygen deficit, could not be described by a single equation because the dimensionless reaeration parameter was a function of two variables, namely the Reynolds number and U_*/U where U_* is the shear velocity and U is the mean flow velocity. Figure 1 illustrates the experimental results. The results of this study are of major significance and value to scientists and engineers concerned with the formulation and value of models of oxygen depletion in river systems and on ways to artificially augment natural aeration of oxygen depleted waters.

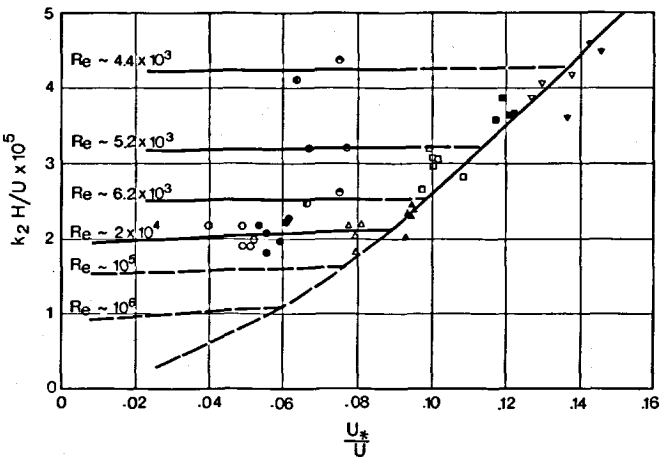


Figure 1. Dependence of the reaeration variable on Reynold's number and dimensionless shear velocity.

Previous work on the diffusion of heat or B.O.D. in straight channels was continued by using a specially designed inclined table in which channels of varying sinuosity could be constructed. In addition to a numerical solution for the convective diffusion equation, the experiments are being undertaken on a dimensional analysis basis to ensure that the parameters studied are independent.

Numerical methods to predict the nearshore wave surface energy from the offshore energy were developed further. Field measurements were made off Burlington Beach in an area where refraction effects are expected to be low. Waves are measured and telemetered to the laboratory by accelerometer wave recorders placed in deep and shallow water. Comparisons are being made of the observed and predicted energy loss from deep to shallow water. This work is expected to continue in 1975 at another location. In addition, experiments will be conducted in the laboratory.

During the spring, the occurrence of severe ice piling on the shores of Lake Simcoe was investigated and the likely cause and mechanism postulated. Calculations based on the thesis seemed to bear out the observations and a research paper was prepared and published. In the autumn, plans were again underway to measure the friction drag of water on the ice in the Grand River. A smaller number of stations was set up in this instance. In the spring the project had to be abandoned owing to very mild weather.

During the year, a very small wind tunnel was designed and constructed in the laboratory to study the feasibility of measuring evaporation from flowing water by means of natural radioactive tracers.

Near the end of the year, a study of oil spill booming techniques and a review of the criteria for placing oil spill booms was started. A research scientist was hired under a term contract to aid the Division with this work.

Laboratory and field studies were initiated to investigate the feasibility of estimating the transport of coarse sediments in rivers from the acoustic noise generated by rolling or impacting particles. Attempts to record gravel noise during spring runoff in the Chilliwack River in British Columbia were, however, unsuccessful because below normal runoff did not produce any movement of sediments at the observation site. The study is to continue in 1974.

A report outlining drainage and sediment control problems was prepared to assist in the formulation of environmental guidelines for land areas undergoing urbanization or development.

A second edition of a manual of S.I. Units for fluid mechanics was prepared and the opportunity taken to correct errors and improve some portions. This manual has proved to be in high demand from many sectors.

Work was also undertaken in support of the Canada/U.S. Water Quality Agreement and the Canada/Ontario Agreement with respect to reducing pollution from combined sewer systems. The Hydraulics Division supervised a contract with a consulting engineer to evaluate and develop a working numerical programme which would predict within acceptable limits the peak flow and the flow hydrograph in a sewer if the rainfall were known and certain characteristics of the terrain drained, described or measured. The studies were undertaken with close cooperation between the consultants and the Division and it was found that really usable knowledge was rather less than claimed in the literature. It was some time before three or four models could be evaluated. Field data were obtained to compare measurements with the models. Field studies of catchment areas were also done directly by the Hydraulics Division in support of the Canada/Ontario Agreement. It was found that measurements of fluid flow in sewers were subject to substantial errors making it virtually impossible to routinely obtain accurate information on pollutant discharges. The Division studied various commercial

sampling and flow measurement devices with the objective of recommending the most suitable and accurate method commensurate with acceptable cost. This work should prove to be of great potential benefit to municipal and consulting engineers.

In support of the Canada/U.S. Agreement, model studies were undertaken of the dispersion of sediment when it is released from a hopper in deep water, as is often done as a means of disposing of dredged material. The behaviour of such material is quite unknown and theories are being developed based on the experimental observations. It has been established that the sediment sludge does not behave in the same manner as a dense sludge of liquid released into a body of less dense liquid. In further support of dredging studies for the Canada/U.S. Agreement, specifications were drawn up and a contract was awarded to consultants to obtain and consolidate existing knowledge and data on the onset of sediment movement. A theory, based on probability, to define the onset of sediment motion has also been prepared and will be followed up with experimental work in the future. This study is to assist in determining whether means can be found to take advantage of sediment transport processes to reduce the frequency of dredging of contaminated sediment.

LAKES RESEARCH DIVISION

The objective of Lakes Research Division, in the broad terms of reference of Environment Canada and the Environmental Management Service, is to provide government with scientific knowledge needed for managing the freshwater resources stored in Canada's lakes. Accordingly, Lakes Research Division has two essential functions: 1) to perform basic research to increase scientific knowledge in the field of limnology, i.e., the science of lakes and lake behaviour or processes; and 2) to deliver scientific tools needed by management to solve present and future environmental problems related to lakes.

During 1973 a new organization of Lakes Research Division became operative, to better cope with revised objectives of the Division and to separate more clearly the responsibilities for resource survey and description (Lakes Resources Subdivision) from process oriented research (Geophysical Limnology Subdivision and Chemical Limnology Subdivision).

During the year, the Palaeoenvironmental Research Group of the Water Resources Branch from Calgary joined CCIW to work closely with Lakes Research Divison and is now emphasizing its activities in the Great Lakes region.

During 1973 the Division remained strongly involved in the International Field Year for the Great Lakes (IFYGL) but the major portion of the activities is now centered around tasks relating to the Canada/U.S. Agreement on Great Lakes Water Quality.

LAKES RESOURCES SUBDIVISION

Lakes Resources Subdivision undertakes and coordinates multi-disciplinary lake studies in connection with: IJC references, federal-provincial agreements under the Canada Water Act, and the Great Lakes Water Quality

Figure 2. Lake Superior network of measurement stations.

Agreement. Development of descriptive lake-assessment techniques, and limnological data processing form a major part of the work of the Descriptive Limnology Section at CCIW, Burlington.

In addition, research direction is provided to the regional Lakes Research Division component at the Freshwater Institute in Winnipeg, and to the newly-formed Pacific Region Detachment in Vancouver.

Great Lakes Surveys

The primary effort of the Descriptive Limnology Section during 1973 was devoted to continuing research surveys of open lake processes. The major survey of the year was carried out on Lake Superior as a portion of the IJC Upper Lakes Reference. Less intensive and less frequent surveys were carried out on Lakes Huron and Ontario while a combined effort, in cooperation with the United States Environmental Protection Agency, provided an intensive surveillance of Lake Erie.

All open-lake survey efforts consisted of comprehensive sampling programmes including physical, chemical, geological, biological, and microbiological parameters. As such, they are cooperative programmes planned by scientific staff of Lakes Research Division and Great Lakes Biolimnology Laboratories and carried out with assistance from Scientific Operations Division and the Great Lakes Water Quality Laboratory of the Water Quality Branch.

Lake Superior Survey: The Lake Superior survey was the first large-scale, comprehensive, lake-wide survey ever carried out on this lake.

The Lake Superior field programmes comprised a series of six monitor cruises; continuous measurements of meteorological parameters in mid-lake; and water temperature and current time series recording at thirteen moorings (Figure 2). The highly successful programmes yielded a large body of information on circulation, temperature structure, nutrients, major ions and trace metals, bottom sediments, productivity, phytoplankton, zooplankton and bacteriology.

Continuous current flow and water temperature information was obtained from late May to early October. The onset of general counter-clockwise flow in the lake was observed at the beginning of June. For the rest of the measurement period, flow direction was remarkably constant but strong fluctuations in current speed occurred, sometimes with a well-defined period of about five days.

The six monitor cruises at intervals of five weeks, starting in mid-May and ending in late November, were sufficient to describe, for example, changes in the nutrient content of surface waters between the times of spring overturn and the start of winter overturn (Figure 3a). For each cruise, strong correlations occurred among circulation, temperature structure, and distribution of measured chemical parameters. Internal adjustment of the distribution of density to the counterclockwise flow occurred, requiring accumulation of warm surface water on the periphery and upwelling in the middle, with the result that in mid-lake surface temperature was lowest, the hypolimnion shallowest, and nutrient concentrations highest (Figure 3b).

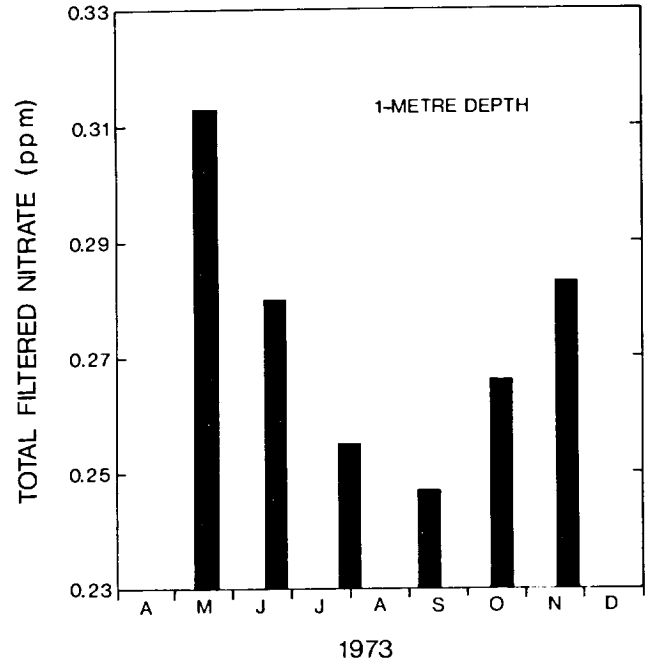


Figure 3a. Lake Superior average nitrate concentration at 1-metre depth.

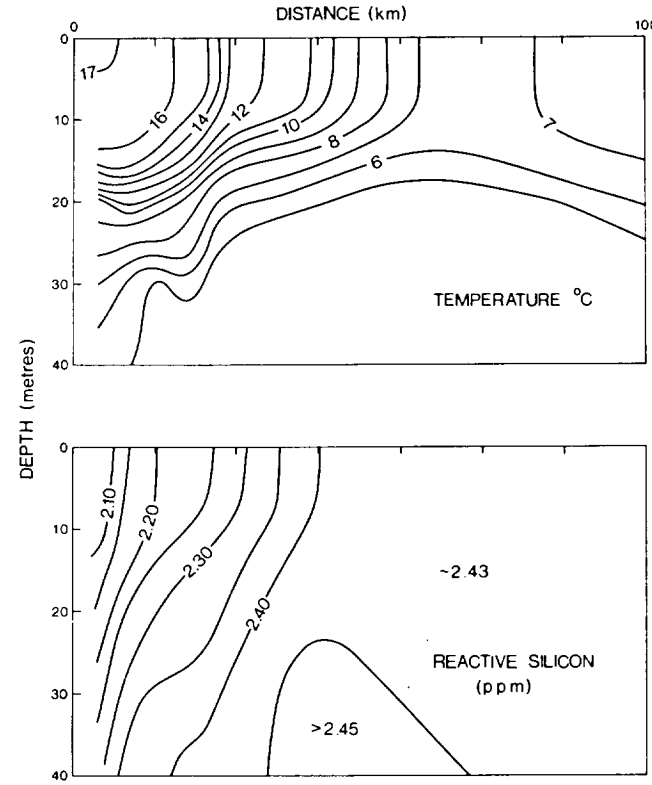


Figure 3b. Vertical cross-section of temperature and reactive silicon concentration for Lake Superior, August 1973.

Lake Erie Surveillance: The experimental measurements carried out on Lake Erie during 1973 were designed to test the ability to determine lake status from a less comprehensive but more intensive series of measurements. Three cruises were carried out by CCIW on which intensive nearshore measurements of the primary nutrients were conducted. These cruises were coordinated with weekly or bi-weekly cruises sponsored by the U.S. Environmental Protection Agency on which a limited number of parameters were measured. Emphasis was placed on determining hypolimnetic oxygen depletion.

While final analysis of these data is not complete, anoxic conditions were again observed in the hypolimnion of the Central Basin. Examination of the phosphorus levels observed during 1973 and prior years has been completed. An examination of data for 1970 shown in Figure 4 indicates that the phosphorus content of Lake Erie in any one year is highly variable. This makes any trend assessment difficult to establish. However, there seems to be a slight decrease in the phosphorus concentrations in the Western Basin, while the Central Basin apparently shows an increase. There is no discernible change in the Eastern Basin levels. Such observations must continue in future years if trend patterns and steady state concentrations are to be established.

A report on the status of chemical parameters in Lake Erie has been prepared for the IJC.

Lakes Huron and Ontario: Few surveys were conducted on Lakes Huron and Ontario during 1973. Three cruises were conducted on Lake Ontario as a follow-up to the International Field Year and two very abbreviated cruises were carried out on Lake Huron on which only the Water Quality network stations were sampled.

Further analysis of the extensive Lake Huron measurements of 1971 and 1972 was carried out and reported to the IJC.

Preliminary analysis of the Lake Ontario IFYGL measurements has been carried out on available data. However, a large portion of the observations remain unverified and will not be available for analysis until some time in 1974. Preliminary analysis of Lake Ontario data has been incorporated in the 1973 IJC status report.

Studies of primary production were made on several cruises on Lake Ontario during IFYGL. Daily production was computed based on a series of limited period *in situ* C^{14} experiments, covering all daylight hours. As an example, the primary production at an offshore station in Lake Ontario is shown in Figure 5.

Trends in Great Lakes Water Quality

Dissolved inorganic nutrients and related water quality in the four international Great Lakes have been summarized and compared in a paper, A Summary and Comparison of Nutrients and Related Water Quality in Lakes Erie, Ontario, Huron and Superior by Dobson, Gilbertson and Sly (in press). Data analysis was devoted to obtaining mean values in surface waters in a large offshore region in each basin. It is recognized, however, that detailed sections and plans of the distributions would also be useful at a more detailed level of interpretation. The summary includes those parameters that will be needed in an assessment of long-term trends.

A preliminary scheme for characterizing surface waters has been derived from analysing observations of Lakes Erie and Ontario. From the relationships observed, it is suggested that the trophic state of the lake can be characterized "mesotrophic" if the following variables fall within the given ranges:

Secchi depth (transparency) 6.0 to 3.0 m
Total chlorophyll *a* 4.4 to 8.8 μg/l
Total phosphorus 8.7 to 17.4 μg/l

This scheme is tentative and requires further verification but does appear to be able to define significantly different trophic conditions observed in the Great Lakes. For example, a graph of secchi depth cycles and interpretive ranges is given in Figure 6. Secchi depth reciprocals are used as a linear scale in the left and secchi depth as a corresponding non-linear scale on the right.

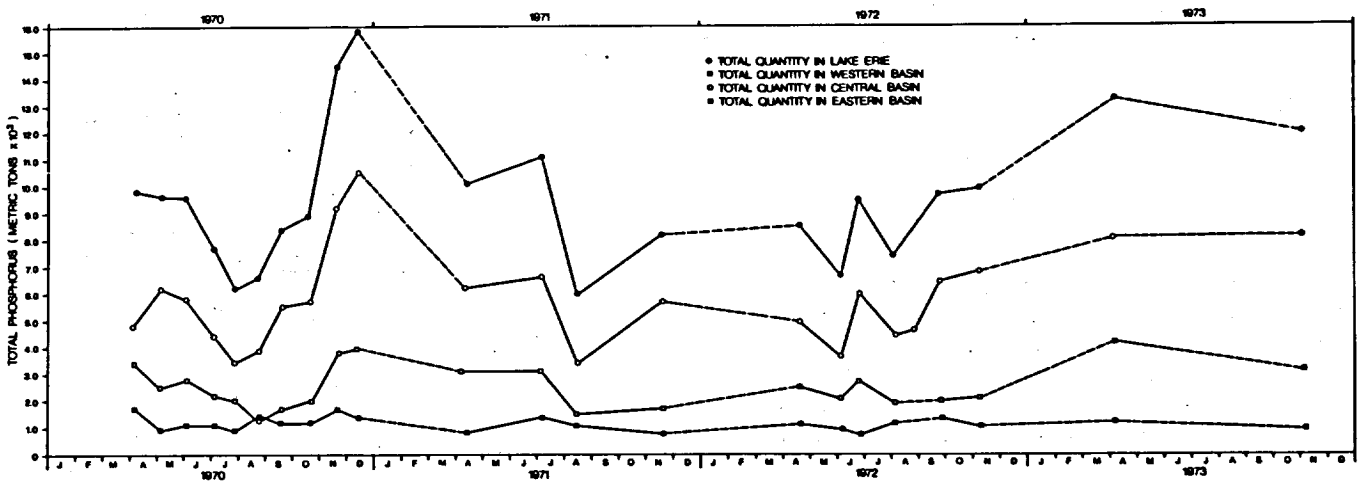


Figure 4. Quantities of total phosphorus in Lake Erie, 1970-73.

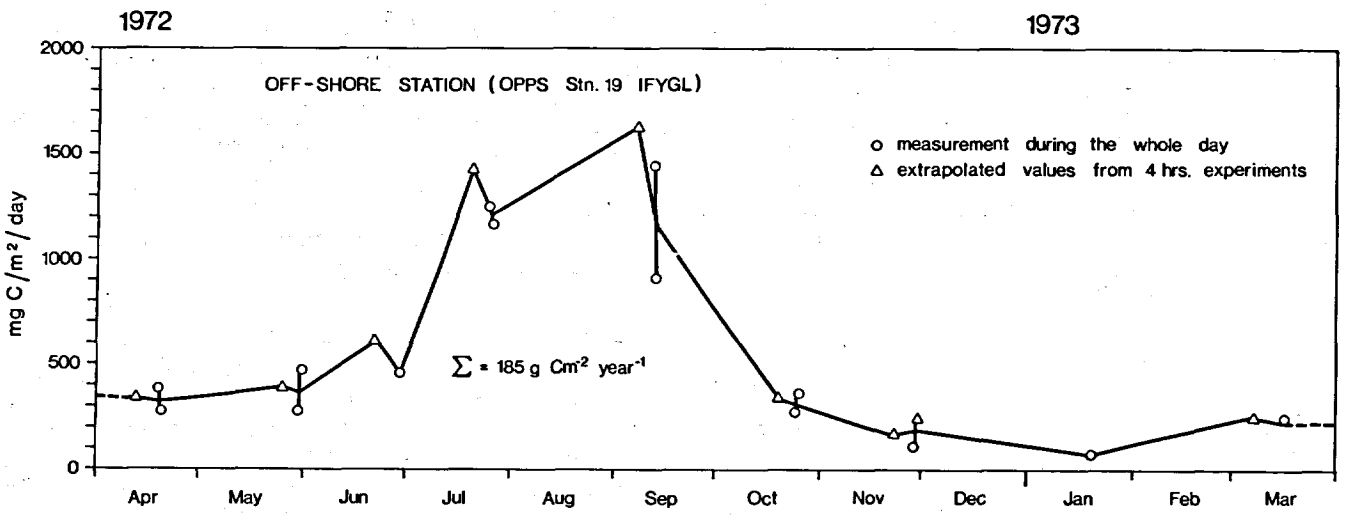


Figure 5. Daily carbon uptake rates in Lake Ontario (offshore station).

Waste Heat Studies

Studies related to the disposal of waste heat in the Great Lakes area have been undertaken by several groups within the Centre: Lakes Research Division, Social Science Research and the Great Lakes Biolimnology Laboratory. This section will deal only with the projects carried out within Lakes Research Division.

The 1973 programme has been carried out through two industrial contracts and one in-house project. These three projects form a portion of the overall effort aimed at defining the environmental effects of waste heat and the costs of alternate methods of heat disposal.

(a) Study of the Benefits and Costs of Offshore Diffusers as Waste Heat Discharges: This project was contracted to H. G. Acres Consulting Services Ltd., Niagara Falls.

A physical model of an offshore diffuser outfall has been developed which simulates the plume dimensions in terms of the thermal contrast to the environment. This model has been applied to all existing power generation sites on the Great Lakes and to typical sites for projected development to determine the benefits gained through reduction of lake area affected by the heated discharge. Estimates were made for the cost increases over direct shore outfalls.

(b) Study of the Effects of Waste Heat on the Water Budget of the Great Lakes: This project was contracted to H. G. Acres Consulting Services Ltd., Niagara Falls.

Waste heat rejected to the waters of the Great Lakes causes a change in the lake energy budget through increases in heat input. This causes the lake temperature to increase and the heat to be dissipated by increased evaporation, radiation and sensible heat. Increased evaporation influences the water budget of the lake.

This study (which is not yet complete) is to assess the magnitude of the water loss to the Great Lakes System due to the addition of heat. The water loss which would occur if wet cooling towers were employed will also be estimated to compare relative influences on the water budget.

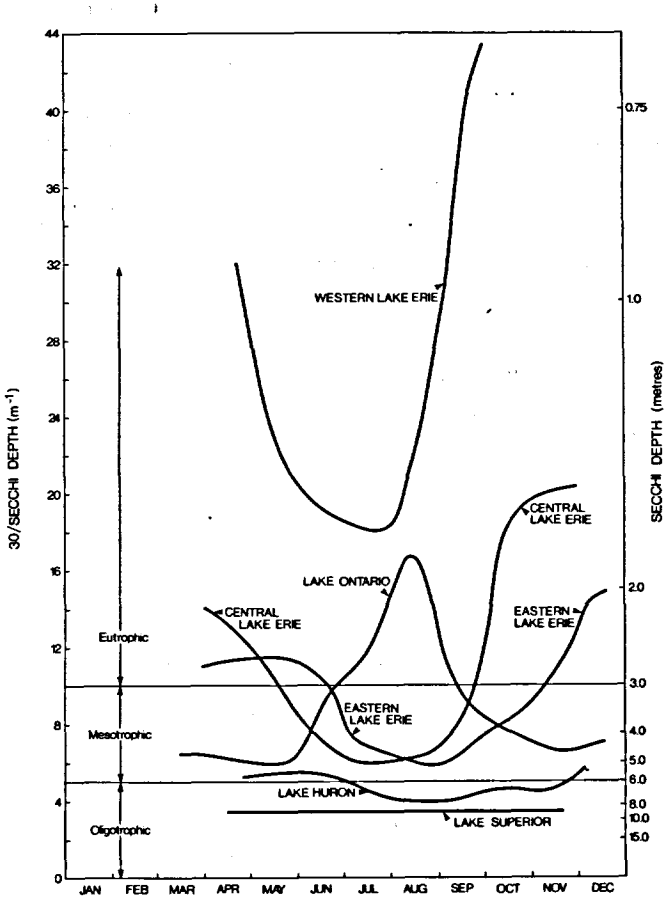


Figure 6. Seasonal cycles of turbidity in surface waters of the Great Lakes as indicated by secchi depth observations. The smoothed curves were drawn from data obtained on synoptic cruises by CCIW in 1969-1971.

(c) Lake Ontario Nearshore Temperature Analysis: Measurements of the nearshore water temperature of Lake Ontario made over the past three years have been compiled and analysed statistically to describe the natural thermal regimes. Means, standard deviation, and coefficient of variation were determined for the data available each month at Kingston, Point Petre, Cobourg, Oshawa, Toronto, Burlington and Port Weller. Similar daily computations were made for Oshawa for January and February to determine winter variations. A mean daily standard deviation for this month was found to be 0.17°C.

Correlations between sites were computed to determine the necessity of the number of stations to describe the nearshore regime. Extremes of the correlations are shown in Figures 7a and 7b which relate Cobourg and Oshawa and Oshawa and Burlington respectively.

Fate of Organic Compounds from Point Source Effluents

In 1973 a feasibility study was carried out to determine the extent and effect of the mixing zone of the effluent from a Kraft Pulp Mill at Marathon, Ontario, on Lake Superior. In this study, Lakes Research Division attempted to identify individual organic compounds (especially those known to be toxic or to cause fish tainting) and to determine their zone of influence in the receiving water.

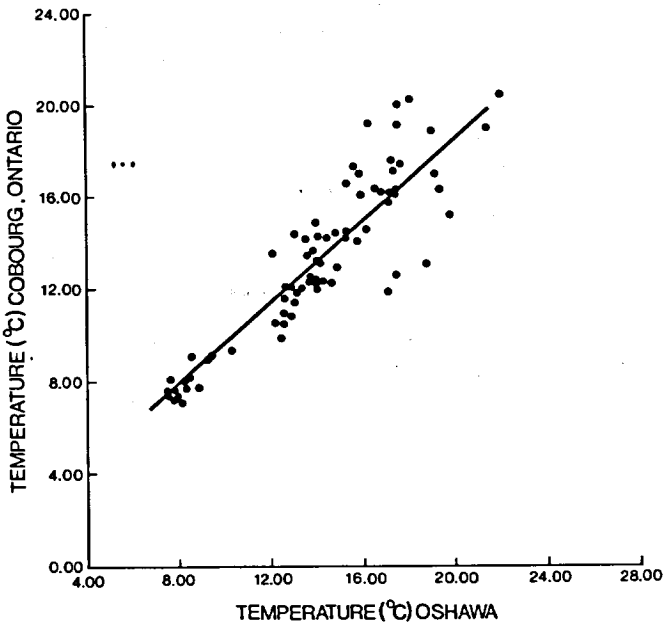


Figure 7a. Correlation of 10-metre depth water temperature off Cobourg and Oshawa.

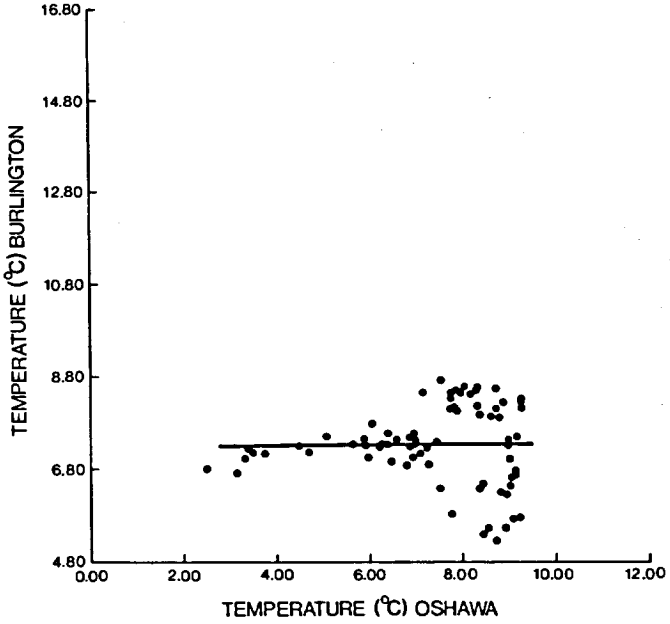


Figure 7b. Correlation of 10-metre depth water temperature off Oshawa and Burlington.

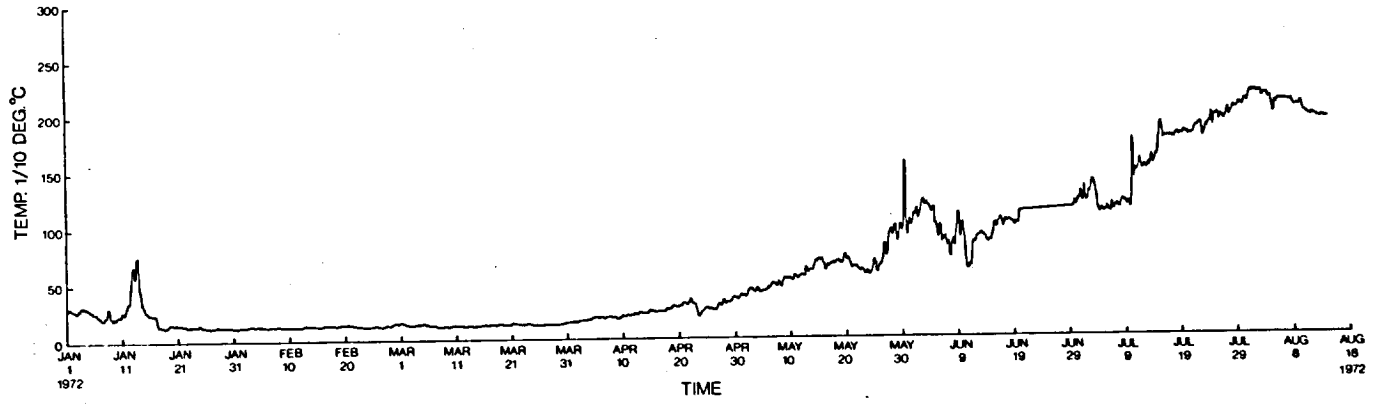


Figure 7c. Normal weighted running mean, Kingston bottom sensor, 1972.

A practical method of extracting the organics was devised using a macroreticular resin (XAD2). Samples were collected in a cooperative field programme with Great Lakes Biolimnology Laboratory. The amounts of organics recovered were found to be closely related to dissolved organic carbon measurements and to sodium ion concentration, indicating overall dissipation by simple mixing with the receiving water. Individual compounds are currently being separated and identified by GC/MS and it is hoped to determine whether significant differences in individual dissipation rates occur due to processes such as absorption, degradation or uptake by organisms.

Determination of Energy Fluxes for Lake Ontario during IFYGL

Meteorological data measured from 19 April to 5 December, 1972, during the International Field Year, have been evaluated to determine the magnitude and time variation of the fluxes of heat and moisture (evaporation or condensation) from Lake Ontario. The analysis has employed conventional exchange coefficients applied to hourly averaged meteorological observations obtained from only the Canadian portion of the IFYGL network. Lake-wide estimates of the fluxes have been obtained by computation of a best fit second order surface to the existing data.

The resulting estimates of daily fluxes of heat and moisture were summed over weekly periods for comparison with other terms of the lake energy budget. The resulting weekly values are shown in Figure 8. While these values must be considered preliminary due to lack of data from the United States network, they give a useful estimate of the total fluxes and of the time variations throughout the year.

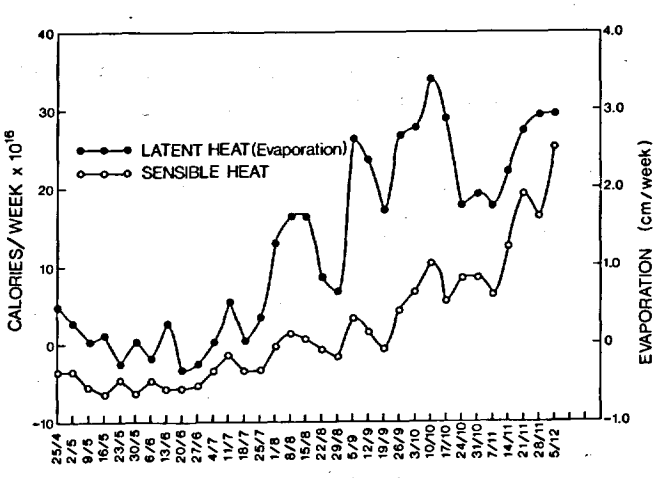


Figure 8. Preliminary estimates of heat fluxes for Lake Ontario during the International Field Year 1972.

Current Measurements in the Great Lakes

Measurements of current flow and temperature in 1973 were made in three lakes: in Lake Superior, as part of the IJC Upper Lakes Reference; off Douglas Point in Lake Huron, in support of a waste heat study; and off Bronte in Lake Ontario, as a major part of an investigation of the characteristics of the nearshore flow regime. The last two studies are described under activities of the Physical Limnology Section. In Lake Superior, time series records were obtained at thirteen moorings (31 current meters) during the May to October period (Figure 2). Included among these were measurements off Eagle Harbor, Michigan, which were part of a study of the Keweenaw Current, carried out in cooperation with the University of Wisconsin, (Madison).

Current meter data processed and edited during the year included 1972/73 winter observations from Lake Ontario for the IFYGL program; most of the data from the projects mentioned above; all of the past information obtained by CCIW in Lake Huron; and some of the existing files for Lake Erie. Limited data processing was also provided for Marine Sciences Directorate (CCIW) and the Ontario Ministry of the Environment.

Meteorological Support Program

Meteorological measurements made in support of the scientific programs of the Centre continued in Lakes Research Division during 1973 (Figures 9a and 9b). The measurements were made (a) as a continuation of the IFYGL Energy Balance study of Lake Ontario, (b) in support of the comprehensive Lake Superior Survey for the Upper Lakes Reference, (c) in support of the Bay of Quinte studies, (d) in support of the Kenora ELA studies and (e) in support of the Wolfe Island ice movement studies (Glaciology).

Data were generally obtained through use of the automatic meteorological system mounted either on buoys or towers. In some cases only solar radiation records were obtained. Data have been processed and validated and used to compute the energy fluxes for Lake Ontario or in support of special project requests.

CCIW Winnipeg Detachment

A small group is working in conjunction with the Freshwater Institute in Winnipeg. Dr. T. Jackson is Acting Head of the group whose work is presented in the following sections.

An additional staff member is being sought as programmes develop in response to IWD Western Region problems. To a substantial degree, the future interest lies with lacustrine aspects of reservoirs.

Dynamics of Fluctuating Surface Currents

The dynamics of fluctuating surface currents responsible for the formation of windrows are being studied on Lake of the Woods. Although this phenomenon is universal to all fresh and marine waters, Lake of the Woods is dominated by windrows of surface foam whenever the wind is sufficiently strong to produce breaking waves. These surface windrows result from the foaming tendency of the eutrophic waters of the lake and its large blooms of blue-green algae "aphanizomina flos aqua." Pulp mill effluents which foam profusely are also characterized by intense surface windrows. Heavy rainfall has been observed

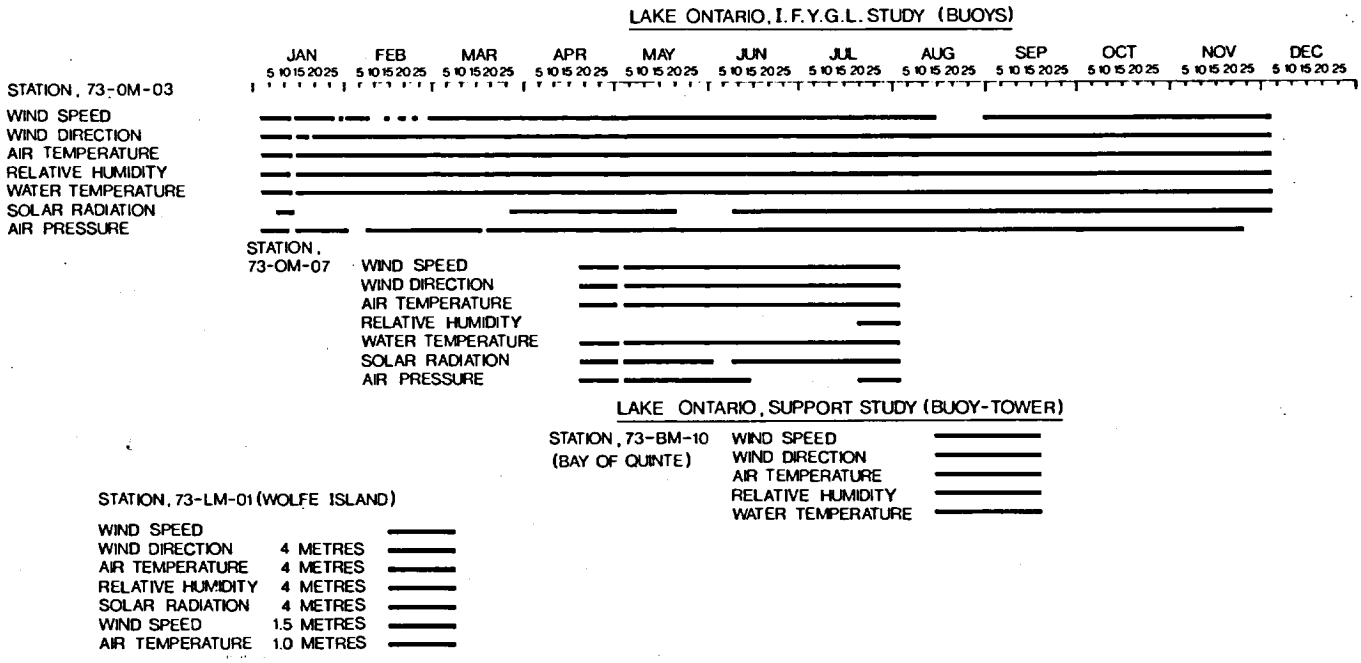


Figure 9a. Record of meteorological measurement data.

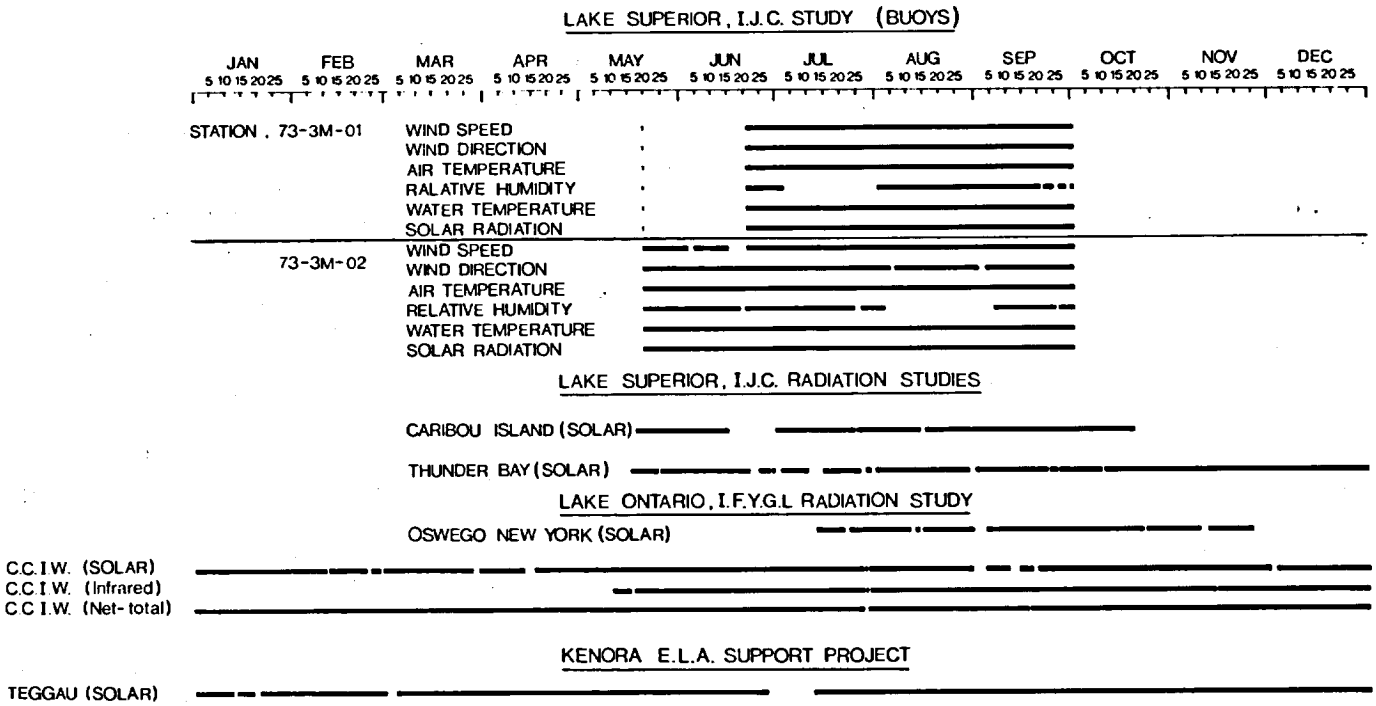


Figure 9b. Record of meteorological measurement data.

to completely attenuate surface windrows by breaking up the foam while leaving the sub-surface, quasi-organized current structures unaffected. These same fluctuating currents also produce a striated effect in subsurface effluents which may be observed in the absence of surface windrows. This is the more usual situation in the Great Lakes which have little tendency to foam.

Windrows of surface foam on Lake of the Woods.

Length and time scales of windrows were measured by time lapse vertical aerial photography as a function of wind speed, fetch, surface waves and water depth. Simultaneous measurements of velocity shear and the vertical correlation of current and temperature fluctuations and their phase relation to visible windrows were curtailed when the instrument platform collapsed during an intense line squall early in the field season.

Biogeochemistry of Lake Sediments

Research in 1973 was concerned with the role of humic matter in the biogeochemistry of phosphate, transformation of labelled phosphate and the biogeochemistry of the sediment-water interface.

Samples were collected from the Experimental Lakes Area (ELA) of northwestern Ontario, from a lake in southwestern Manitoba and for Clay Lake, Ontario. Some cores have been prepared for electron microprobe analysis and the mud and water samples analysed for Fe, Al, Ca, P and C. Considerable time has been spent on testing various procedures to extract and isolate humic complexes of metal and phosphate.

Results so far strongly suggest that the organic phosphorus compounds of approximate molecular weight 250 may be nucleosides or a similar type of compound. Lake sediments show some regularities in the Sephadex fractions in their chemical composition and properties. Information is developing on the binding of phosphate and added ^{32}P in humic matter, and on the partitioning of added phosphate between the water and mud. Information is also being developed on the relation between phosphorus, iron and aluminum in the fulvic and humic acid from lake muds (ELA).

Palaeoenvironmental Interpretation of Cultural Eutrophication

An investigation of the change in succession of fossil communities is being carried out on lake cores from the Bay of Quinte, Lake Ontario. This may reflect changes in the trophic status of the body of water.

Results clearly indicate that such changes are associated with cultural development. Pursuing the question further, the chironimid necrocoenosis is being investigated to establish whether it follows the natural orderly sequence of community succession on an accelerated time scale in culturally reduced eutrophication or whether some stages are obliterated. Questions are also being asked to determine whether the effect of pollutants is reversible and whether they affect chironimids directly or indirectly through depletion of oxygen levels.

Pacific Region Detachment

During 1973 CCIW established a detachment in Vancouver to carry out CCIW operations in the Pacific Region of the Inland Waters Directorate. Much time during the first months of operation was spent in overseeing the acquisition and installation of two laboratory trailers at the Pacific Environment Institute, 4160 Marine Drive, West Vancouver. In spite of a four month delay in delivery of these trailers, field work on four British Columbia lakes was undertaken by Detachment staff.

Pacific Region Limnological Survey

The objective of the Pacific Region Limnological Survey is to establish a series of data reports on the physical, chemical and geological limnology of the major lakes of the Pacific Region (Figure 10). It is anticipated that this continuing study will eventually cover most of the significant lakes of the Pacific Region. A detailed literature search is performed to appraise limnological knowledge of each lake before the lake is surveyed in he field. The field work is designed to provide a detailed picture of geological processes operating within the lake, and to allow a general classification of the lake by its descriptive limnology.

Pitt Lake, draining into the Fraser River close to Vancouver, was studied in 1973 because of its proximity to the new laboratory. Pitt Lake is tidally influenced through its connection with the lower Fraser River, and exhibits a large delta-form structure at the south end of the lake where the Pitt River drains to the Fraser. It has been theorized that this "delta" has been deposited by tidal currents entering the lake.

Great Central Lake on Vancouver Island has been the object of a five year fertilization experiment operated by the Pacific Biological Station, Nanaimo. Because this fertilization project has effectively doubled the phosphate loading to Great Central Lake over the natural level in each of the last five years, Dr. J.D.H. Williams of the CCIW is investigating phosphate diagenesis in the surficial sediments of this lake. To assist Dr. Williams in his program, the

Pacific Region CCIW staff elected to study Great Central Lake under the Limnological Survey project. Sounding, surface grab sampling, and coring of this lake were done during 1973 in conjunction with Dr. Williams' study.

Kamloops Lake, on the Thompson River System of the B.C. Interior, is being intensively studied by a number of government agencies under a Federal-Provincial agreement signed during 1973. The Pacific Region detachment anticipates completing an intensive physical, chemical and biological study on Kamloops Lake during the 1974 field season, and in preparation for this, Kamloops was designated as a Limnological Survey lake during 1973. A detailed echo sounding survey was run in the lake to delineate sediment distributions, made complex by the influence of the large Thompson River flowing through it. Over 40 samples were taken with a Shipek sampler and about 10 cores were collected. Sample analysis and data reduction on Kamloops Lake material were given priority during late 1973 and early 1974.

Babine Lake Studies

The CCIW detachment attempted two projects on Babine Lake during 1973 in cooperation with the established Babine Watershed Change Program. Studies were planned on the sedimentology, historical geology, and sedimentary geochemistry of this large and important lake which drains via Skeena River to the Pacific Ocean. These studies were hampered during 1973 by logistic difficulties but it is anticipated that the Babine Lake work will be completed during the field season of 1974.

Future Studies

During 1974, it is anticipated that the Pacific Region detachment staff will increase to five scientists with accompanying technical, field operational, and clerical support. Projected studies under the Limnological Survey Project include the completion of work on Great Central Lake, Pitt Lake, Babine Lake, and Kamloops Lake (geological studies only). In addition it is planned to initiate a geological programme on Kootenay Lake in southeastern B.C. and to acquire the capability to work on remote sub-Arctic lakes in the Yukon.

The greater part of the Detachment's effort, however, will go to Kamloops Lake for an integrated study involving physics, chemistry, and biology. The study will be undertaken as a national programme with additional support from CCIW in the form of equipment, field personnel and analytical assistance.

As a general summary, more than 50% of all the Division's resources are presently committed to support the Canada/U.S. Agreement. Consequently in the Division, scientific research aimed at more fundamental problems has been reduced. Hopefully, however, continuation of long-term research aimed at a more basic understanding of processes in lakes will be broadened again in the near future.

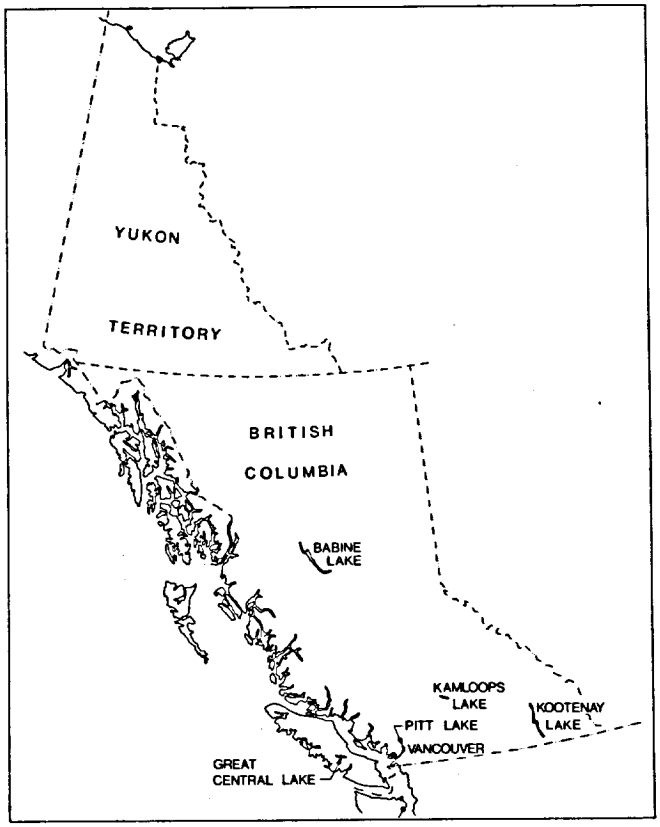


Figure 10. Lakes under study by the Pacific Region Detachment.

CHEMICAL LIMNOLOGY SUBDIVISION

This group of specialists provides fundamental understanding of chemical processes in lake waters within the broad field of chemistry. In addition, the subdivision carries out studies on the impact of introductions of natural and man-made substances in lake systems, with special emphasis on their limnological behavior, complex interactions and relationship to lake water quality.

Water Chemistry Section

The projects carried out in this section include measurements of the partial pressure of carbon dioxide in air over Lake Ontario, laboratory investigations of the methylation of lead, the impact of chelated and excess copper on algae, the identification of individual trace organic compounds from lake water by GC-MS-computer analysis, the solubilities of various metal carbonate species, and the thermodynamics of model brine solutions.

Complexing Capacity of Lake Waters

A sensitive and accurate method to determine the complexing capacity of lake waters was developed in cooperation with Dr. René Gächter (visiting scientist from the Swiss Federal Institutes of Technology, Federal Institute for Water Resources and Water Pollution Control). This method was applied to a study of the relationship of the complexing capacity of the nutrient medium and its relation to the inhibition of algal photosynthesis by copper.

It was found that the complexing capacity of a water sample does not guarantee that the equivalent amount of copper could be tolerated by the system without adversely affecting phytoplankton production. The results of this study suggest that (free)ionic copper is probably already toxic to planktonic algae at concentrations in the order of 10^{-10} mole/l.

Methylation and Toxicity of Lead

Preliminary experiments indicated that inorganic (lead nitrate) and organic lead (di- and tri-methyl) can be converted by microorganisms to volatile tetramethyl lead only under anaerobic conditions in lake sediment. The conversion from di- and tri-methyl lead to tetramethyl lead is much more rapid than that from lead nitrate in a simulated lake water-sediment culture system. The methylation of lead has not been reported in the literature before. The methyl lead compounds (di- and tri-methyl) were found to be much more toxic to algae and bacteria than the inorganic lead.

In connection with this joint project with Great Lakes Biolimnology Laboratories, a method has been developed to determine the various forms of methyl lead. Studies in progress include factors affecting the methylation process, the pathway of the methylation and the concentration of methyl lead compounds by aquatic biota.

Metal-Fulvate Complexes

Conditional stability constants, K, of some metal fulvate complexes have been determined at 25°C using specific ion electrodes. The log K values are graphically shown in Figure 11. The order of metal affinity towards fulvic acid (a natural ligand) is in general agreement with that towards artificial ligands such as NTA and EDTA: Hg(II) > Cu(II) > Cd(II).

Soluble Organic Compounds in Lake Water

Sampling was undertaken on all four of the international Great Lakes. Ten metre samples from geographically separated stations (main lake) were obtained for each lake, except Erie, during both spring and autumn periods. For Lake Erie, the sampling occurred during spring, mid-summer and late autumn as well as summer sampling at hypolimnion depths and a mid-lake time series. All samples were filtered immediately (0.22 μ) and stored in full sterile glass bottles previously cleaned with chromic acid.

All samples were continuously extracted with chloroform (as 0.1 M NaCl solutions). Samples are being analysed by gas chromatography-mass spectrometry and comparison of the spectral data is being undertaken with data stored in a computerized spectral library.

Chloroform extractable material was found in the following concentrations (average and range given in mg/l):

	Spring	Summer/Autumn
Ontario	.32 (.18-.93)	.30 (.22-.50)
Erie	.28 (.18-.53)	.31 (.21-.56)
Huron	.17 (.11-.21)	.29 (.24-.38)
Superior	.25 (.16-.44)	.26 (.25-.28)

Resin Acids

Resin acids are produced by coniferous trees, and are introduced into waters in pulp and paper manufacturing. They are fairly toxic to aquatic life, so their fate in the environment is of practical importance as well as an interesting problem in biochemistry. A number of strains of bacteria (all grain-negative rods) which are capable of growing in media containing resin acids as the only carbon source have been isolated from water and soil. The action of these organisms on resin acids is being investigated.

The CO_2 Project

From August, 1972, to March, 1973, the non-dispersive infrared CO_2 analyser and air sampling system was installed on the "Martin Karlsen". The CO_2 concentration in the air over Lake Ontario was measured continuously on five cruises and the partial pressure of CO_2 on the lake was calculated. The air concentration was lowest in the fall (~320ppm) and highest in the winter (~335ppm). A diurnal cycle, caused by photosynthetic activity, was observed in the summer months, with lowest values in the evening. The partial pressure on the surface layers of the lake was below atmospheric in the summer, causing a CO_2 flux into the lake of 0.1 – 0.5 gC m^{-2} day^{-1}. In the winter, the lake concentrations were above atmospheric and, because of storms, the flux out was 2 – 3 gC m^{-2} day^{-1}.

In the fall of 1973, an improved version of the sampling system, which allowed a direct determination of CO_2 partial pressures in water, was taken to the Bay of Quinte for measurements on the limnocorrals installed by

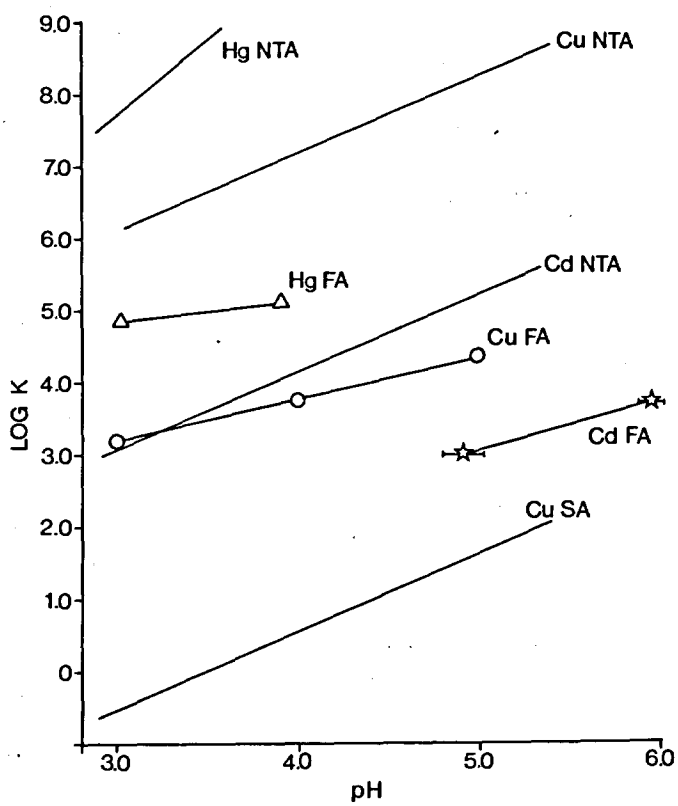


Figure 11. pH dependence of some conditional stability constants.

Dr. D. Lean. Subsequently the equipment was installed on a tower about a mile offshore near Burlington to obtain better CO_2 flux measurements in conjunction with experiments by Mr. E. I. Mukammal of AES. The equipment functioned improperly and the experiment was terminated when the tower collapsed in a storm in October. Fortunately, the analyser had been taken ashore for servicing.

Multicomponent Brines

Thermodynamic measurements are underway on the system H_2O – NaCl – Na_2SO_4 – $MgSO_4$ which is saturated with (halite) NaCl, and future studies will include those on the same system saturated with other minerals.

Metal Carbonates

A rapid system to measure the solubilities of simple carbonates and hydroxycarbonates under a controlled atmosphere of CO_2 pressure was set up and preliminary data were obtained for otavite ($CdCO_3$), malachite ($Cu_2(OH)_2CO_3$), cerrussite ($PbCO_3$), and poorly characterized carbonates of Ni and Zn. The results for malachite and cerrussite agree with previously published data; the results for otavite indicate that it is about an order of magnitude more stable than previously reported.

Precision in Monitor Cruise Data

At the 95% confidence level, there was little significant difference between bottle and pump sampling methods for most of the parameters examined. Precision was largely dependent on the sampling rather than the analytical procedures and it is recommended that any efforts at improvement be directed along these lines. Recommendations have also been made that the monitor programme incorporate regular statistical sampling and that the results be presented along with the data listings.

Geochemistry Section and Geological Survey of Canada Detachment

This section has been active in studies of the distribution and fate of phosphorus in sediments of the Okanagan lakes; the forms and occurrence of iron hydroxides and phosphates in lake sediments; the occurrence in sediments of chlorophyll and its derivatives; sedimentation rates and geochemical inputs to sediments of the Great Lakes, including palynological studies by a detachment from the Geological Survey of Canada; and the chemical forms of nitrogen in sediment organic matter.

Staff of the section also participated in a cooperative study of the biochemical transformations of organic matter from the effluent plume of a pulp mill.

Phosphorus in the Okanagan Lakes

The study of the distribution of phosphorus in the surficial sediments of mainstem lakes of the Okanagan Valley, British Columbia was completed. The forms of phosphorus in the sediments and the factors controlling their accumulation were in general similar to those found in other lakes. Apatite derived from erosion of terrigenous materials from the surrounding watersheds or from shallow water deposits within the lakes, accounted for 70% of the sediment phosphorus in Lake Skaha and over half of that in the other lakes. Apatite plays only a minor role in the soluble phosphate budget of the lakes.

Initially, soluble phosphate, which is subsequently removed from the lake waters by sedimentation, accumulates in the sediment as 'sorbed orthophosphate' and organic phosphorus. The content of both of these forms in the surface sediments increases with increasing water depth. Sorbed phosphorus is usually associated with iron in the sediments and organic phosphorus is correlated to the sediment organic matter. The precipitation of calcite in the epilimnion of Kalamalka Lake during the summer months is not accompanied by an appreciable uptake of orthophosphate by the calcite particles. The phosphorus profiles in sediment cores from Wood and Skaha Lakes indicate an abrupt change in conditions of phosphorus sedimentation, following early settlement of the Okanagan Valley, due to the increased erosion in the watersheds surrounding the lakes. The decline of organic phosphorus with depth in the cores is matched by an approximately equal increase in apatite content, indicating mineralization of organic phosphorus. This mechanism of retention of phosphate by diagenetic formation of apatite acts as a very efficient 'sink', retaining almost all phosphorus in the sediments of Wood and Skaha Lakes and occurs in all the Okanagan mainstream lakes.

Forms of Iron Hydroxides in Lake Sediments

Work has commenced on the forms of iron in the Great Lakes sediments. Fe(III) and Fe(II) species were determined in samples from Lakes Erie and Huron. Thermodynamic considerations show that ferrosoferric hydroxide ($Fe_3(OH)_8$) should exist under the moderately reducing conditions found in most of the Great Lakes sediments. Preliminary results indicate that this compound exists in the moderately reduced sediments of the lakes. Studies are continuing.

Diagenetic Formation of Iron Phosphates in Recent Lake Sediments

A method for approximating the thermochemical constants for many basic iron phosphates has been developed and the data so derived used to develop models depicting the phase compatibilities and the general diagenetic behavior of iron phosphates in subaqueous freshwater environments. The models have been combined with measurements on the interstitial waters of Lake Erie to define the chemical requirements for the formation of vivianite and other iron phosphates in the Great Lakes sediments.

In aerobic lake sediments, ferrosoferric (and manganousferric) hydroxyphosphates are the stable minerals (see Fig. 12 for the most probable phases) which may be derived by phosphating ferromanganese oxides or by the oxidation of ferrous phosphates. Strengite and simple ferric phosphates are unlikely to be important diagenetic constituents of freshwater sediments. The stable and most probably phosphate minerals in reducing environments are

vivianite, reddingite and anapaite. The precipitation and dissolution of these iron phosphates (particularly vivianite) in the Great Lakes sediments are considered an important buffer mechanism which regulates both the levels of phosphorus in the interstitial waters and the release of phosphorus to the overlying lake waters.

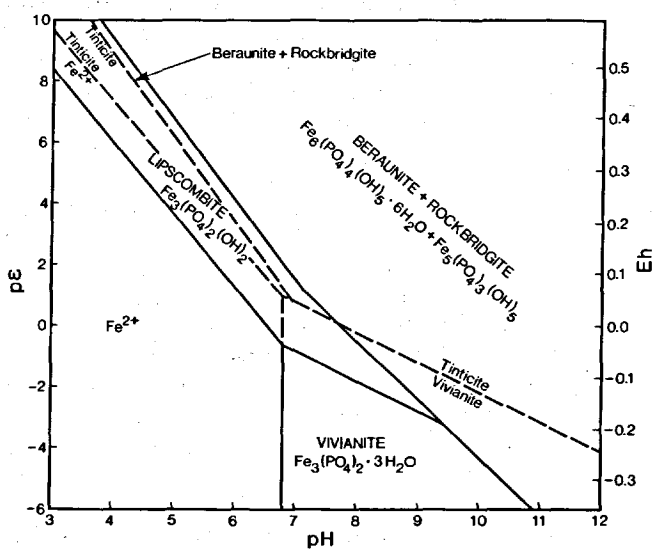


Figure 12. Phase relationships for iron phosphate minerals most likely to be encountered in lake sediments.

Stable Isotope Limnology

Most geochemical processes involve a fractionation of the isotopes of the participating elements. Studies of the sources, behavior and fates of selected isotopes in water can therefore yield important clues on the history of the water itself. Although the use of radioisotopes for dating water in aquifer systems has been well publicized, the technique of using stable natural isotopes to fingerprint pollution sources, determine water residence time or measure rates of water movement, has received limited attention. The acquisition of an isotope ratio mass spectrometer (VG Micromass, Model 602C) in March, 1973 now makes it possible to apply this powerful technique to limnological and environmental problems at CCIW.

Facilities are now available for analyzing water samples and geological materials for natural stable-isotope ratios of sulfur (S^{34}/S^{32}) and carbon (C^{13}/C^{12}). The analytical capability for determining similar isotope ratios for nitrogen (N^{15}/N^{14}) and oxygen (O^{18}/O^{16}) will be added in the coming years.

Several activities were initiated during the year: diagenetic fractionation of sulfur isotopes in the Great Lakes sediments; identification of sources of sulfur in the Great Lakes using isotope-ratio variations as tracers; sulfur isotopic variations in precipitation and lake waters in the Sudbury area, Ontario. In lakes which do not develop bottom anoxia, a reasonable hypothesis is that the sulfate exchange at the mud-water interface may cause a measurable sulfur isotopic effect in the overlying water. Laboratory studies, in fact, show that Lake Ontario sediments possess a significant retention capacity for sulfate and that the change in δS^{34} caused by the sulfate adsorption ranges from 0.9 – 6.0% (Fig. 13). Apparently, adsorption/desorption processes may play a role in determining the isotopic composition of natural waters as well as recent and ancient sediments.

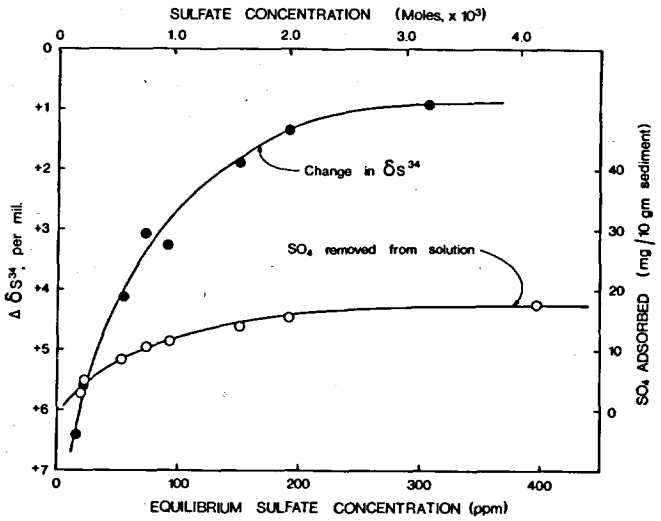


Figure 13. Sulfate adsorption isotherm with corresponding changes in δS^{34} of the sulfate remaining in solution.

Chlorophyll Derivatives in Sediment Cores from Lakes Erie and Ontario and South Bay

This project was completed and the results showed that the pheophytin *a* to organic carbon ratio was a reliable relative paleoproductivity change indicator in Great Lakes sediments. Unaltered chlorophyll *a* and the most degraded chlorophyll derivative, pheophorbide *a*, did not maintain their ratios to organic carbon. The value of the pheophytin *a* to organic carbon ratio was not comparable between lakes so that only relative paleoproductivity changes within a lake could be determined.

Point Source Effluent Study

Tracking and sampling the effluent plume of a pulp mill in Marathon, Ont. was undertaken in conjunction with the Great Lakes Biolimnology Laboratory of the Fisheries and Marine Service and the Descriptive Limnology Section. The samples were obtained for analysis of carbohydrates and proteins to ascertain the biochemical transformation of wood sugars in a pulp mill effluent plume entering the open lake.

Fifty sediment samples were taken in the area of the outfall for analysis of carbon, carbohydrates and lignins. There was no visible sign of fiber beds in this high energy nearshore zone.

Sedimentation Rates and Geochemical Inputs to Great Lakes Sediments

Present-day sedimentation rates were determined for 14 core locations, representing basins of fine-grained

sediment in Lakes Ontario, Erie and Huron. Present-day sedimentation rates were estimated by averaging the weight of sediment deposited above the *Castanea* (chestnut) pollen decline, dated 1930 for Lake Ontario and 1935 for Lake Erie. Early-colonial sedimentation rates were estimated by averaging the weight of sediment deposited between the *Castenea* horizon and the *Ambrosia* pollen rise, dated 1850. Present-day sedimentation rates were high in Lake Erie, ranging from 847 to 5049 $gm^{-2}yr^{-1}$, low to intermediate in Lake Ontario, ranging from 366 to 1156 $gm^{-2}yr^{-1}$ and low in Lake Huron ranging from 147 to 325 $gm^{-2}yr^{-1}$. The results show that there has been a three-fold increase in sedimentation rate in Lake Erie since 1935 and the Kingston basin of Lake Ontario since 1930.

The nutrient and Hg concentrations are enriched at the sediment surface in all the cores from Lakes Ontario and Erie, while the Huron cores show little change at the surface from their background concentrations. The enrichments are attributed to increased nutrient and Hg loading to the Ontario and Erie sediments, with the major increases after about 1950. The present-day loading of nutrients and Hg to the sediment parallels the rates of sedimentation at each location, being greatest in Lake Erie. Early-colonial loading of nutrients and Hg to Lakes Ontario and Erie are generally similar to the modern loading of Lake Huron (Fig. 14). The total loading of sediment, nutrients and Hg was estimated for each lake. Present-day sediment accumulation of 4,600, 23,400 and 3,900 thousands of metric tons was estimated for Lakes Ontario, Erie and Huron respectively.

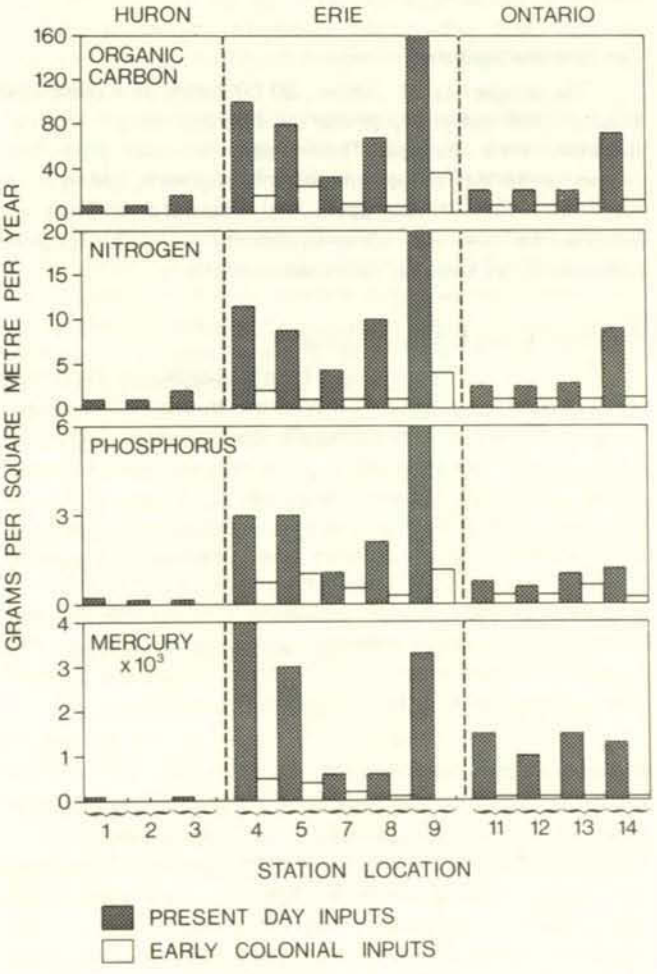


Figure 14. A comparison of present-day and early-colonial inputs of organic carbon, nitrogen, phosphorus and mercury to the sediments of Lakes Ontario, Erie and Huron.

Sediment Organic Matter Studies

The fine-grained surface sediments of Lake Ontario contain 49 to 55 percent of the total nitrogen as insoluble combined amino acids and amino sugars. About 38-44 percent of the total nitrogen is in the form of unknown organic nitrogen compounds. Less than one percent of the total amino acids are present in the interstitial waters as free and soluble combined amino acids. The sediments appear to contain intact protein or peptide chains, little different to those found in Lake Ontario plankton samples. Ethanolamine, urea, asparagine, glutamine and citrulline were also characterized in the sediments, accounting for less than one percent of the total nitrogen.

The free amino acids released by the proteolytic enzyme pronase were determined on humic and fulvic acid and interstitial water extracts from Lakes Ontario and Erie surface sediment samples and zooplankton. The enzyme showed the same specificity towards the sediment organic matter extracts as towards casein, providing direct evidence for the occurrence of peptide bonds in the sediment organic matter. The lability of the organic matter extracts towards pronase hydrolysis followed the order: Interstitial waters $\approx$ zooplankton $>$ fulvic acids $>>$ humic acids. No amino acids were released from fresh sediment by pronase hydrolysis, suggesting that in situ sediment organic matter is inert towards enzymatic cleavage by pronase. Further experiments suggested that the inhibition of enzyme activity in the sediment is due to the presence of sediment-humic acids.

Palynological and Geological Accomplishments of the Geological Survey of Canada Detachment

Pollen analyses were carried out on a long core from central Lake Erie to provide the necessary chronologic framework for paleomagnetic and oxygen and carbon isotope studies performed on the same core. Paleomagnetic analyses were carried out by Prof. Creer, University of Edinburgh, U.K. Profs. P. Fritz and S. Poplawski, University of Waterloo, completed a Geological Survey contract study on this core and submitted a report and O^{18} and C^{13} determinations on molluscan identifications.

About 40 piston cores collected from Lake Ontario during previous years' cruises were opened and the sediments were logged and described in detail.

Two pollen diagrams were prepared and plant macrofossil, mollusc and ostracode extractions are near completion on a buried peat layer from Lake Huron. Radiocarbon dates of 9,370 and 8,830 years B.P. were obtained at the base and top of the peat, respectively.

A piston coring and echo-sounding cruise was successfully carried out on Georgian Bay from October 22 -

November 1, 1973. Of particular interest was the discovery of a buried peat layer in Hope Bay confirming extremely low water levels in Georgian Bay.

Impacts and Pathways Section

The major research effort of this section has been a multi-disciplinary study of nutrient dynamics at the Bay of Quinte. The project attracted cooperative researchers from the Universities of British Columbia, Guelph, and Toronto. Important contributions to the project were made by staff of the Technical Operations Section (Scientific Operations Division) and Engineering (Scientific Support Division).

Other projects of the section include evaluation of certain gas chromatography techniques, chemical and biochemical research on PCB's, study of the environmental impact of non-ionic detergents, and oil-water studies.

Bay of Quinte Studies

The fields of study included gas transport (O_2, CO_2, N_2), sedimentology, geochemistry, nutrient kinetics, biology, and bioenergetics. The aim was to develop a flow diagram for the flux rates of carbon, nitrogen, phosphorus and, to a lesser degree, trace elements, and to assess the effect of various nutrient enrichments on productivity and species composition.

Certain compartments of carbon, nitrogen and phosphorus were monitored in an ecosystem contained in 3 limnocorrals situated in 4 M of water in the Bay of Quinte. These were triangular shaped having 25 feet on each side and extending from the surface to at least 2 feet into the rich sediments. Radioisotopes $^{32}P - PO_4$ and $^{14}C - HCO_3$ were added, and the rates at which they moved between the principal forms were monitored. One corral received no enrichment, another received PO_4 at a rate of 2.5 g/m^2/year, while the third was enriched with the same amount of PO_4 and NO_3 at a rate of 38 g/m^2/year.

The primary production, algal and zooplankton biomass and species composition were monitored and effects of nutrient enrichment noted. Relative uptake rates of ammonia and nitrate (using ^{15}N) were measured. The utilization of PO_4, HCO_3 were correlated to primary productivity, zooplankton grazing rates, and sedimentation rates. Bi-weekly sampling was continued for 3.5 months and still continues on approximately monthly intervals.

The role of bacteria in the utilization and recycling of nutrients is part of this study. Traditionally methods of determining the number (and subsequently biomass) of living cells have been by direct microscopic counts and by plate counts of viable cells. These methods are very time-consuming and subject to serious criticisms. Adenosine triphosphate (ATP) determinations are currently being used as a specific indicator of living microbial biomass. ATP is a high energy compound found in every living cell and it is used in all cellular activities. Many investigators have found there is a constant ratio between ATP and cell carbon in a variety of bacteria, algae, and zooplankton. The cellular ATP pool responds rapidly to changes in the metobolic activity of microorganisms. It is thought, therefore, that ATP will be a useful index of total living biomass for evaluating the effect of any environmental, nutritional, or toxic variable.

Research was also begun to determine heterotrophic uptake of dissolved organic compounds, dehydrogenase, and alkaline phosphatase. These parameters will be used as indicators of bacterial metabolic activities and will be correlated with ATP microbial biomass data.

The sedimentation rate was measured in the limnocorrals by periodically collecting material caught in sediment traps. The sedimenting material was concentrated with a high speed, flow-through centrifuge, freeze-dried, weighed and stored for subsequent chemical and radioisotope analysis.

Lush growths of periphyton developed on the uppermost 2 M of each limnocorral. Quantitative samples of the algal mat and its associated fauna were collected regularly for chemical and radioisotope analysis. These data will be incorporated into C and P budgets and models and will elucidate the effects of elevated surface to volume numbers in 'small' enclosure experiments.

The data obtained will be used to attempt to develop correlations between static measurements of biomass and rate processes to be used in the development of lake models.

Gas Chromatography

The properties of Teflon, 30-60 mesh, as a combined support and stationary phase for liquid/solid gas chromatography were studied. Teflon columns have separation properties similar to porous polymer supports, giving short retention times at low operating temperatures. They are suitable for the gas chromatography of polar organic compounds in aqueous or organic solutions.

Polychlorinated Biphenyls (PCB's)

The optical properties of polychlorinated biphenyls (PCB's) were investigated. Commercial mixtures and residue samples comprise approximately one hundred individual PCB isomers. These differ in their physical and chemical nature and in their physiological effects. A total of nine of the major and additional ten of the minor constituents of three common mixtures have been predicted to exist in environmentally stable optical atropisomers. This fact is regarded to have major influence on the biochemical activities and biodegradation of those antipodes. The presence of optical isomers of these ubiquitous contaminants appears to have been hitherto neglected.

Bacterial Degradation Studies

It has been found that several bacterial species from lake sediments can use lower percent chlorination of polychlorinated biphenyls (PCB 1221 and PCB 1242) but not higher chlorinated PCB (1254) as sole carbon and energy source for growth. The major metabolic products identified by the combined gas chromatographic and mass spectrophotometric techniques are exclusively aliphatic and aromatic hydrocarbons. None of the metabolites contained any chlorine.

Environmental Impact of Nonionic Detergents

Nonionic surfactants are used in household detergents and industrial cleaners, and for deresinification in the pulp and paper industry. While total Canadian consumption of nonionic surfactants is difficult to determine, 15 to 20 million pounds per year is a reasonable estimate. In this light, a study to examine the biodegradability of these substances under laboratory and field conditions and to evaluate their environmental impact in lakes, has recently been initiated.

Oil-Water Studies

Material balances suggest that present input of benzene-extractable materials in Burlington Bay is about an order of magnitude lower than that reported in 1969.

Our laboratory data indicate that in spills of crude oils and residual fuels, especially at low temperatures, the formation of water-in-oil emulsions requires low mixing intensities, i.e., that their appearance in such spills should be expected.

A survey of initial evaporation rates from thin oil slicks showed a dependence on oil thickness. Thin crude oil layers were found to lose their gasoline fraction in the first few hours of exposure. An empirical relationship was developed for the prediction of losses during the first hour of exposure as a function of temperature, wind velocity, oil thickness, and oil type.

A gas-chromatographic method is being developed for estimating light-end losses from crude oil, based on consecutive G.C. analyses of fresh and aged oil samples.

Recommendations have been prepared for the Environmental Emergencies Handbook of Environment Canada on the use of oil herding materials in oil spill accidents. This is an outline of the oil herders' effectiveness, limitations, and promising areas of application. Their limited use is encouraged in some specific oil spill situations for a fair testing of their performance and for the field experience in their use.

Cooperative efforts have continued with the Environmental Protection Service unit at CCIW and the Water Sciences Subdivision (Ottawa) in joint projects and in the evaluation of outside projects and spill control materials and techniques.

GEOPHYSICAL LIMNOLOGY SUBDIVISION

The subdivision carries out research on the geology and physics of lake systems as a fundamental framework in which valid interpretation can be made of lake water chemistry and associated biological response.

The two Sections, comprising the subdivision, continued their major research thrusts but in addition were deeply involved in studies under the Canada/U.S. Agreement of 1972 and the International Joint Commission References on the Upper Great Lakes and Studies of environmental impact of dredging. These studies involved sediment sampling and coring in Lakes Superior and Georgian Bay, physical processes in the nearshore zone as they relate to waste heat and the characteristics of dredged sediment.

In addition, 1973 saw the development of a study plan, under the I.J.C. Land Drainage Reference Group, to evaluate the impact of land use practice on the water quality of the Great Lakes. The involvement of the subdivision relates to studies to determine the impact of dissolved and particulate materials on the lakes. To this end, study plans are being formulated to conduct surveys, primarily geolocical and geochemical, on the derivation of nutrients, trace metals and persistent toxic compounds from shoreline erosion and river input in the Canadian Sector of the Great Lakes watershed.

Interaction of the Physical Limnology and Geolimnology Sections continued to evolve with joint programming being undertaken under the auspices of the CCIW Nearshore Task Force. A nearshore experimental site was selected, equipment and personnel requirements were formulated to commence a long term study of the action of breaking waves and associated physical processes on shallow water and beach sediment.

Geolimnology Section

Regional Sedimentology and Geochemistry

During 1973 the Regional Sedimentology and Geochemistry programme completed sampling of the Great Lakes System (excluding Lake Michigan), with the grid sampling of Lake Superior and Georgian Bay.

During the field sampling, continuous low frequency echo-sounding profiles were run between sampling stations in order to map the distribution of sediment types. The sediment distribution derived from echo-sounding with sample analysis as control, is given for the Great Lakes in Figure 15. The distribution of sediment types in Lake Michigan was derived from previously published material and interpreted to conform with sediment classifications used in the remainder of the Great Lakes. Three major units, till and bedrock, glacio-lacustrine sediments and muds, together with major sand deposits are characterized and shown in Figure 15. The characteristics of each of the three units may be summarized as follows:

Till and Bedrock: Till and bedrock cannot be differentiated from sounding records. The tills, when recovered by sampling, vary in colour from medium gray to brown and are composed of cobbles and pebbles in a very stiff, silty clay matrix which may frequently be sandy. The tills are generally overlain by lag gravel deposits.

Glacio-lacustrine Sediments: The glacio-lacustrine sediments are dark gray to light brown silty clays occasionally sandy and enriched in calcium carbonate. They are moderately stiff and greasy, frequently laminated and occasionally contain ice rafted pebbles. In almost all cases, the glacio-lacustrine clays are overlain by a thin fine sand up to 6 cms thick. This sand is believed to have originated as a lag deposit formed by the winnowing of the fine materials from the surface of the deposit by current and wave activity.

Mud: The muds are generally located in the offshore deeper

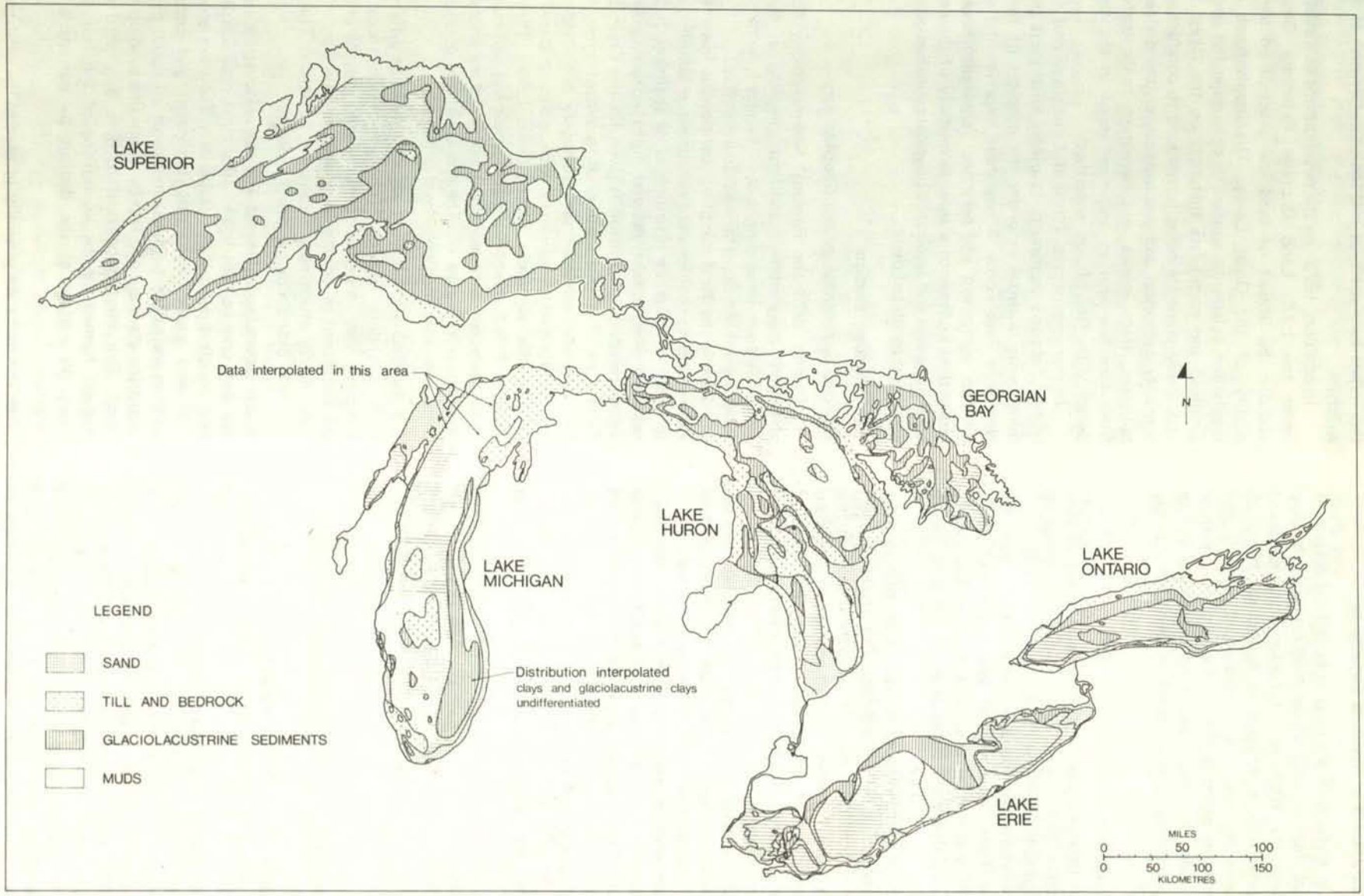


Figure 15. The Great Lakes bottom sediment distribution.

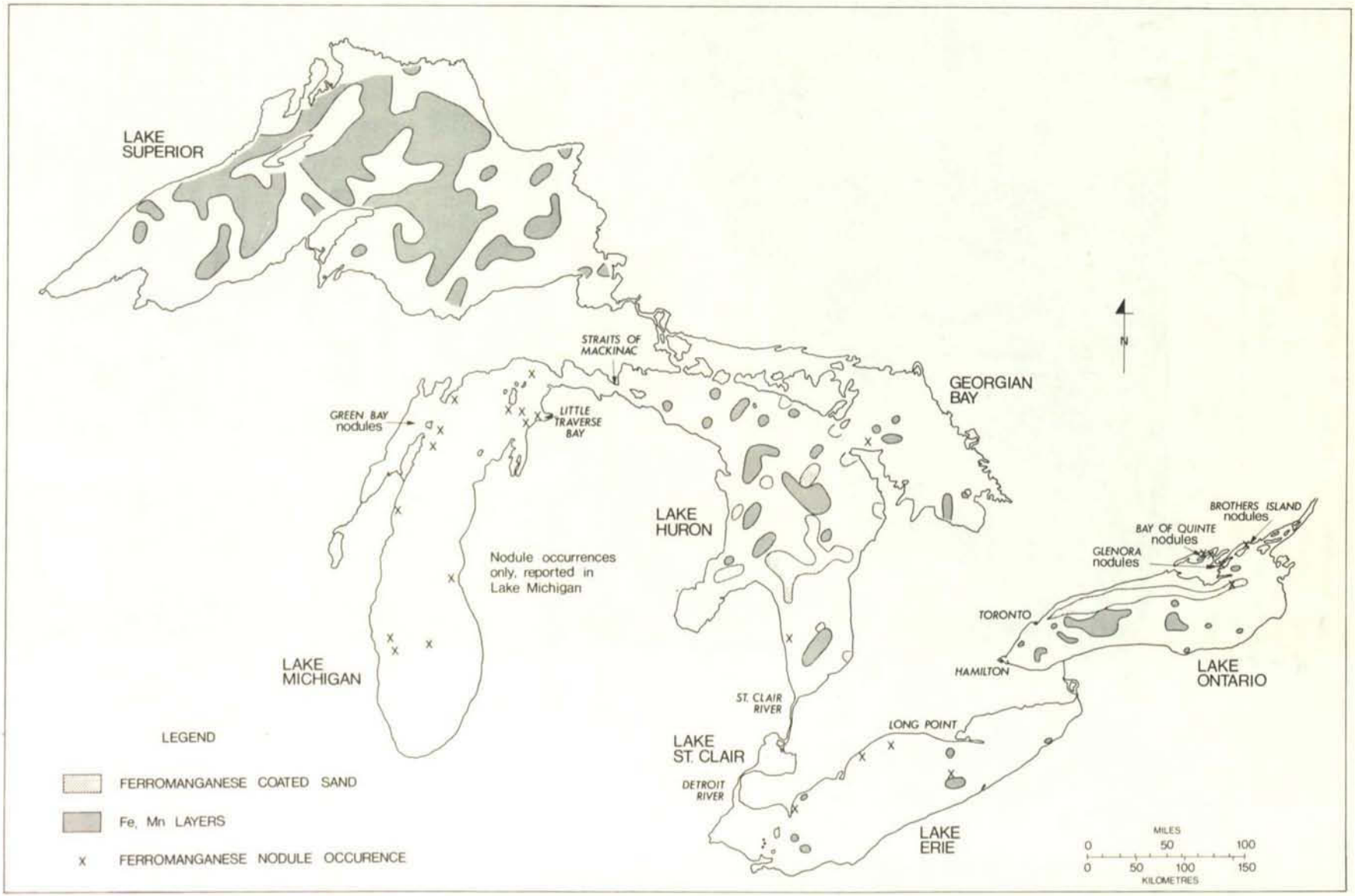


Figure 16. Occurrence of ferromanganese nodules, coated sands and Fe, Mn layers.

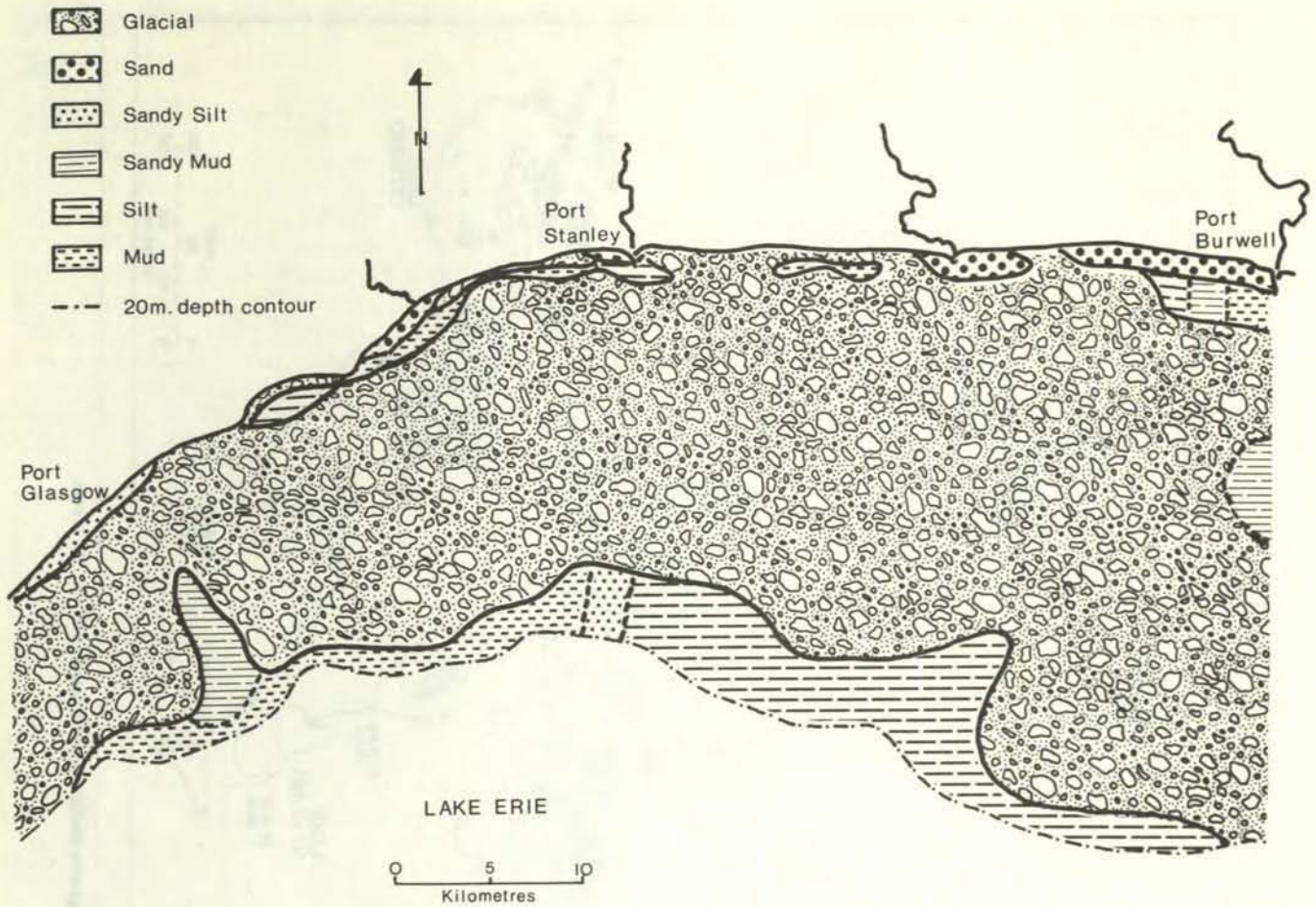


Figure 17. Map of sediment distribution, Port Burwell to Port Glasgow.

water areas of the lakes. They consist of soft, fluid, fine-grained silty clays and clays, gray to gray black in colour. In Lake Superior the muds are much firmer and lighter in colour due to slower rates of sedimentation. A distinctive feature, often observed in the lake muds, is a thin hard crust of yellowish-brown amorphous iron oxide. At some locations, the layer shows a segregation into a black manganese layer overlaying a yellow-brown layer.

The distribution of sediments containing the iron manganese layers together with ferromanganese coated sands and discreet nodule occurrences in the Great Lakes is summarized in Figure 16.

Additional sediment surveys were carried out in the Bay of Quinte, Lake Ontario, to determine the regional sediment distribution and chemical composition. Sampling of the region was completed during the year and the analyses for particle grain size, major and trace elements are nearing completion. This programme in the Bay of Quinte is being undertaken as a part of ongoing biological and chemical studies being undertaken by the division and the Great Lakes Biolimnology Laboratory.

Nearshore Studies

The 1973 Nearshore Sediment Inventory Programme extended coverage of the Lake Erie nearshore zone from Port Burwell to Port Glasgow, Lake Erie, Ontario. Preliminary results indicate that surficial sediments are 80% glacial drift and associated lag deposits and 20% modern sediment (Figure 17).

The glacial material forms a broad offshore terrace that extends the length of the study area. Samples recovered from the drift surface are typically pebbly clay tills and sandy gravel lag sediments.

Modern sediments, derived from the erosion of shore bluffs and offshore glacial drift, occur along the shoreline and at the lakeward limit of the zone. In the complex inshore area, sand accumulates alongshore behind artificial obstructions and sandy silts; sandy muds, silts and muds occur in small discontinuous deposits further lakeward. Preferential accumulation of sand on the west side of harbour entrances throughout the area indicates net eastward drift in the littoral zone. The offshore sediments consist primarily of silts and muds with a notable increase in clay content towards the west. This suggests that only the eastern portion of the deposit receives sufficient energy to prevent deposition of clay-size sediment or to remove it after deposition by reworking. An examination of lakewide circulation models reveals that there is, in fact, an area of low current velocities corresponding to the higher clay

concentrations found at the western end of the offshore deposit.

The Nearshore Jetting Programme determines the thickness and basal material of nearshore sediment deposits. In 1973 surveys were carried out in four deposits in eastern Lake Erie. Maximum thicknesses measured in the Fort Erie-Point Abino, Mohawk Point, Long Point Bay, and Long Point-Erie deposits were 4.5 m., 5.5 m., 11 m., and 8.5 m., respectively. The underlying material was mainly bedrock east of Port Colborne and glacial sediment west of Port Colborne.

Coring operations based on a modified Beachcor hydraulic corer were carried out in nearshore Lake Ontario at Burlington and Niagara. Maximum recovery was 103 cm. Cores are currently being analysed for pollen content to determine whether pollen dating is applicable to sandy nearshore sediments.

Sediment Data Archive (SEDATA)

1973 saw the installation at CCIW of a computer-based storage and retrieval system for sediment data collected in and around Canadian Lakes. The sediment data archive (SEDATA) uses the SAFRAS system obtained under license from the University of Western Ontario and is capable of flexible input of unformatted data and selective retrieval merging and editing of files. File building is commencing and eventually will comprise records on more than 10,000 sediment samples and observations.

Sediment Transport Tracers

Tracer experiments were carried out off Confederation Park, Burlington Bar, Lake Ontario, during summer 1973 to complement those of fall 1972. The tracer medium was a synthetic glass sand with 3.4% antimony (Sb) as the tag. Preliminary examination of the tracer patterns indicates that the summer months are characterized by conditions of little net movement at the depth of tracer injection, Figure 18, due to general lack of significant storms and the isolating effect on the bottom caused by annual peak water levels. Contemporaneous monitoring of beach zone bottom profiles indicates that accretion was dominant during this period.

Great Lakes Shore Erosion Summary

This project, undertaken by Lakes Research Division, formed part of the joint Canada/Ontario Great Lakes Shore Damage Survey, described elsewhere under the report of the Shore Properties Section of the Marine Sciences Directorate. Its objective is to determine, using existing IGLLB data and historical aerial photographs and land surveyors records, the long-term rate of erosion along the erodible shorelines of the Great Lakes. Data gathering is in progress and the results will be included in the coastal zone atlas scheduled for completion in mid-1974. The results of the project contribute greatly to classification of the shoreline based on erodibility and delineating areas of abnormal erosion for more in-depth investigations.

Pleistocene and Holocene Stratigraphy of the Laurentian Great Lakes

A new project initiated this year had as its objective a study of the stratigraphy of Great Lakes sediments. This research will not only provide information on the history of the Great Lakes but also will, through a study of the various sedimentary processes that have taken place in the past, lead to a more precise interpretation of present-day sediment characteristics and distributions.

Field work this year was concentrated on Lake Superior, particularly the northern part. During two cruises on the M/V MARTIN KARLSEN, 60 gravity and piston cores ranging in length up to 18 metres were collected. Preliminary logging of these cores show that many have penetrated to till and thus will provide a complete record of sedimentation in Lake Superior during the last 11,000 years. Overlying the till is a sequence of red and gray varved clays deposited in late-glacial time and these are overlain by post-glacial fine-grained gray and brown silty clays. Detailed stratigraphic, mineralogical and palynological studies of these cores are being undertaken.

Other research on Great Lakes stratigraphy carried out in collaboration with Geological Survey of Canada personnel involved a study of a nine metre piston core from South Bay, Manitoulin Island, and a series of cores penetrating a buried gravel bar at the western end of Lake Ontario. The South Bay core provides a complete record of sedimentation from late-glacial to the present time and is particularly interesting in that it contains two organic layers indicating former low level stages. Shells and peat from these layers are being dated by C-14 methods. Organic matter associated with the gravel bar in Lake Ontario is also being dated.

In addition to providing information on sedimentological processes and lake history, sediment studies can disclose

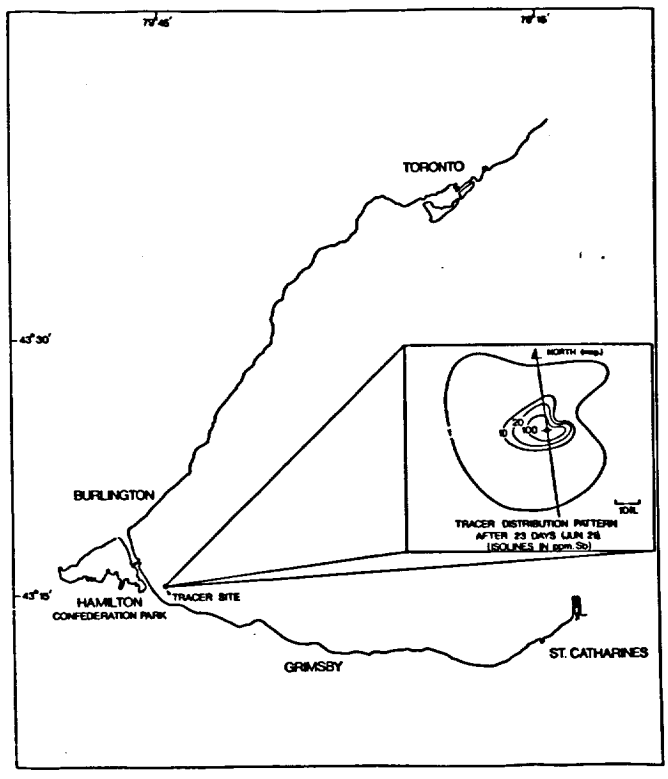


Figure 18. Sediment tracer experiments, western Lake Ontario, 1973.

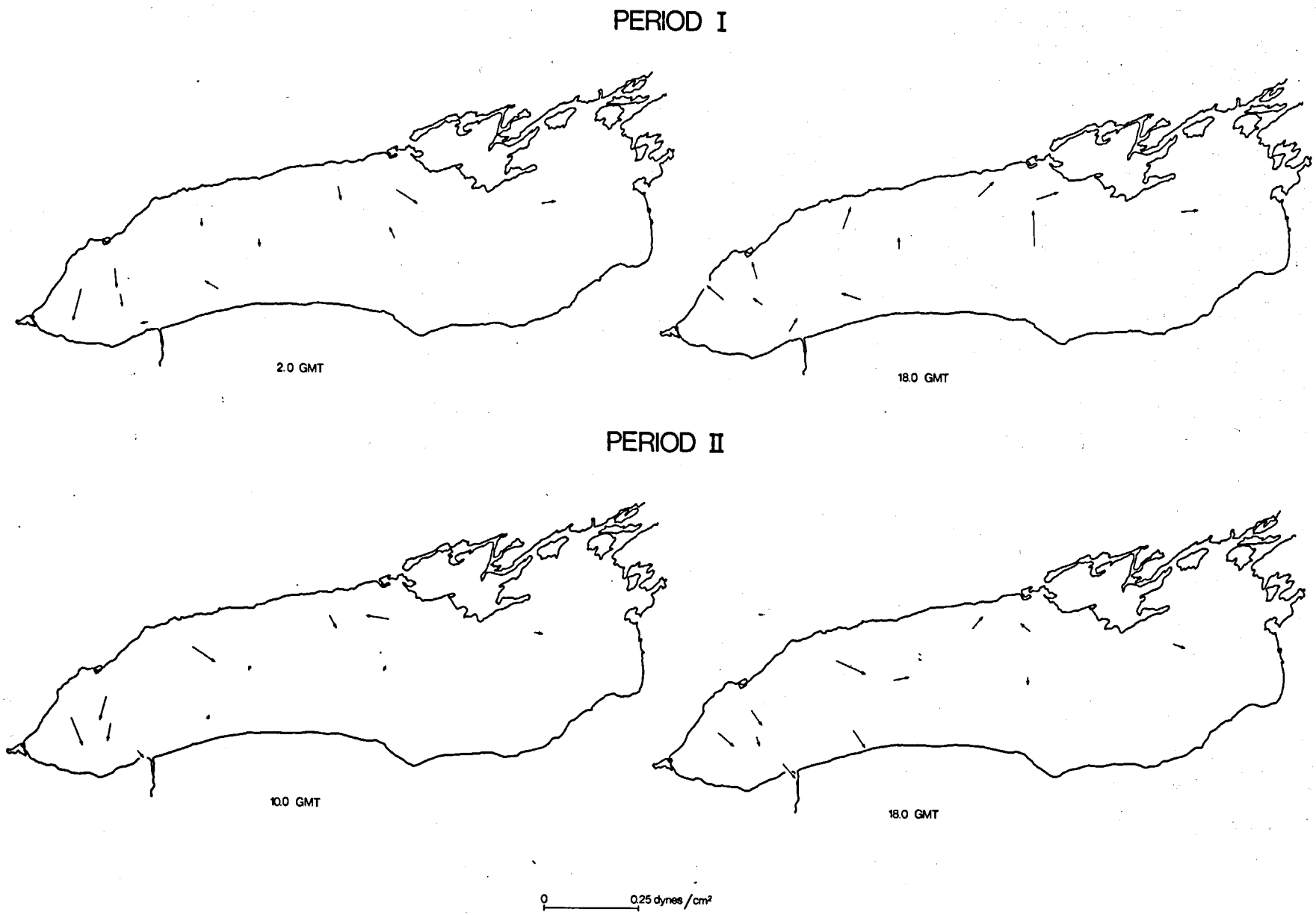


Figure 19. Resultant wind stress vectors averaged for the hours shown during the periods April 18 to May 18, and from May 29 to June 27, 1972.

the presence of minerals related to chemical processes in a lake. In this regard, of special interest was the identification of the phosphate mineral, vivianite, which was found in small nodules, crystal clusters, and irregular masses in post-glacial clayey sediments from Lakes Superior, Erie and Ontario. This mineral has formed authigenically within the sediment and is thus related to the phosphorus cycle in these lakes.

Engineering Geology

In November, an Engineering Geologist joined the staff to carry out geotechnical evaluation of lacustrine and shoreline sediments in connection with research activities of the section.

Priority was given to the set up and establishment of laboratory equipment needed for soil mechanics' tests. Most of this equipment is presently operational, and steps are taken to complete the development of more complex testing instruments.

Geotechnical properties of offshore surficial sediments will be investigated in connection with the characterization of contaminated dredged materials for their potential use as landfills. Studies are being conducted to determine the influence of mineralogical composition, organic matter, and amorphous constituents upon compressibility, plasticity, permeability, and shear strength.

Geotechnical properties of onshore Pleistocene and Recent sediments will be investigated in relation to their stability and erodibility with the aim to determine the causes of abnormally high erosion rates.

The shoreline erosion studies being conducted jointly with the Civil Engineering Department of the University of Waterloo, were continued throughout the year and a final report on this activity is currently being prepared.

Paleoenvironmental Studies

The Paleoenvironmental Research Group of the Water Resources Detachment arrived in Ontario on June 1, 1973 and took up occupancy at the Canada Centre for Inland Waters at the beginning of July.

The months of June, July and August were spent in the Bay of Quinte area, undertaking a survey of shelled invertebrates (Ostracodes and Molluscs) and of the water quality of the environments in which the shelled invertebrates were found to live. The survey extended from Trenton to the Glenora Ferry, as well as including the north shore of Lake Ontario, between Wellington and Point Petre including West and East Lakes. The fauna were found to be scarce in that part of Big Bay studied, however, empty shells were found to be abundant in many local areas.

In conjunction with Dr. J. Williams, CCIW, one metre cores were obtained from Big Bay and the bay south of Belleville. The top half or two-thirds of the cores also contained a reduced number of shelled invertebrate fauna. The causes of this reduction are under investigation.

Physical Limnology Section

Storm Surge Studies and Model Verification

An extensive analysis of the International Field Year data was undertaken in 1973. In a study with F. C. Elder of the wind stress field over Lake Ontario, a number of features influencing the dynamics of water circulation were noted. One such feature is the land-lake breeze system. Daily oscillations in the strength and direction of stress field averaged over two periods, April 18 to May 18 and from May 29 to June 27, 1972, are shown in Figure 19. Relatively large daily fluctuations in the current may be produced by such a wind field.

A method was developed for determining the phase relations and correlations between vector time series. In an application of the technique to lake modelling, an analysis of isotherm fluctuations and current fluctuation at IFYGL station number six, shows that the long period internal waves known as "inertial waves" satisfy simple mass continuity in the upper layer. Figure 20b shows the high correlation, C^-, at the inertial period and in 20a the associated phase reversal, ($\phi^- = 180°$). The phase relation may be interpreted to mean that the epilimnion thickness is largest when the clockwise rotating "inertial" current vectors have just completed half a cycle of onshore motion.

Finally, some results from the storm surge investigation are given in Figure 21 for the Belle River station on the southeastern shore of Lake St. Clair. The line which is derived by regression analysis for six storms during the fall and winter relates wind speed squared resolved in a northerly direction to the predicted storm surge. These curves were prepared by W. P. Budgell of MSD for the purpose of forecasting storm warnings in the Lake St. Clair area.

Hydrodynamic Modelling

In the area of computer simulation of lake circulations, a variety of problems were considered during the year. Of primary importance in this regard, is the model verification study that is being carried out in the framework of the 1972 Field Year on Lake Ontario. A number of significant physical episodes were selected from the field data and a three-dimensional numerical model was used in an attempt to simulate the behaviour of the lake during these episodes. These studies show that models based on conventional hydrodynamic concepts are quite successful during periods of relatively weak stratification. Initial results however, indicate somewhat less satisfactory performance for the summer months, most likely due to the low vertical resolution of the lake models presently in use.

With regard to long-term operation of the lake circulation model, a preliminary feasibility study was undertaken consisting of a continuous computation for the 1970 shipping season on Lake Erie. Using the Buffalo-minus-Toledo water levels as an indicator of the model performance, the experiment was an unqualified success, the correlation coefficient between observed and computed wind set-up averaging out to .90 for the nine months of operation. This study was carried out in the framework of the interdisciplinary modelling programme at CCIW, and the computed lake circulations are combined with data from ship cruises in order to study the distribution of chemical parameters in the Great Lakes.

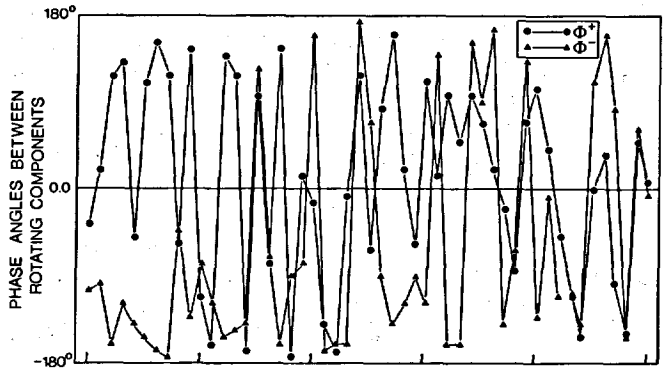


Figure 20a. Phase angles between the thermocline displacement and upper layer currents for each of the two oppositely rotating components.

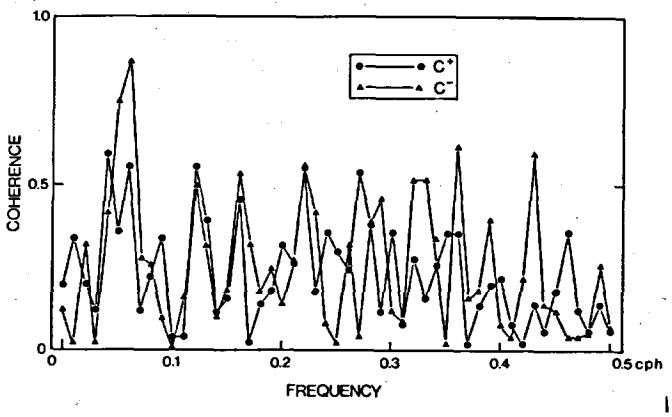


Figure 20b. Coherences between the thermocline displacement and current at station 6 for each of the two rotating components.

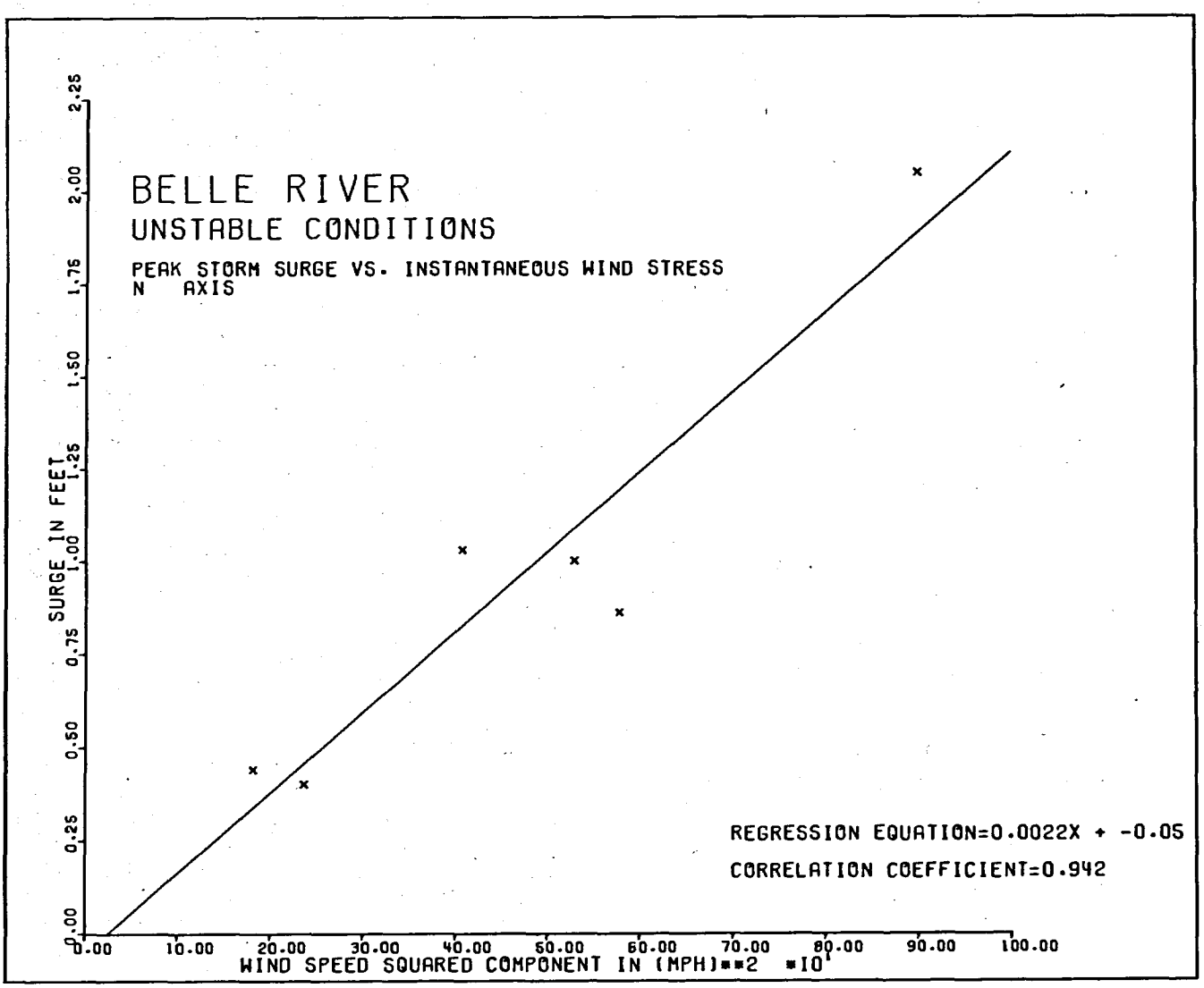


Figure 21. Peak water level surge plotted as a function of the instantaneous wind speed squared along the north direction, unstable stability.

Among further applications of computer simulation techniques, CCIW staff members collaborated with the Marine Sciences Directorate, Ottawa, in preparing a film, which graphically depicts the spread and movement of oil spills that could occur near proposed ports on the east and west coasts. The film was produced by photographing output from the CCIW computer on a cathode-ray tube, while running models developed by MSD for areas in the Straits of Georgia, Bay of Fundy and Gulf of St. Lawrence. It is anticipated that this form of visual display will find increasing application in data processing as well as modelling projects.

Diffusion/Nearshore Physical Processes

The analysis of the experimental data from several diffusion experiments carried out in Lake Ontario during IFYGL was completed. A number of diffusion diagrams showing the dependence of eddy diffusivities on the observed environmental parameters were constructed in such a way that they are useful for modelling practical diffusion problems. Such diffusion diagrams may be used to predict mean concentration distributions of diffusing substances in the lakes. However, from a biological standpoint, in order to assess the suitability of water mass as a medium for living organisms, the mean concentration field alone is inadequate. The variance of the concentration field, the magnitude and duration of the concentration peaks and the frequency of occurrence of concentration levels are all important parameters in order to assess the possible effects of the diffusing substance on living organisms. In order to predict these statistical parameters a complete knowledge of the probability distributions of concentrations are required. Experiments were designed to measure the concentration history at a fixed point in the wake of a continuous point source dye plume in coastal currents of Lake Ontario. A preliminary analysis of the data suggests that the concentration probabilities fit the Logarithmico-normal distribution (Figure 22).

Further study is planned to develop a statistical model to predict statistical parameters of interest to assess the quality of water masses.

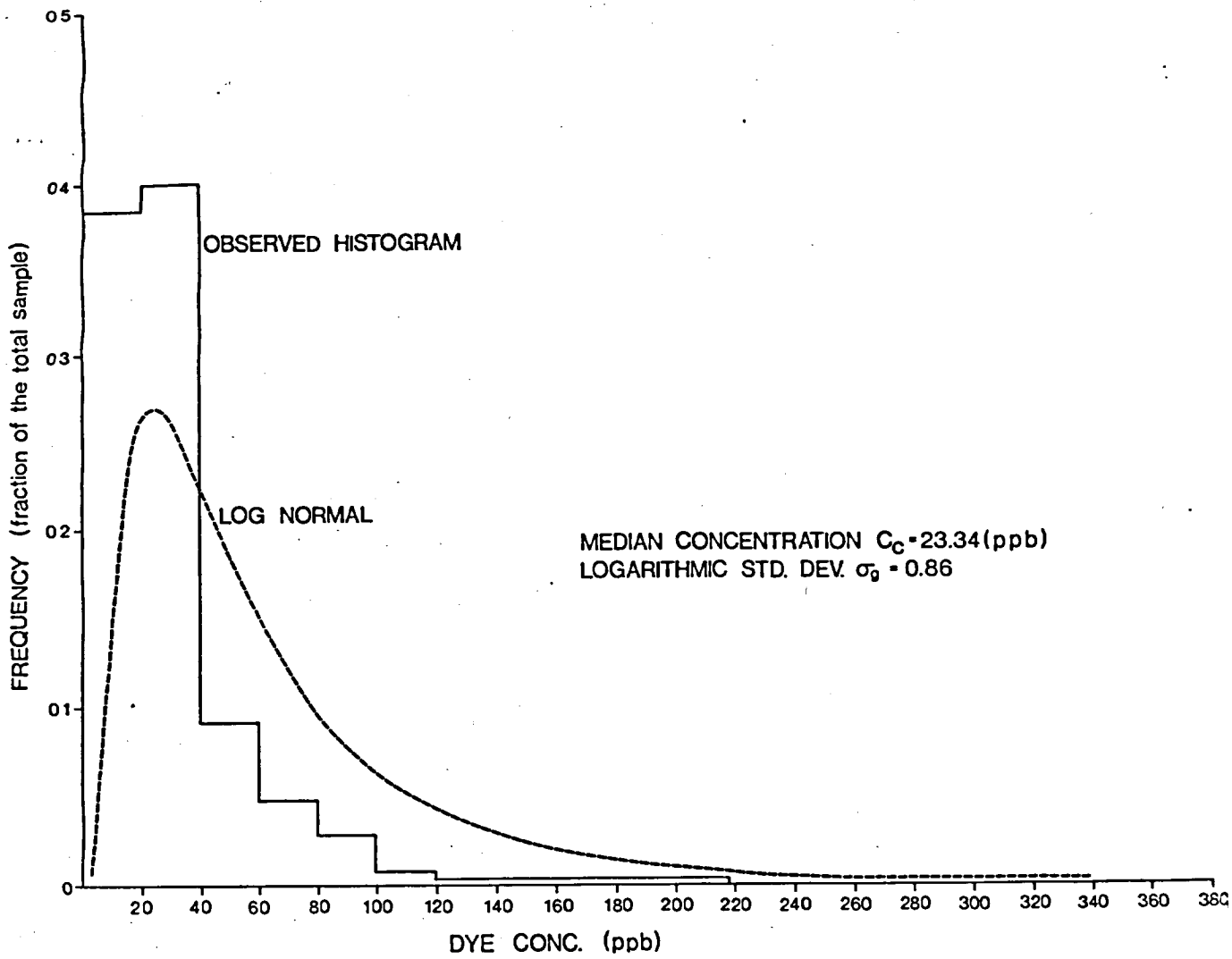


Figure 22. Fitted log-normal distribution to observed concentrations at a fixed point in the wake of a continuous point source in coastal currents.

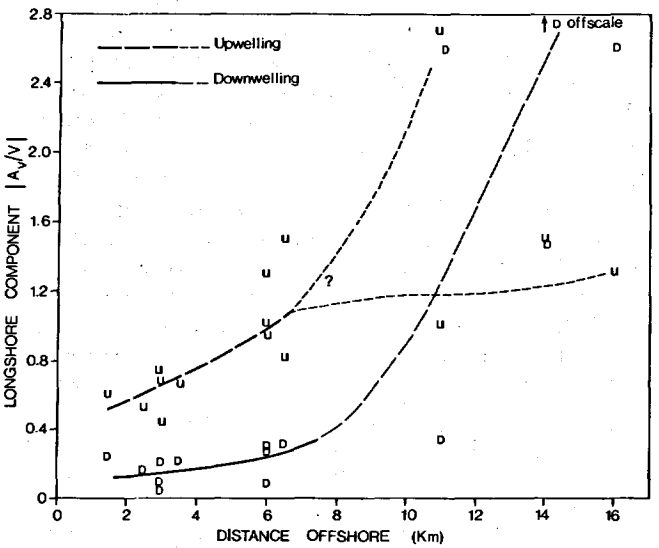


Figure 23. A plot of the ratio of the amplitude, A_V of rotary (periods near 17 hours) currents relative to the mean flow, V, versus distance offshore during upwelling (U) and downwelling (D) of the thermocline. Note the abrupt increase of A_V/V at distances of 8 km offshore and greater.

Summary of Findings on Nearshore Circulation

After processing most of the current meter data obtained in 1970 and 1972 off Oshawa in Lake Ontario, it has been found that the horizontal circulation nearshore within 8 or 10 km of the coast has distinct characteristics. If one compares the intensity of rotary wavelike currents (periodicities of near 17 hours) with the mean current during distinct periods when the thermocline is either downwelled or upwelled, the amplitudes of the wave-like currents are seen to be relatively small until about 8 km offshore where the intensity increases abruptly (Figure 23). Within this zone, the "wave"* intensity relative to the mean alongshore flow is lower during downwelling of the thermocline. These characteristics and the physical processes responsible for them will be studied during the next year. Upwelling and downwelling of the thermocline is usually confined to the same nearshore zone within 8 km of the coast as indicated by representative profiles of temperature across the nearshore zone off Oshawa (Figs. 24a, 24b, 24c and 24d). Data were obtained under contract by the University of Waterloo.

*17-hour currents rotating clockwise.

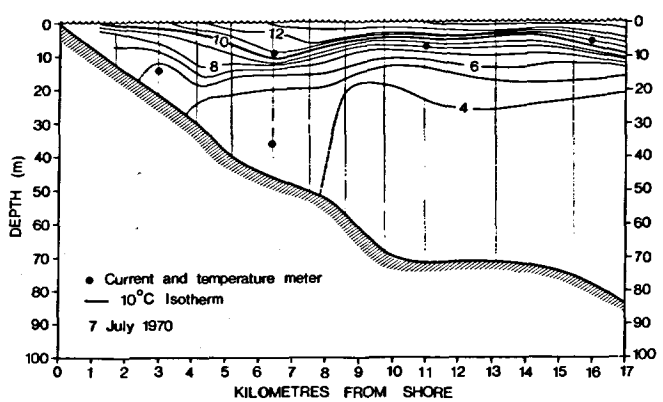


Figure 24a. Upwelled thermoclines nearshore.

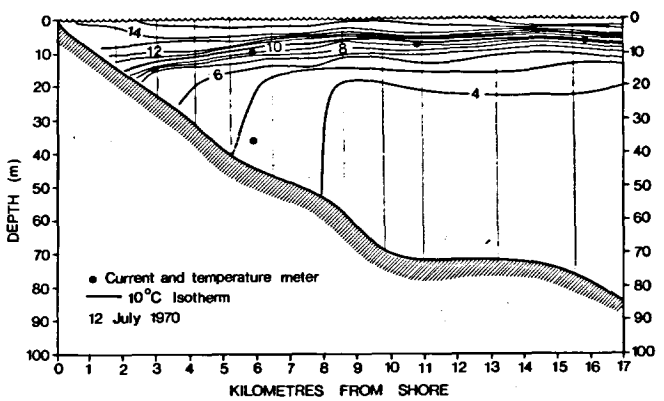


Figure 24b. Downwelled thermoclines nearshore.

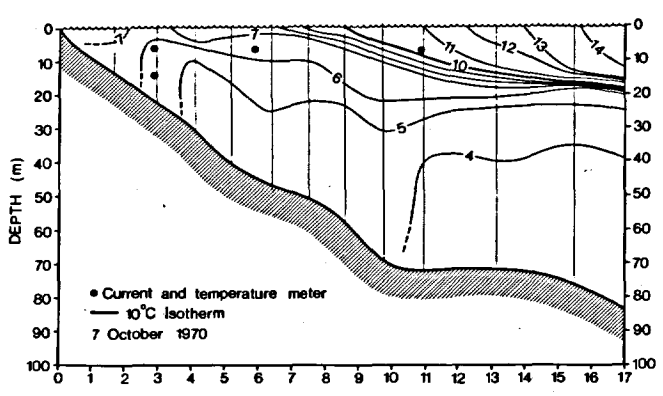


Figure 24c. Upwelled thermoclines nearshore.

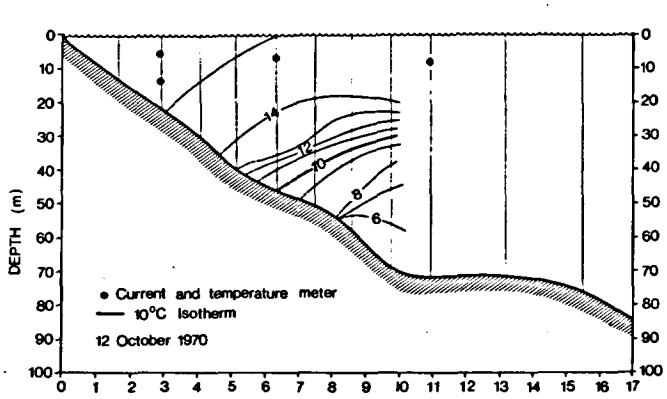


Figure 24d. Downwelled thermoclines nearshore.

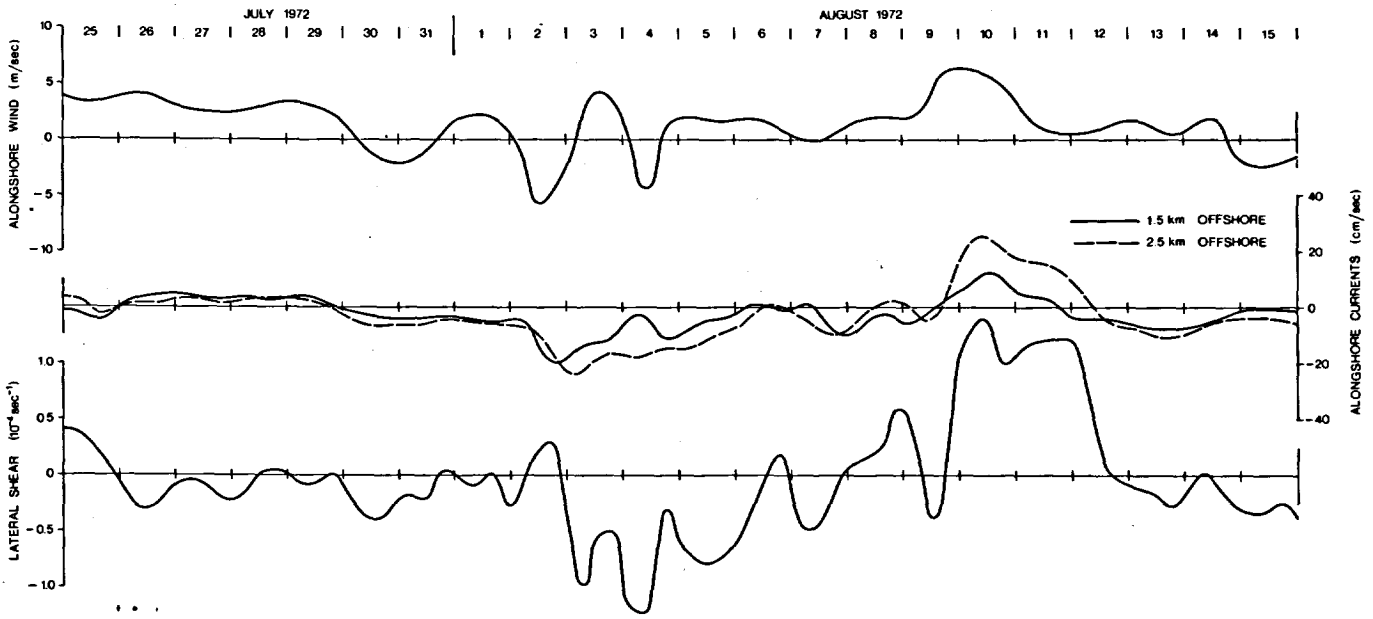


Figure 25. Lateral shear versus time as computed from the alongshore currents at two meters in the nearshore zone. Note the large values of lateral shear measured after the wind drops and reverses.

Observations of the horizontal currents across the nearshore zone indicate that reversals in the direction of alongshore currents are accompanied by large differences in the speeds at various distances offshore. An examination of several episodes of reversing currents (Figure 25) reveals that large lateral shears** occur with frequencies approximately equal to those of the large weather systems passing through the area. As the wind-driven alongshore currents nearshore are decelerated and reversed by reversing winds, it is often observed that plumes of dye and suspended materials are rapidly dispersed. It is believed that the large value of lateral shear observed during current reversals are responsible for the observed rapid dispersion. During prolonged steady winds, when alongshore currents may be quite fast, lateral shear in the nearshore zone is usually low and the accompanying dispersion of suspended and dissolved material appears to be correspondingly low.

Calculation of Lake Residence Time

After processing the temperature and outflow data obtained from various sources for Okanagan Mainstem Lakes, both the distributions of outflow and lake-wide temperature for selected depths over a seasonal cycle were determined. It was found that the magnitudes of outflow, and stratification and variation in time and space, had significant effect on the retention of original water mass for a lake as compared to the equivalent non-stratified condition.

The average retention time of a lake was determined by calculating the moment arm (Figure 26):

$$R_{ave} = \frac{1}{V_0}\,[0.5\Delta V_1 + 1.5\Delta V_2 + 2.5\Delta V_3 + \ldots + (t_n + 0.5)V_n]$$

where

R_{ave} denotes the average retention time of a lake, V_0 the initial volume of the lake and ΔV the change in volume of original waters. Subscripts 0, 1, 2, 3, . . . n, denote the time unit.

It was found that R_{ave} was related to the time over which 50% of the original lake volume is replenished. This time may be defined as the half-life:

$$V(t)/V_0 = 1/2, \text{ thus}$$

$$e^{-xt_h} = 1/2$$

where t_h denotes the half-life and x, the rate of export of water.

IFYGL Conclusion and Analysis

The IFYGL Heat Content Surveys continued into the spring of 1973 in order to complete one full year of data collection. During the balance of the year the data from this programme have been edited and computer programmes have been written for final analyses. Preliminary cruise reports were issued for all of the surveys. The final computation and report will be made in the next few months.

IFYGL Temperature Transect Data

Analysis of the temperature transects and water movement data obtained from the IFYGL cruises on Lake Ontario was advanced throughout the year.

**lateral shear = alongshore velocity differences at two points divided by distance separating the points.

Investigations were carried out on large-scale basin-wide diffusion phenomena. The results of this study are possibly significant in that they suggest that the mean concentration distribution of a conservative substance in the open lake can be explained as a diffusion process and that the horizontal mixing time scale of a typical Great Lakes basin is of the order of a few months only.

Other investigations on the effect of stratification on the residence time of lakes, and on the problems of similitude between vertical diffusion in limnocorrals and in

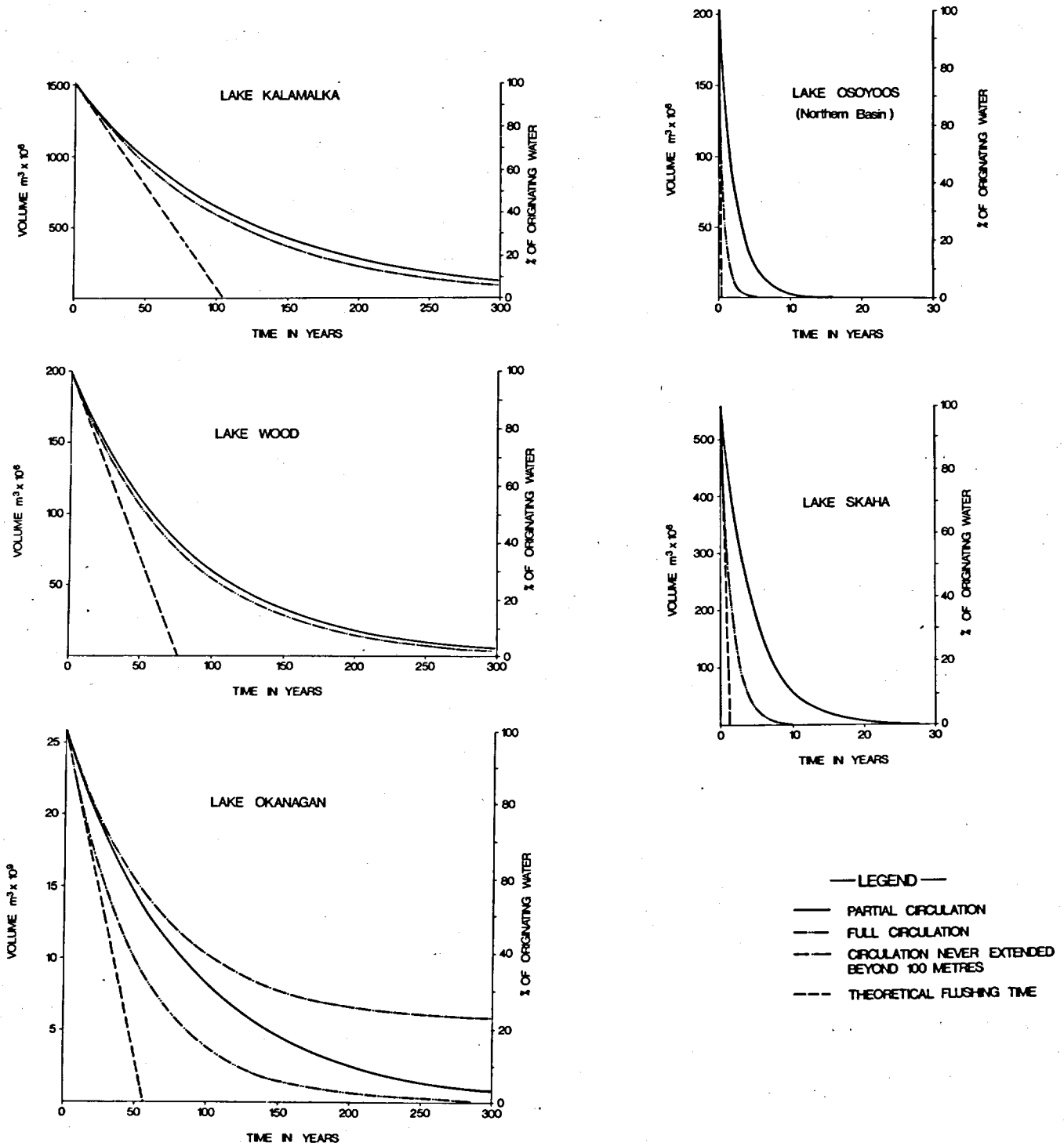


Figure 26. The retention of the original waters at the beginning of the first year of the Okanagan Mainstem Lakes.

the open lake were completed.

Baie du Doré Programme

As part of a long-term research effort into the dynamics of the Great Lakes Coastal Zone, an array of moored instruments was established near Baie du Doré in Lake Huron. The array contained current meters, surface meteorological packages, and fixed temperature profilers. The experiment also served to complement data collected by the University of Waterloo and Ontario Hydro. (The site is near the Bruce Nuclear Power Station). The Fixed Temperature Profiler system, which saw its first use during IFYGL and has since been improved, was further tested by this experiment and the basic design has proven to be viable in harsh field conditons. Analysis of the 1973 Baie du Doré data is in progress.

SCIENTIFIC OPERATIONS DIVISION

At the beginning of 1973, Scientific Operations Division (SOD) was established as part of the CCIW-based organization of Inland Waters Directorate. Portions of both the Lakes Research Division and the Scientific Support Division were brought together into this new Division to simplify the management of the complexly interrelated scientific and support activities of IWD at CCIW. The components of SOD (Microbiology Laboratories, Physical Sciences Laboratories, Remote Sensing, Technical Operations, and Data Management) are each, to differing degrees, characterized by their 3-fold functions of:

- –providing services to many or virtually all of the other scientific organizations at CCIW
- –conducting research and development studies related to the methodology of each Section
- –conducting or participating in environmental research projects related to the specialization of each Section.

In addition, through the office of the Division Chief, there is considerable involvement in the planning and direction of multi-agency programmes of study concerning effective management of lake systems.

Division Chief and Administration

In addition to the supervision and administration duties pertaining to SOD, the Division Chief spent approximately one-third of his time in functions related to membership on various national and international committees. Most of this concerned his position as Canadian Co-Chairman, International Joint Commission Upper Lakes Reference Group. During 1973, the ULRG developed, and commenced to implement, a multi-million dollar study of Lakes Superior and Huron, involving five states, the province of Ontario, as well as the U.S. and Canadian governments, to be completed by the end of 1975.

Membership on a federal-provincial Lake Winnipeg Water Quality Study Working Group had led, by the closing days of 1973, to the initial planning stages of a 3-year study plan.

Because of these functions the Microbiological Laboratories, through its various units, was involved in many diverse areas in 1973. Some of these studies involved field work such as the International Joint Commission Studies on the St. Mary's River, St. Lawrence River, Lake Superior, Lake Erie and Lake Ontario, while in other instances samples were brought to the Laboratory for analyses from Bronte Creek Provincial Park, Welland Canal, Burlington Canal, and the Grand River.

Microbiology Laboratories staff were also involved in studies of (1) the relationship of fecal sterols to bacterial indicators, (2) assimilative capacity of Great Lakes waters, (3) the relationship of temperature and nutrient levels to bacterial multiplication, and (4) preservation techniques for bacterial cultures and preservation of water samples.

Staff also reviewed more than 15 grant applications, contract proposals and papers, monitored 7 contracts, and participated in a number of committees.

Methods Development and Technical Support

A year long joint study with the Ottawa EPS Bacteriological Laboratory and the Water Quality Division, Burlington on the Ottawa River, Grand River and the Burlington Canal was completed during 1973. Water samples were collected weekly, daily and often twice daily and tested for nineteen different microbiological, chemical and physical factors in order to establish an ideal sampling frequency, sampling time, number of samples to be collected, parameters which should be tested for and the length of time water samples may be kept before analysis. Another study associated with this program was an investigation into the relationship of fecal sterols and bacteria, with findings indicating that no significant relationship exists between these two indicator systems for health aspects of water quality. However, fecal sterols were found to be ideal indicators of excretal contamination of industrial waste where bacteriological data is suggestive or doubtful and they could also be used as indicators of the efficiency of various sewage treatment processes.

A joint study with a commercial firm, a member of the Bureau of Fisheries, EPA, U.S.A. and our laboratories, on the efficiency of membrane filters in recovering bacteria from water, led to a paper which indicated great differences in various manufacturers 'membranes' ability to recover bacteria.

Twenty-four cores from Lake Erie and Lake Ontario were examined for twelve different bacterial populations, oxygen uptake rates and various chemical parameters in order to study the effect of landwash on sediment bacterial populations and to develop microbiological methods for examining sediments.

Upper Lakes Study

During May-November, 1973 the Water Quality Assessment Unit undertook an extensive microbiological survey of Lake Superior to obtain microbiological baseline data in order to develop criteria for non-degradative water quality standards as well as to establish health-oriented bacterial indicator systems for the Great Lakes. Special studies were made on 4 of these cruises to relate specific nutrient decomposition and recycling in the lake through enumeration of sulfur cycle and nitrogen cycle organisms.

Microbiological Laboratories

The Microbiology Laboratories have three main functions. One is to develop and evaluate microbiological, virological and mycological *methodology* and criteria for monitoring, assessing and maintaining water quality from the viewpoint of health hazards and eutrophication. This involves taking these techniques into the field and becoming involved in monitoring of international waters and participation in and development of microbiological programs in the Inland Waters Directorate water quality network.

The second function is *environmental research* and the thrusts of this function are, the establishment of the extent of a waste's (sewage, industrial waste, farm run-off) influence on water bodies and the rate of its degradation and the determination of the distribution of specific microorganisms and their roles in the aquatic ecosystem. Based on these studies of microorganism distribution and function, a National Culture Collection for lake organisms is being established.

The third function is to privide *technical microbiological, mycological and virological support* to inhouse, inter-service and provincial projects.

Coupled with these roles, and indirectly related, is the laboratories interest in evaluating microbial pollution of air (bacteria, fungi, and viruses) due to sewage treatment processes and the disposal of sewage wastes.

The Lake Superior program involved a total of six cruises, covering approximately 1,800 miles on which an average of 353 water samples were collected at several depths and analysed for various bacteriological parameters (Table 1).

During our studies on the distribution of microbial species in Lake Superior, an interesting observation on bacterial activity at 4°C was noted. As shown in Figure 27 the rate of oxygen utilization of 4°C by an isolate (psychrophilic) from Lake Superior (*Flavobacterium Sp.*) was comparable to the rate of oxygen utilization by a river bacteria (mesophilic) at 20°C. This finding made it imperative to determine the temperature optima of these lake bacteria in order to understand their role in relation to temperature in the seasonal assimilative capacity of the lake. Chemostat studies are presently being carried out to establish growth rates of lake bacteria at different temperatures. Results of these studies will provide information on heterotrophic microbial productivity in relation to nutrient input in receiving waters.

Table 1. Lake Superior Sampling Program

Date	No. of Samples	Parameters Tested
May	359	A B D F
June	373	A B C D
July-August	373	A B C E
September	379	A B C
October	307	A B C D
November	326	A C E
Total Number of Samples	2,117	
Average per Cruise	353	

A – Coliforms, Fecal Coliforms, Fecal Streptococcus, Bacterial Biomass
B – *Pseudomonas Sp.*
C – Bacteria Showing Phosphatase activity
D – Organic Sulfur reducers, Thiobacillus, Desulfovibrio
E – Nitrifying, Denitrifying and Ammonifying bacteria and Azotoacter
F – Nitrifying and Ammonifying bacteria

Microbiological Aspects of a Point Source Study on Lake Superior at Marathon, Ontario

To supplement the main lakes monitor program, Microbiology Laboratories participated in a joint multidisciplinary field study with Great Lakes Biolimnology and Lakes Research Division personnel on the impact of industrial waste discharges from pulp and paper mills on the distribution of microbial species in the lake.

During the one week study, microbiology samples were collected at various depths from fixed stations as well as stations within the daily varying plume flow. All samples were collected within a 2-square mile area adjacent to Marathon, Ontario. Microbiological analyses were performed on these samples to relate population levels of aerobic heterotrophs, *Desulfovibrio Sp.* and *Thiobacillus Sp.* in relation to the available nutrients (paper mill wastes) so that some understanding of the physiological effects of the waste material could be determined. Preliminary data analysis indicated a negative correlation between these bacteria and nitrogen, phosphorus and depth. No consistent trend was observed between the tested bacterial species and other chemical measurements.

Laboratory experiments, using a batch type fermentor, to examine biodegradation of Marathon paper mill wastes by bacteria collected from the Marathon sampling site, indicated that approximately 78% of the wastes were degraded within 48 hours by the indigenous bacterial species.

Microbial Taxonomy

Recent developments in computerized techniques as applied to bacterial taxonomy, together with novel concepts of classification, have overcome many of the problems encountered when attempts are made to classify bacteria isolated from natural environments. Techniques whereby the overall similarities of organisms are assessed, and subsequently classified on the bases of these similarities, appear ideally suited to the taxonomy of the unique and often highly variable, bacteria commonly

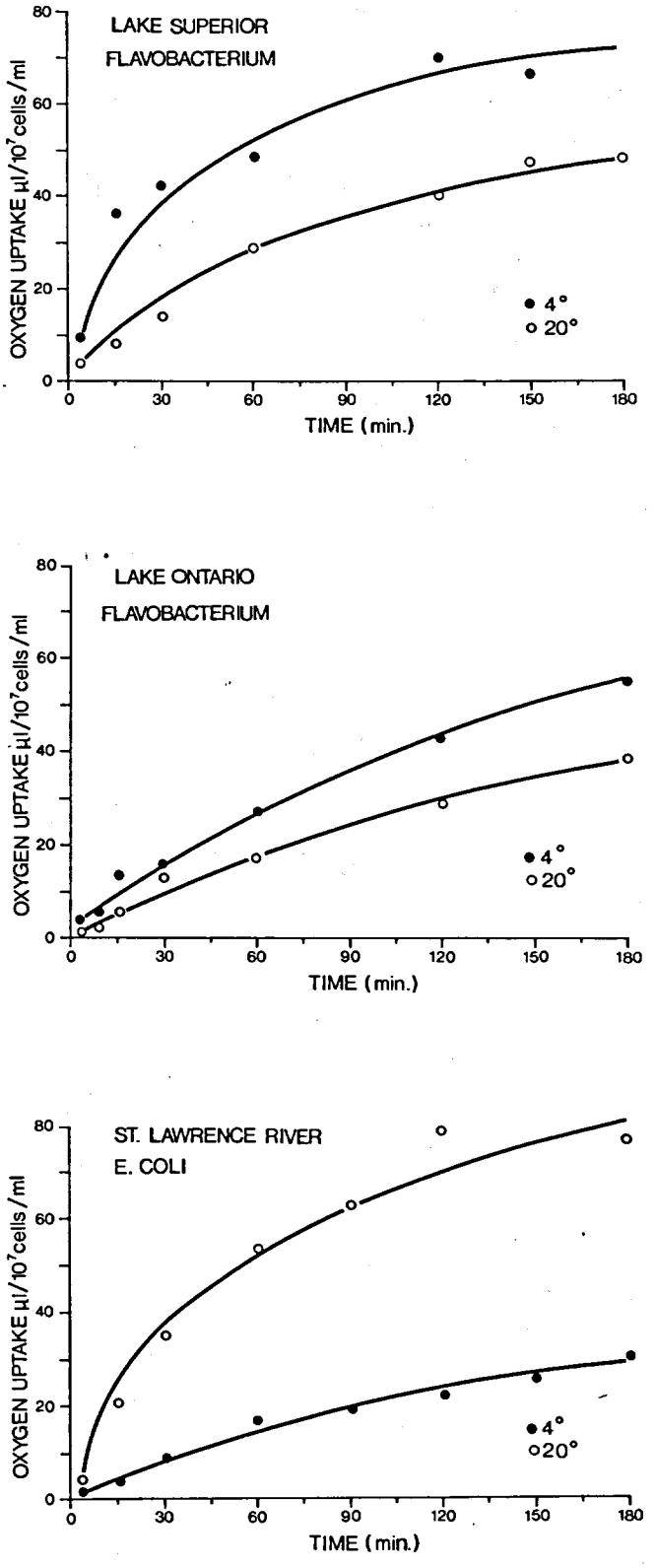


Figure 27. Effect of temperature on the oxygen utilization.

isolated from water-bodies such as the Great Lakes. Extension of these ideas and techniques indicates that such an approach will not only enable classification of organisms to be carried out but may also enable population structure to be accurately analysed. Changes in trophicstate of water-bodies will result in changes in the population structure of indigenous organisms; determination of changes in bacterial populations (most probably at the sub-specific level) should provide an early indication of changes in the trophic state.

Over 2,000 bacterial isolates were collected from both Lake Erie and Lake Superior between May and December 1973 (these two lakes being considered the most and least eutrophic respectively in the Great Lakes chain) and these isolates have each been subjected to over 150 characterization tests. The development of a range of tests applicable to the fresh-water isolates, and a semi-micro multipoint inoculation system has enabled the large volume of work involved to be accommodated routinely. Together with this, a series of computer programmes are being developed which will not only group the isolates but will also identify them.

Results of this study will not only provide information concerning the bacterial flora of the two lakes under investigation, but will indicate any cyclical population changes occurring as a result of such factors as temperature variation throughout the year. In addition, any differences in populations under the differing trophic conditions of Lake Erie and Lake Superior will become apparent. Investigations of these same lakes in subsequent years will indicate changes occurring over longer periods of time and may be correlated with other indications of change in trophic state. The study will be extended in subsequent years to include other lakes in the Great Lakes chain.

Closely allied to this study is the development of techniques to preserve isolates in such a way that their viability is retained with as little change as possible in their inherent characteristics. Methods of freeze-drying under investigation appear ideally suited for preservation of fresh-water isolates. Once such techniques have been adequately investigated, it is hoped to provide freeze-drying facilities for other workers and to develop and maintain a culture collection of fresh-water bacteria.

Virology

The virology programme initiated this year was based on contracted studies with three Canadian Universities and monitored by a consultant virologist, Dr. M.S. Mahdy. The following studies were integrated in three different contracts undertaken by the University of Western Ontario, the University of Guelph, and the University of Ottawa. While many of these studies are long-term, some of them such as (a) and (b) have been completed and others such as (c) and (e) have had certain phases completed.

(a) To measure the attachment of known doses and types of viruses to collection vessels. To develop methods to eliminate such attachment if it occurs.

(b) To determine the effect of transportation and handling processes on the viability of viral infec-

tivity prior to samples being received by the examining authority.

(c) To measure and compare the quantitative efficiency and the practicability of selected techniques for the concentration of small amounts of virus in large volumes of water. Experimentally seeded samples of tap, river and lake water were used for this purpose.

(d) To measure and control the quality of the methods selected for use. This was done by including in the samples collected and supplied by the Centre, coded specimens experimentally seeded with known doses and types of viruses.

(e) To establish and employ complementary techniques that enhance the sensitivity of detection of viruses in concentrated water samples. Such techniques include immunoabsorption, immuno-electron microscopy, and radio-immunoassay employing polyvalent antisera.

(f) To isolate, quantify and identify viruses in samples collected from: Ottawa River, Lake Ontario between the Toronto Harbour and Niagara Falls, influent and effluent of sewage treatment plants and from sites below, within, and above the plants. Preliminary information is thus obtained about the contamination of the above bodies of water. Data will also indicate the efficiency of sewage treatment processes in virus removal, and the contribution of treatment plants to viral pollution of water. The effect of dilution factors on pollution will also be recognized.

(g) To detect, quantify and group-identify animal viruses in farm effluent and to obtain data on the survival of animal viruses.

A very successful Symposium on "Viruses in the Environment and their Potential Hazards" was held at CCIW on November 14, 1973. From the presentations and following floor and panel discussions, conclusions reached were:

- Viruses are present in the environment at levels infective to man with the major risk being of low-level environmental transmission of viral infections that may be subsequently spread through person-to-person contact.
- That present indicators of fecal contamination are not adequate indicators of viral pollution and thus it is possible that water supplies apparently free of fecal contamination, may in fact be contaminated with viruses.
- The incidence of fish tumours apparently increases in chemically polluted waters. These waters are also polluted with human viruses, thus carcinogenesis may be effected through a combined effect of these agents. CCIW is sponsoring further research in 1974 on this matter at the University of Guelph.

Physical Sciences Laboratories Section

This Section has two operating laboratories, Radiochemistry and Electron Microscopy. The Radiochemistry Laboratory is concerned with the behaviour of radionuclides entering the Great Lakes system from the rapidly growing nuclear power industry and other sources, and the use of nuclear methods to aid scientific research at CCIW. The Electron Microscopy Laboratory is developing techniques for observing and analysing microscopic objects of a

Table 2. 1973 Radionuclide Survey of Great Lakes Waters

Lake	Sample Station		Date	Level in pCi/litre	
	N. Lat.	W. Long.		^{137}Cs	^{125}Sb
Superior	47° 12′ 24″	89° 40′ 00″	20/5/73	0.063 ± .006	0.046 ± .015
	47° 50′ 51″	87° 27′ 36″	18/5/73	0.087 ± .006	0.041 ± .011
	47° 12′ 30″	85° 37′ 36″	13/5/73	0.077 ± .007	0.045 ± .013
Huron	45° 42′ 15″	83° 16′ 09″	10/5/73	0.041 ± .005	0.046 ± .014
	45° 01′ 06″	82° 37′ 42″	10/5/73	0.042 ± .005	0.101 ± .017
	43° 38′ 00″	82° 13′ 12″	10/5/73	0.035 ± .004	0.087 ± .011
Erie	41° 52′ 36″	82° 52′ 53″	29/5/73	0.035 ± .007	0.096 ± .016
	42° 10′ 30″	81° 03′ 12″	30/5/73	0.023 ± .007	0.089 ± .017
	42° 34′ 18″	79° 45′ 12″	30/5/73	0.015 ± .005	0.093 ± .017
Ontario	43° 25′ 00″	79° 16′ 30″	5/6/73	0.032 ± .006	0.083 ± .016
	43° 39′ 44″	77° 43′ 25″	5/6/73	0.042 ± .006	0.083 ± .013
	43° 43′ 51″	76° 30′ 13″	6/6/73	0.070 ± .007	0.142 ± .017
	43° 18′ 10″	79° 47′ 18″	24/5/73	0.057 ± .007	0.078 ± .016
Pickering	43° 48′ 25″	79° 02′ 08″	29/5/73	0.027 ± .006	0.103 ± .018
	43° 48′ 05″	79° 03′ 25″	29/5/73	0.035 ± .006	0.090 ± .020
	43° 48′ 03″	79° 05′ 05″	29/5/73	0.025 ± .006	0.070 ± .017
Douglas Point	44° 19′ 13″	81° 36′ 36″	11/6/73	0.019 ± .006	0.082 ± .016
	44° 19′ 51″	81° 36′ 26″	11/6/73	0.018 ± .005	0.076 ± .017
	44° 20′ 26″	81° 35′ 34″	11/6/73	0.014 ± .010	0.124 ± .038

geological, biological and microbiological nature to aid CCIW scientists in limnological and environmental impact studies.

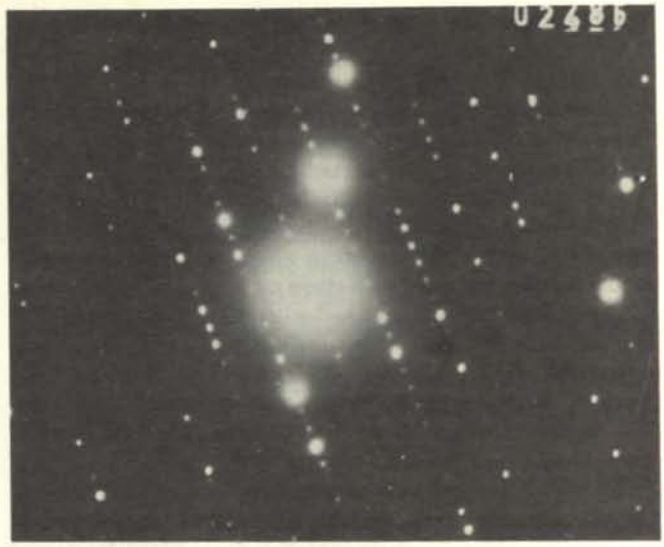
Radiochemistry Laboratory

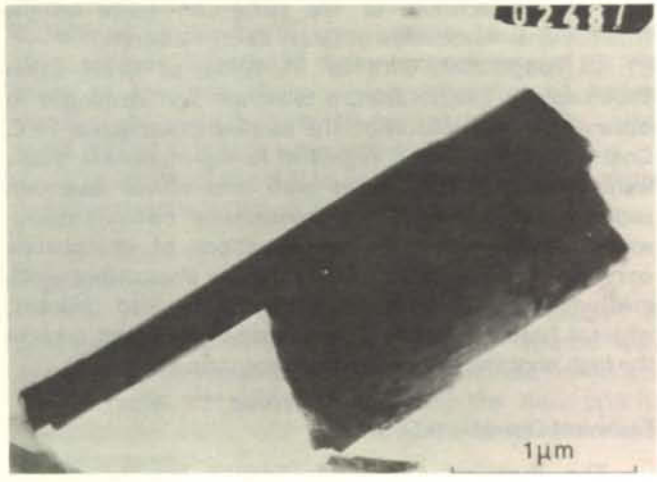
A survey of the levels of artificial radionuclides in Great Lakes waters, sediments and biota got underway in 1973 with measurements of γ-emitting radionuclides in water samples from Lakes Superior, Huron, Erie and Ontario. Samples were also taken offshore from the two Ontario nuclear generating stations at Douglas Point on Lake Huron and Pickering on Lake Ontario to measure any radioactive input to the lakes from these sources. Only two γ-emitting radionuclides that do not occur naturally were found, ^{137}Cs and ^{125}Sb, but at extremely low concentrations as shown in Table 2. No input was detectable from the nuclear generating stations so the levels are due to fallout from nuclear weapons testing. Consequently, there now exists a set of baseline values to measure the future impact of the nuclear power industry.

The movement of sediment in a near-shore zone of Lake Ontario was followed using an insert of neutron activable glass sand in conjunction with Geolimnology Section, LRD. The glass sand which was ground and sieved by Ontario Research Foundation, contained about 4% by weight of antimony. Core samples were periodically taken on a grid pattern around the point of insertion and analyzed for antimony by neutron activation. Dried sections of the cores weighing about 100 mg were irradiated for 10 minutes at 1×10^{13} n cm^{-2} s^{-1} and the ^{122}SB γ-ray at 560 Kev measured after allowing most of the ^{24} Na to decay. The detection limit was about 0.5 ppm antimony while the concentration of antimony in the sediment was less than 0.2 ppm, so that no background interference occurred.

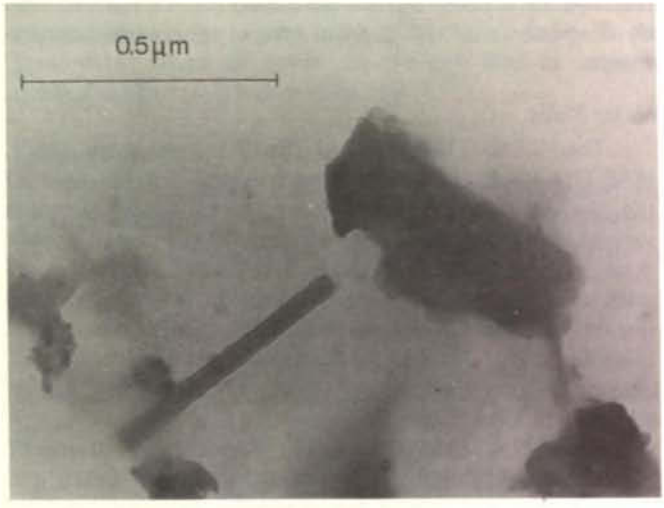
Electron Microscope Laboratory

A study of the distribution of asbestos fibres in Lake Superior was started during 1973 to determine whether dumping of asbestos containing mining and milling tailings from operations in Minnesota was affecting Canadian waters. Initially, the tailings were studied in cooperation with Geolimnology Section, LRD, to determine what specific asbestiform minerals could be expected in the lake water. Samples of different particle size fractions obtained from Geolimnology Section's size distribution analysis of the tailings, were scrutinized in the scanning electron microscope. It was found that the asbestiform minerals were concentrated in the finer particles and accounted for the bulk of the material in the less than 2 μm fraction. A sample of this fraction was mounted in the transmission electron microscope and electron diffraction patterns taken of individual fibres. Those obtained were all identical with that of cummingtonite from a standard sample of this mineral. Preliminary results of analyses of water samples from a station in Thunder Bay and another, 5 miles off Silver Bay, Minnesota were: Thunder Bay – 1×10^6 fibres per litre and Silver Bay – 9×10^6. The Thunder Bay fibres were distributed normally with a mean length of 0.2 μm while those from Silver Bay ranged from 0.1 to 4 μm long.





Micrograph and electrondiffraction pattern of fibre in water off Silver Bay.



Chrysotile fibres in water sample from near Isle Royale.

The Thunder Bay fibres had the characteristic "hollow-tube" appearance of chrysotile but those from off Silver Bay, where the tailings are dumped, were identified by electron diffraction, as cummingtonite. It would appear from these early results that no significant transboundary movement of the tailings occurs.

In cooperation with Biolimnology Laboratories of F.R.D., an investigation of the effects of PCB on the internal structure of the green algae, Ankistrodemus Falcatus, was carried out by electron microscopy. Two batches of green algae were inoculated with 50 and 10 ppb of PCB and incubated for 2 days. A third batch of algae was used as a control. After fixation and embedding in Epon, thin sections were examined under the transmission electron microscope. Compared to the control, the PCB treated algae indicated a marked change in the internal structure. There was a disruption of the chloroplasts and an increase in the number of vacuoles which explained the decrease in the photosynthetic activity of the algae after treatment with PCB at the ppb level. The results were presented by Dr. Val Glooschenko at the 1973 Conference on the International Association of Great Lakes Research.

In cooperation with Dr. P. Wong, of Great Lakes Biolimnology Laboratories, a technique was developed to observe the localization of the alkaline phosphatase in E. Coli. Bacteria grown in high and in low-phosphate media were processed and stained with lead nitrate and thin sections observed with the transmission electron microscope. Those with high concentrations of phosphatase enzymes, which were induced by the low phosphate growth medium, were heavily stained by black lead deposits, whereas bacteria without any phosphatase, which grew in the high phosphate medium, were not stained.

Technical Operations Section

The Technical Operations Section has the responsibility for the multi-disciplinary field measurements carried out from major and minor vessels in support of scientific projects conducted at CCIW, the Pacific and Western Regions. The Section provides on request, the expertise required to support all scientific field research undertaken by conponents of CCIW from several services and departments.

Major Ships

The C.S.S. LIMNOS and the chartered vessel, M.V. MARTIN KARLSEN continued to carry out the bulk of the Great Lakes work this year. Up to March 31, these surveys were augmented, from time to time, with work done by the C.C.G.S. PORTE DAUPHINE, through contract arrangements with the Great Lakes Institute, University of Toronto. On completion of the IFYGL program on Lake Ontario in March, the emphasis shifted, under the IJC Upper Lakes Reference, to work in the Upper Lakes, particularly Lake Superior.

The C.S.S. LIMNOS carried out a large variety of cruises including monitor, mooring, sediment survey and coring cruises and several special surveys (nutrient recycling in the water column; distribution of sulphur isotopes in the sediments) making a total of 31 for the 1973 season. They can be broken down as follows:

9 Heat Content Surveys (IFYGL)	Lake Ontario
3 U.S. Biochemical Surveys (IFYGL)	Lake Ontario
4 Mooring Cruises (IFYGL)	Lake Ontario
1 Engineering/Water Quality Trials	Lake Ontario
4 Monitor Cruises (1 special)	Lake Erie
2 Water Column Studies	Lake Erie
1 Coring Cruise (Upper Lakes IJC Ref)	Georgian Bay
1 Mooring Cruise (Upper Lakes IJC Ref)	Lake Huron
3 Mooring Cruises (Upper Lakes IJC Ref)	Lake Superior
3 Sediment Surveys (Upper Lakes IJC Ref)	Lake Superior, Georgian Bay, and North Channel, Lake Huron

The monitor cruises in Lake Erie were the first for the LIMNOS since 1968. The regional sediment surveys in Lake Superior, Georgian Bay and the North Channel of Lake Huron, part of the IJC Upper Lakes Reference, completed the overall survey of the Great Lakes (with the exception of Lake Michigan, which is entirely within U.S. jurisdiction). The coring cruise, also in Georgian Bay, was conducted to define more carefully, the sub-bottom strata observed in the echograms and to delineate the low-level boundaries of Georgian Bay. Very few problems were encountered during the year and those that did arise were quickly rectified by ships' personnel and/or Engineering Systems staff.

To meet the requirement of the increased emphasis on the Upper Lakes, six monitor cruises were successfully completed by the M.V. MARTIN KARLSEN in Lake Superior. In addition, the following cruises were also completed on the Great Lakes to make a total of 21 for the KARLSEN in 1973:

1 Heat Content Survey (IFYGL)	Lake Ontario
2 OOPS Cruises (IFYGL)	Lake Ontario
1 Buoy Retrieval (IFYGL)	Lake Ontario
2 Geology Cruises	Lake Ontario
4 Monitor Cruises	Lake Ontario
2 Geology Cruises	Lake Superior
1 Monitor Cruise	Lake Erie
2 Monitor Cruises	Lake Huron

The total miles steamed for both ships in 1973 was 28% more than last year (Table 3).

Completed schedules for the major ships are given in separate tables.

During the greater part of 1973, the C.C.G.S. PORTE DAUPHINE was based at CCIW and funded by MSD. This arrangement with the Ministry of Transport permitted the vessel to complete about 13 cruises, most of which were

staffed and co-ordinated by Technical Operations personnel. The cruises included Heat Content Surveys of Lake Ontario (as part of IFYGL) and current meter moorings in Lake Ontario and the St. Lawrence River. During the months of June, July and August, the DAUPHINE, staffed by MSD personnel carried out hydrographic work in the lower St. Lawrence River.

The C.S.S. ADVENT, the new addition to the CCIW "fleet" spent the first month of the field season undergoing trials and renovations to make it more suitable for limnological work on the lakes. For the remainder of the year, the vessel participated in a variety of cruises on Lakes Ontario, Erie, St. Clair and Superior including hydrographic surveys, equipment trials, coring, N.T.A. monitoring, virology, mycology and support of the Point Source Effluent study at Marathon on Lake Superior.

Until the expiry of her charter in August 1973, the M.V. LAC ERIE was actively involved in regional sediment surveys and geophysical studies on the Great Lakes. In addition, she completed a number of other tasks including launching and recovering moorings, servicing the meteorological buoy network, N.T.A. monitoring, and engineering field trials.

The C.S.L. SHARK, in addition to supporting several other programs during 1973, provided support for all diving operations in Lakes Ontario, Erie, and St. Clair.

Small Craft

The Technical Operations Section continued to participate in the Vessel Assignments Committee to co-ordinate, through the Central Region, Marine Sciences Directorate, the assignment of small craft to the various scientific sections at CCIW, universities and other outside agencies.

Personnel

Personnel from the Section were assigned to major and minor ships throughout the season, and to small craft involved with "shore-based" operations at the Bay of Quinte, Burlington, Marathon and the Lower St. Lawrence.

The staff were responsible for all deck observations, meteorological observations, field equipment and co-ordination of vessel movement.

A short in-house course in basic electricity and electronics (designed to broaden the capabilities of Technical Operations personnel in areas which would be of practical value in future field projects), was run in February.

Seven students were employed during the summer months of field operations. Nine term employees have also been hired bringing the total number in the Section to 37.

Program Support

Technical Operations Section continued their support of numerous "shore-based" operations during 1973.

a. Meteorological Measurement Programs
b. Lake Ontario Shore Sensor Program
c. N.T.A. Monitoring
d. Point Source Study at Marathon
e. Wave Climatology and Beach Stability
f. M.S.D. Wave River Program
g. Bay of Quinte (nutrient dynamics)
h. Water Quality Studies on the St. Lawrence and St. Mary's River (WQB)
i. Oil Spill Cleanup and Remote Sensing
j. Deep Water Port Feasibility Study at Kamouraska, Que. (MSD)

Diving Unit

During 1973, the diving unit actively supported 18 scientific programs in the Great Lakes and St. Lawrence River, with tasks ranging from cable laying and inspection to selective hand coring for chemical analyses. In 207 diving days, the unit logged 924 diving hours. Extensive use was made of the new diving system consisting of surface supplied air, unisuits, Kirby-Morgan masks and the underwater T.V. system with video tape and communications.

The diving tender C.S.L. SHARK, supported all diving in Lakes Ontario, Erie and St. Clair.

Riggers/Stores

The rigging unit continued to equip and support all field parties with which staff from the Section were associated. Instrument towers, trailers and modifications to various types of buoys were among the high priority commitments along with normal maintenance of winches and generators.

Reports

Technical Operations has assumed the responsibility of preparing preliminary descriptive limnology reports upon the completion of each monitor cruise. Although they provide only a very cursory look at lake conditions the up-to-date nature of these reports will lead to improve quality control of the data collected.

Other Activities

Personnel also participated in air/sea rescue operations in co-operation with the Coast Guard and managed to save the life of a helicopter pilot downed in Lake Superior in June.

Table 3. Schedules for C.S.S. LIMNOS and M. V. MARTIN KARLSEN

Ship	Started Operations	Completed Operations	No. of Cruises	Miles Steamed	Days at CCIW (%)	Active Days (%)
C.S.S. LIMNOS	Jan. 8	Dec. 10	31	22,386	32	68
M.V. MARTIN KARLSEN	Jan. 3	Dec. 7	21	23,818	40	60

Table 4. Great Lakes Studies, 1973. C.S.S. LIMNOS

	SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
JAN		1 CCIW	2 CCIW	3 CCIW	4 CCIW	5 CCIW	6 CCIW
	7 CCIW	8 Depart CCIW 1212 hrs.	9 Lake Ontario	10 Heat Content	11 Survey	12 Arrive CCIW 0840 hrs.	13 CCIW
	14 CCIW	15 Depart CCIW 1124 hrs.	16 Lake Ontario	17 Heat Content Survey	18 Arrive CCIW 2225 hrs.	19 CCIW	20 CCIW
	21 CCIW	22 CCIW	23 CCIW	24 CCIW	25 CCIW	26 CCIW	27 CCIW
FEB	28 CCIW	29 Depart CCIW 1103 hrs.	30 Lake Ontario Heat Content Survey	31 Arrive Toronto 2345 hrs.	1 In Transit	2 CCIW	3 CCIW
	4 CCIW	5 Depart CCIW 1030 hrs.	6 Lake Ontario	7 U.S. Biochemical	8 Survey	9 Arrive CCIW 0800 hrs.	10 CCIW
	11 CCIW	12 Depart CCIW 1003 hrs.	13 Lake Ontario	14 Heat Content Survey	15 Arrive CCIW 1625 hrs.	16 CCIW	17 CCIW
	18 CCIW	19 CCIW	20 CCIW	21 CCIW	22 CCIW	23 CCIW	24 CCIW
MAR	25 CCIW	26 Depart CCIW 0955 hrs.	27 Lake Ontario	28 Heat Content Survey	1 Arrive CCIW 0930 hrs.	2 CCIW	3 CCIW
	4 CCIW	5 CCIW	6 CCIW	7 CCIW	8 CCIW	9 CCIW	10 CCIW
	11 CCIW	12 Depart CCIW 1057 hrs.	13 Lake Ontario Heat Content Survey	14 Arrive CCIW 2045 hrs.	15 CCIW	16 CCIW	17 CCIW
	18 CCIW	19 Depart CCIW 1052 hrs.	20 Lake Ontario	21 U.S. Biochemical	22 Survey	23 Arrive CCIW 0905 hrs.	24 CCIW
	25 CCIW	26 Depart CCIW 0955 hrs.	27 Lake Ontario Heat Content Survey	28 End of Cruise 1150 hrs.	29 Lake Ontario	30 Moorings	31 Arrive CCIW 1305 hrs.
APR	1 CCIW	2 Depart CCIW	3 Lake Ontario	4 Moorings	5 Arrive CCIW	6 CCIW	7 CCIW
	8 CCIW	9 Depart CCIW 1000 hrs.	10 Lake Erie	11 Monitor	12 Lake Erie	13 Monitor	14 Lake Erie
	15 Monitor	16 Lake Erie	17 Arrive CCIW 2330 hrs.	18 CCIW	19 CCIW	20 CCIW	21 CCIW
	22 CCIW	23 CCIW	24 Depart CCIW 1055 hrs.	25 Lake Superior	26 Regional	27 Sediment	28 Survey
MAY	29 Lake Superior	30 Regional	1 Sediment	2 Survey	3 Lake Superior	4 Regional	5 Sediment
	6 Survey	7 Lake Superior	8 Arrive Thunder Bay 0845 hrs.	9 Depart Thunder Bay 0700 hrs.	10 Lake Superior	11 Regional	12 Sediment
	13 Survey	14 Lake Superior	15 Regional	16 Sediment	17 Survey	18 Arrive Sault Ste. Marie 1023 hrs.	19 Depart Sault Ste. Marie 1855 hrs.
	20 Lake Superior	21 Moorings	22 Lake Superior	23 Moorings	24 Lake Superior	25 Moorings	26 Lake Superior
	27 Moorings	28 Lake Huron	29 Moorings	30 Arrive CCIW 0000 hrs.	31 CCIW	1 CCIW	2 CCIW
JUNE	3 CCIW	4 Depart CCIW 1055 hrs.	5 Lake Ontario	6 Heat Content Survey	7 Arrive CCIW 1620 hrs.	8 CCIW	9 CCIW
	10 CCIW	11 Depart CCIW 1110 hrs.	12 Lake Ontario	13 U.S. Biochemical	14 Survey	15 Arrive CCIW 0230 hrs.	16 CCIW
	17 In Transit	18 Depart Port Stanley 1212 hrs.	19 Lake Erie	20 Water Column	21 Study	22 Arrive Port Colborne 0558 hrs.	23 In Transit
	24 CCIW	25 Depart CCIW 1329 hrs.	26 Lake Ontario	27 Heat Content Survey	28 Moorings	29 Arrive CCIW 0945 hrs.	30 CCIW
JULY	1 CCIW	2 CCIW	3 CCIW	4 CCIW	5 CCIW	6 CCIW	7 CCIW
	8 CCIW	9 ----------	10 ----------	11 DRY DOCK	12 ----------	13 ----------	14 ----------
	15 ----------	16 ----------	17 ----------	18 DRY DOCK	19 ----------	20 ----------	21 ----------
	22 CCIW	23 CCIW	24 Depart CCIW 0910 hrs.	25 Lake Erie	26 Monitor	27 Lake Erie	28 Monitor
AUG	29 Lake Erie	30 Arrive Port Stanley 1235 hrs.	31 Port Stanley	1 Depart Port Stanley 1420 hrs.	2 Lake Erie	3 Water Column Study	4 Arrive Port Stanley 1830 hrs.
	5 Port Stanley	6 In Transit	7 Depart Sarnia 2040 hrs.	8 Lake Superior	9 Moorings	10 Lake Superior	11 Moorings
	12 Lake Superior	13 Moorings	14 Lake Superior	15 Moorings	16 Lake Superior	17 Moorings	18 Lake Superior
	19 Moorings	20 Lake Superior	21 Moorings	22 Arrive Sarnia 2320 hrs.	23 Sarnia	24 Sarnia	25 Sarnia
	26 Sarnia	27 Depart Sarnia 1405 hrs.	28 Lake Erie	29 Special Monitor	30 Arrive Port Colborne 0025 hrs.	31 In Transit	1 Port Stanley
SEPT	2 Port Stanley	3 Port Stanley	4 Depart Port Stanley 1500 hrs.	5 Lake Erie	6 Water Column Study	7 Arrive Port Stanley 0626 hrs.	8 In Transit
	9 In Transit	10 Depart Owen Sound 1335 hrs.	11 Regional	12 Sediment Survey	13 Georgian Bay	14 Arrive Owen Sound 1107 hrs.	15 Owen Sound
	16 Owen Sound	17 Depart Owen Sound 0025 hrs.	18 Regional	19 Sediment Survey	20 Georgian Bay	21 Arrive Owen Sound 1222 hrs.	22 Owen Sound
	23 Owen Sound	24 Depart Owen Sound 1110 hrs.	25 Sediment Survey	26 Arrive Owen Sound 1520 hrs.	27 Owen Sound	28 Owen Sound	29 Depart Owen Sound 2353 hrs.
OCT	30 Lake Superior	1 Moorings	2 Lake Superior	3 Moorings	4 Lake Superior	5 Moorings	6 Lake Superior
	7 Moorings	8 Arrive CCIW 1010 hrs.	9 CCIW	10 CCIW	11 CCIW	12 CCIW	13 CCIW
	14 CCIW	15 CCIW	16 CCIW	17 CCIW	18 Depart CCIW 0805 hrs.	19 Lake Ontario Moorings, Arr. CCIW	20 CCIW
	21 CCIW	22 Depart CCIW 1055 hrs.	23 Georgian Bay	24 Coring	25 Georgian Bay	26 Coring	27 Georgian Bay
	28 Coring	29 Georgian Bay	30 Coring	31 Georgian Bay	1 Arrive CCIW 0350 hrs.	2 CCIW	3 CCIW
NOV	4 CCIW	5 Depart CCIW 1010 hrs.	6 Lake Erie	7 Monitor	8 Lake Erie	9 Monitor	10 Lake Erie
	11 Monitor	12 Lake Erie	13 Monitor	14 Arrive Sarnia 0328 hrs.	15 Depart Sarnia	16 Lake Huron	17 Moorings
	18 Lake Huron	19 Moorings	20	21 Arrive CCIW 1610 hrs.	22 Depart CCIW 1123 hrs.	23 Eng. Trials, Arr. CCIW 1345 hrs.	24 CCIW
	25 CCIW	26 CCIW	27 CCIW	28 CCIW	29 CCIW	30 CCIW	1 CCIW
DEC	2 CCIW	3 CCIW	4 Depart CCIW 0800 hrs.	5 Lake Ontario	6 Moorings	7 Lake Ontario	8 Moorings
	9 Lake Ontario	10 Arrive CCIW 1325 hrs.	11 CCIW	12 CCIW	13 CCIW	14 CCIW	15 CCIW
	16 CCIW	17 CCIW	18 CCIW	19 CCIW	20 CCIW	21 CCIW	22 CCIW
	23 CCIW	24 CCIW	25 CCIW	26 CCIW	27 CCIW	28 CCIW	29 CCIW

Table 5. Great Lakes Studies, 1973. M.V. MARTIN KARLSEN

	SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
JAN		1 CCIW	2 CCIW	3 Depart CCIW 1125 hrs.	4 Lake Ontario	5 Heat Content Survey	6 Arrive CCIW 1345 hrs.
	7 CCIW	8 CCIW	9 Depart CCIW 1010 hrs.	10 Lake Ontario	11 Organic Particle Study	12 Arrive CCIW 0820 hrs.	13 CCIW
	14 CCIW	15 Depart CCIW 1145 hrs.	16 Organic Particle Study	17 Lake Ontario	18 Organic Particle Study	19 Phase II	20 Arrive CCIW 0905 hrs.
	21 CCIW	22 CCIW	23 CCIW	24 CCIW	25 CCIW	26 CCIW	27 CCIW
FEB	28 CCIW	29 CCIW	30 CCIW	31 CCIW	1 CCIW	2 CCIW	3 CCIW
	4 CCIW	5 CCIW	6 CCIW	7 CCIW	8 CCIW	9 CCIW	10 CCIW
	11 CCIW	12 CCIW	13 CCIW	14 CCIW	15 CCIW	16 CCIW	17 CCIW
	18 CCIW	19 CCIW	20 CCIW	21 CCIW	22 CCIW	23 CCIW	24 CCIW
	25 CCIW	26 CCIW	27 CCIW	28 CCIW	1 CCIW	2 CCIW	3 CCIW
MAR	4 CCIW	5 Depart CCIW 1540 hrs.	6 Lake Ontario	7 Organic Particle	8 Study	9 Arrive CCIW 0815 hrs.	10 CCIW
	11 CCIW	12 Depart CCIW 1110 hrs.	13 Lake Ontario	14 Organic Particle	15 Study	16 Phase II	17 Arrive CCIW 0830 hrs.
	18 CCIW	19 Depart CCIW 1145 hrs.	20 Lake Ontario	21 Monitor	22 Lake Ontario	23 Monitor	24 Arrive CCIW 1600 hrs.
	25 CCIW	26 CCIW	27 CCIW	28 CCIW	29 CCIW	30 CCIW	31 CCIW
APR	1 CCIW	2 CCIW	3 CCIW	4 CCIW	5 CCIW	6 CCIW	7 CCIW
	8 CCIW	9 Depart CCIW 1025 hrs.	10 Coring	11 Lake Ontario	12 Arrive CCIW 1755 hrs.	13 CCIW	14 CCIW
	15 CCIW	16 Depart CCIW 1105 hrs.	17 Lake Ontario Terrestial Heat	18 Arrive CCIW 1910 hrs.	19 CCIW	20 CCIW	21 CCIW
	22 CCIW	23 CCIW	24 Depart CCIW 1125 hrs.	25 Lake Ontario	26 Monitor	27 U.S. Biochemical	28 Survey
MAY	29 Arrive CCIW 0855 hrs.	30 CCIW	1 Depart CCIW 0915 hrs.	2 Lake Ontario Radon & Moorings	3 Arrive CCIW 1522 hrs.	4 CCIW	5 CCIW
	6 CCIW	7 Depart CCIW 1030 hrs.	8 Lake Huron	9 Monitor	10 Lake Huron	11 Monitor	12 Sault Ste. Marie
	13 Lake Superior	14 Monitor	15 Lake Superior	16 Monitor	17 Lake Superior	18 Monitor	19 Thunder Bay
	20 Lake Superior	21 Monitor	22 Lake Superior	23 Monitor	24 Arrive Sault Ste. Marie 0845 hr	25 Sault Ste. Marie	26 Sault Ste. Marie
	27 Sault Ste. Marie	28 Sault Ste. Marie	29 Depart Sault Ste. Marie 1437 hrs	30 Lake Superior	31 Coring	1 Geophysical	2 and
JUNE	3 Geochemical	4 Lake Superior	5 Lake Superior	6 Coring	7 Geophysical	8 and	9 Geochemical
	10 Lake Superior	11 Arrive Sault Ste. Marie 1300 hrs.	12 Sault Ste. Marie	13 Sault Ste. Marie	14 Sault Ste. Marie	15 Depart Sault Ste. Marie 1200 hrs.	16 Lake Superior
	17 Monitor	18 Lake Superior	19 Monitor	20 Lake Superior	21 Monitor	22 Lake Superior	23 Monitor
	24 Lake Superior	25 Monitor	26 Lake Superior	27 Monitor	28 Arrive Sault Ste. Marie 1440 hrs.	29 In Transit	30 In Transit
JULY	1 In Transit	2 ----------	3 ----------	4 DOWN	5 TIME	6 ----------	7 ----------
	8 ----------	9 ----------	10 ----------	11 DOWN	12 TIME	13 ----------	14 ----------
	15 CCIW	16 CCIW	17 CCIW	18 CCIW	19 CCIW	20 CCIW	21 CCIW
	22 CCIW	23 In Transit	24 In Transit	25 In Transit	26 Depart Sault Ste Marie 2018 hrs.	27 Lake Superior	28 Monitor
AUG	29 Lake Superior	30 Monitor	31 Lake Superior	1 Monitor	2 Lake Superior	3 Monitor	4 Lake Superior
	5 Monitor	6 Lake Superior	7 Monitor	8 Arrive Sault Ste. Marie 1155 hrs.	9 Sault Ste. Marie	10 Sault Ste. Marie	11 Sault Ste. Marie
	12 Sault Ste. Marie	13 Depart Sault Ste. Marie 1645 hrs.	14 Lake Superior	15 Coring	16 Lake Superior	17 Coring	18 Lake Superior
	19 Coring	20 Lake Superior	21 Coring	22 Lake Superior	23 Arrive Sault Ste. Marie 0500 hrs.	24 In Transit	25 In Transit
	26 Depart Sarnia 0930 hrs.	27 Lake Erie	28 Monitor	29 Lake Erie	30 Monitor	31 Lake Erie	1 Arrive Sault Ste. Marie 0615 hrs.
SEPT	2 Sarnia	3 Sarnia	4 Depart Sarnia 1555 hrs.	5 Lake Superior	6 Monitor	7 Lake Superior	8 Monitor
	9 Lake Superior	10 Monitor	11 Lake Superior	12 Monitor	13 Lake Superior	14 Monitor	15 Lake Superior
	16 Monitor	17 Lake Superior	18 Sault Ste. Marie	19 Lake Huron	20 Monitor	21 Arrive Sarnia 0145 hrs.	22 In Transit
	23 In Transit	24 CCIW	25 CCIW	26 CCIW	27 CCIW	28 CCIW	29 CCIW
OCT	30 CCIW	1 CCIW	2 CCIW	3 CCIW	4 CCIW	5 CCIW	6 CCIW
	7 CCIW	8 CCIW	9 Depart CCIW 1746 hrs.	10 In Transit	11 In Transit	12 In Transit	13 Lake Superior
	14 Monitor	15 Lake Superior	16 Monitor	17 Lake Superior	18 Monitor	19 Lake Superior	20 Monitor
	21 Lake Superior	22 Monitor	23 Lake Superior	24 Monitor	25 Lake Superior	26 In Transit	27 In Transit
NOV	28 In Transit	29 Arrive CCIW 1140 hrs.	30 Depart CCIW 1120 hrs.	31 Lake Ontario	1 Monitor	2 Lake Ontario	3 Monitor
	4 Arrive CCIW 0350 hrs.	5 CCIW	6 CCIW	7 CCIW	8 CCIW	9 CCIW	10 CCIW
	11 CCIW	12 CCIW	13 Depart CCIW 1108 hrs.	14 In Transit	15 In Transit	16 In Transit	17 In Transit
	18 Lake Superior	19 Monitor	20 Lake Superior	21 Monitor	22 Lake Superior	23 Monitor	24 Lake Superior
	25 Monitor	26 Lake Superior	27 Monitor	28 Lake Superior	29 Monitor	30 In Transit	1 In Transit
DEC	2 In Transit	3 Arrive CCIW 2145 hrs.	4 Depart CCIW 1250 hrs.	5 Lake Ontario	6 Monitor	7 Arrive CCIW 0135 hrs.	8 CCIW
	9 CCIW	10 CCIW	11 CCIW	12 CCIW	13 CCIW	14 CCIW	15 CCIW
	16 CCIW	17 CCIW	18 CCIW	19 CCIW	20 CCIW	21 CCIW	22 CCIW
	23 CCIW	24 CCIW	25 CCIW	26 CCIW	27 CCIW	28 CCIW	29 CCIW

Table 6. Great Lakes Studies, 1973. C.C.G.S. PORTE DAUPHINE

	SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
JAN		1	2 Depart Toronto 2140 hrs.	3 Lake Ontario	4 Heat Content Survey	5 Arrive Toronto 0900 hrs.	6 Toronto
	7 Toronto	8 Toronto	9 Depart Toronto 0950 hrs.	10 Heat Content Survey & Coring	11 Arrive Toronto 0007 hrs.	12 Toronto	13 Toronto
	14 Toronto	15 Depart Toronto 1140 hrs.	16 Lake Ontario	17 Heat Content Survey	18 Arrive Toronto 1104 hrs.	19 Toronto	20 Toronto
	21 --------	22 ---------	23 --------	24 Toronto	25 ---------	26 ---------	27 ---------
FEB	28 Toronto	29 Depart Toronto 1150 hrs.	30 Lake Ontario	31 Heat Content Survey	1 Arrive Toronto 0438 hrs.	2 Toronto	3 Toronto
	4 --------	5 --------	6 ---------	7 Toronto	8 ----------	9 ----------	10. ----------
	11 --------	12 --------	13 ---------	14 Toronto	15 ----------	16 ----------	17 ----------
	18 ---------	19 --------	20 ----------	21 Toronto	22 ----------	23 ----------	24 ----------
	25 ---------	26 --------	27 ----------	28 Toronto	1 ---------	2 ----------	3 ----------
MAR	4 ---------	5 ---------	6 ----------	7 Toronto	8 ----------	9 ----------	10 ----------
	11 Toronto	12 Depart Toronto 1552 hrs.	13 Heat Content Survey	14 Arrive Toronto 2017 hrs.	15 Toronto	16 Toronto	17 Toronto
	18 ---------	19 ----------	20 ----------	21 Toronto	22 ----------	23 ----------	24 ----------
	25 Toronto	26 Depart Toronto 0955 hrs.	27 Heat Content Survey	28 Arrive Toronto 1405 hrs.	29 Toronto	30 Toronto	31 Toronto
APR	1 Toronto	2 Depart Toronto 1105 hrs.	3 Lake Ontario	4 Heat Content	5 Survey	6 Arrive Toronto 0224 hrs.	7 Toronto
	8 ---------	9 ---------	10 ----------	11 Toronto	12 --------	13 ---------	14 ----------
	15 ---------	16 ---------	17 ----------	18 Toronto	19 ---------	20 ----------	21 ----------
	22 ----------	23 ----------	24 ----------	25 Toronto	26 ----------	27 ----------	28 ----------
MAY	29 Toronto	30 Depart CCIW 1030 hrs.	1 Lake Ontario	2 Heat Content Survey	3 Arrive CCIW 0530 hrs.	4 CCIW	5 CCIW
	6 CCIW	7 CCIW	8 CCIW	9 CCIW	10 CCIW	11 CCIW	12 CCIW
	13 CCIW	14 CCIW	15 CCIW	16 CCIW	17 Depart CCIW	18 In Transit	19 Arrive Quebec
	20 Quebec	21 Depart Quebec	22 Quebec	23 Anchorage Site	24 Arrive Quebec	25 Quebec	26 Quebec
	27 Quebec	28 Arrive Anchorage	29 St. Lawrence	30 St. Lawrence	31 St. Lawrence	1 St. Lawrence	2 Point au Pic
JUNE	3 Point au Pic	4 St. Lawrence	5 St. Lawrence	6 St. Lawrence	7 St. Lawrence	8 St. Lawrence	9 Point au Pic
	10 Point au Pic	11 St. Lawrence	12 St. Lawrence	13 St. Lawrence	14 St. Lawrence	15 St. Lawrence	16 Point au Pic
	17 Point au Pic	18 St. Lawrence	19 St. Lawrence	20 St. Lawrence	21 St. Lawrence	22 St. Lawrence	23 St. Lawrence
	24 Depart Anchorage Area	25 Quebec	26 In Transit	27 In Transit	28 In Transit	29 Arrive CCIW	30 CCIW
JULY	1 CCIW	2 CCIW	3 CCIW	4 CCIW	5 CCIW	6 CCIW	7 CCIW
	8 CCIW	9 CCIW	10 CCIW	11 CCIW	12 CCIW	13 CCIW	14 CCIW
	15 CCIW	16 CCIW	17 Leave CCIW 1000 hrs.	18 In Transit	19 In Transit	20 In Transit	21 In Transit
	22 Arrive Quebec	23 Depart Quebec 1200 hrs.	24 Mooring Survey off St. Francois	25 Mooring	26 Mooring	27 Arrive Quebec 1430 hrs.	28 Quebec
AUG	29 Quebec	30 Survey Site Tower Location	31 Tower Site	1 Tower Site	2 Tower Site	3 Arrive Quebec 1400 hrs.	4 Quebec
	5 Quebec	6 Survey Site	7 Survey Site	8 Survey Site	9 Survey Site	10 Survey Site	11 Survey Site
	12 Survey Site	13 Survey Site	14 Survey Site	15 Survey Site	16 Survey Site	17 Arrive Quebec 1700 hrs.	18 Quebec
	19 Quebec	20 Survey Site	21 Survey Site	22 Survey Site	23 Survey Site	24 Arrive Quebec 1200 hrs.	25 Quebec
	26 Quebec	27 Depart Quebec 0800 hrs.	28 In Transit	29 In Transit	30 In Transit	31 In Transit	1 Arrive CCIW
SEPT	2 CCIW	3 Depart CCIW	4 Lake Ontario Hamilton-Scourge	5 Hamilton-Scourge	6 Hamilton-Scourge	7 Hamilton-Scourge	8 CCIW
	9 CCIW	10 Hamilton-Scourge	11 Hamilton-Scourge	12 ----------	13 ----------	14 ----------	15 CCIW
	16 CCIW	17 --------	18 ---------	19 Hamilton-Scourge	20 ----------	21 ----------	22 CCIW
	23 CCIW	24 ---------	25 ----------	26 Hamilton-Scourge	27 ----------	28 ----------	29 CCIW
OCT	30 CCIW	1 CCIW	2 CCIW	3 CCIW	4 CCIW	5 CCIW	6 CCIW
	7 CCIW	8 CCIW	9 Depart CCIW 1100 hrs.	10 Lake Ontario Coring	11 Arrive CCIW 1600 hrs.	12 CCIW	13 CCIW
	14 CCIW	15 CCIW	16 Depart CCIW	17 Lake Ontario Hamilton-Scourge	18 Arrive CCIW	19 CCIW	20 CCIW
	21 CCIW	22 CCIW	23 CCIW	24 Depart CCIW 1550 hrs.	25 Remote Sensing ERTS	26 Remote Sensing ERTS	27 Remote Sensing ERTS
NOV	28 Arrive CCIW 1850 hrs.	29 Depart CCIW	30 Lake Ontario Hamilton-Scourge	31 Hamilton-Scourge	1 Hamilton-Scourge	2 Arrive CCIW	3 CCIW
	4 CCIW	5 CCIW	6 CCIW	7 CCIW	8 CCIW	9 CCIW	10 CCIW
	11 CCIW	12 CCIW	13 CCIW	14 CCIW	15 CCIW	16 CCIW	17 CCIW
	18 ----------	19 ---------	20 --------	21 CCIW	22 --------	23 ---------	24 --------
	25 ----------	26 ----------	27 ----------	28 CCIW	29 --------	30 ----------	1 --------
DEC	2 ----------	3 ----------	4 ----------	5 CCIW	6 ---------	7 ----------	8 ----------
	9 CCIW	10 Depart CCIW 0800 hrs.	11 Monitor-NTA	12 Lake Ontario	13 Moorings Wolfe Island Area	14 Arrive CCIW 0300 hrs.	15 CCIW
	16 CCIW	17 Location of Buoys	18 Toronto Area	19 CCIW	20	21	22
	23	24	25	26	27	28	29

Table 7. Great Lakes Studies, 1973. C.S.S. ADVENT

	SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
JAN		1	2	3	4	5	6
	7	8	9	10	11	12	13
	14	15	16	17	18	19	20
	21	22	23	24	25	26	27
FEB	28	29	30	31	1	2	3
	4	5	6	7	8	9	10
	11	12	13	14	15	16	17
	18	19	20	21	22	23	24
MAR	25	26	27	28	1	2	3
	4	5	6	7	8	9	10
	11	12	13	14	15	16	17
	18	19	20	21	22	23	24
	25	26	27	28	29	30	31
APR	1	2	3	4	5	6	7
	8	9	10	11	12	13	14
	15	16	17	18	19	20	21
	22	23	24	25	26	27	28
MAY	29	30	1	2	3	4	5
	6	7	8	9	10	11	12
	13 Outfitting	14 CCIW	15 CCIW	16 CCIW	17 CCIW	18 CCIW	19 CCIW
	20 CCIW	21 CCIW	22 Depart CCIW 1225 hrs.	23 Lake	24 Ontario	25 Bathymetric	26 Survey
	27 Arrive CCIW 1915 hrs.	28 CCIW	29 CCIW	30 CCIW	31 CCIW	1 CCIW	2 CCIW
JUNE	3 CCIW	4 CCIW	5 Equipment	6 Trials	7 CCIW	8 CCIW	9 CCIW
	10 CCIW	11 CCIW	12 Equipment	13 Trials	14 CCIW	15 Equipment Trials	16 CCIW
	17 CCIW	18 CCIW	19 CCIW	20 CCIW	21 CCIW	22 CCIW	23 CCIW
	24 CCIW	25 CCIW	26 CCIW	27 CCIW	28 CCIW	29 CCIW	30 CCIW
JULY	1 CCIW	2 CCIW	3 CCIW	4 CCIW	5 Equipment Trials	6 CCIW	7 CCIW
	8 CCIW	9 CCIW	10 CCIW	11 CCIW	12 CCIW	13 CCIW	14 CCIW
	15 CCIW	16 CCIW	17 Depart CCIW 0900 hrs.	18 In Transit	19 In Transit	20 In Transit	21 In Transit
	22 Arrive Sault Ste Marie 1545 hrs.	23 Downtime Sault Ste. Marie	24 Downtime Sault Ste. Marie	25 Downtime Sault Ste. Marie	26 Downtime Sault Ste. Marie	27 In Transit	28 Marathon
AUG	29 ----------	30 ----------	31 Marathon	1 Project	2 ----------	3 ----------	4 ----------
	5 ----------	6 ----------	7 Marathon	8 Project	9 ----------	10 ----------	11 ----------
	12 ----------	13 ----------	14 Marathon	15 Project	16 ----------	17 ----------	18 ----------
	19 ----------	20 ----------	21 Marathon	22 Project	23 ----------	24 ----------	25 Depart Marathon 0430 hrs.
SEPT	26 In Transit	27 In Transit	28 In Transit	29 Arrive CCIW 1400 hrs.	30 CCIW	31 CCIW	1 CCIW
	2 CCIW	3 CCIW	4 CCIW	5 CCIW	6 CCIW	7 CCIW	8 CCIW
	9 CCIW	10 CCIW	11 CCIW	12 CCIW	13 Depart CCIW 0900 hrs	14 Arrive Port Stanley 1640 hrs.	15 Port Stanley
	16 Port Stanley	17 Dredge Impact Study	18 Lake Erie	19 In Transit	20 Dredge Impact Study	21 Lake St. Clair	22 Windsor
	23 Windsor	24 Dredge Impact Study	25 Lake St. Clair	26 Depart Windsor 1530 hrs.	27 In Transit	28 Arrive CCIW 1635 hrs.	29 CCIW
OCT	30 CCIW	1 Depart CCIW 1410 hrs.	2 Lake Ontario Virology	3 Arrive CCIW 1030 hrs.	4 CCIW	5 CCIW	6 CCIW
	7 CCIW	8 CCIW	9 CCIW	10 CCIW	11 CCIW	12 CCIW	13 CCIW
	14 CCIW	15 CCIW	16 CCIW	17 Hamilton Harbour NTA Monitor	18 CCIW	19 CCIW	20 CCIW
	21 CCIW	22 CCIW	23 Lake Ontario Mycology	24 CCIW	25 CCIW	26 CCIW	27 CCIW
NOV	28 CCIW	29 CCIW	30 CCIW	31 Depart CCIW 1610 hrs.	1 Lake Ontario Virology	2 Arrive CCIW 1118 hrs.	3 Depart CCIW 0910 hrs.
	4 Arrive Port Stanley 1530 hrs.	5 ----------	6 Dredge	7 Impact	8 Study	9 Lake Erie	10 ----------
	11 ----------	12 ----------	13 ----------	14 ----------	15 In Transit	16 Erieau	17 ----------
	18 ----------	19 Lake Erie Coring	20 In Transit	21 ----------	22 Port Colborne	23 ----------	24 ----------
	25 ----------	26 Lake Erie Coring	27 Depart Port Colborne 1200 hrs.	28 Arrive Niagara-on-the-Lake 0230 hrs.	29 Niagara-on-the-Lake	30 In Transit	1 CCIW
DEC	2 CCIW	3 In Transit	4 Lake Ontario Coring	5 CCIW	6 CCIW	7 CCIW	8 CCIW
	9 END	10 OF	11 CRUISES	12	13	14	15
	16	17	18	19	20	21	22
	23	24	25	26	27	28	29

Table 8. Great Lakes Studies, 1973. M.V. LAC ERIE

	SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
JAN		1	2	3	4	5	6
	7	8	9	10	11	12	13
	14	15	16	17 NTA Monitor	18 Arrive CCIW 1245 hrs.	19 CCIW	20 CCIW
	21 CCIW	22 CCIW	23 CCIW	24 CCIW	25 CCIW	26 CCIW	27 CCIW
FEB	28 CCIW	29 CCIW	30 CCIW	31 CCIW	1 CCIW	2 CCIW	3 CCIW
	4 CCIW	5 CCIW	6 CCIW	7 CCIW	8 CCIW	9 CCIW	10 CCIW
	11 CCIW	12 CCIW	13 CCIW	14 CCIW	15 CCIW	16 CCIW	17 CCIW
	18 CCIW	19 Depart CCIW 0900 hrs.	20 NTA Monitor Arr.CCIW 1710 hrs.	21 CCIW	22 CCIW	23 CCIW	24 CCIW
MAR	25 CCIW	26 CCIW	27 CCIW	28 CCIW	1 CCIW	2 CCIW	3 CCIW
	4 CCIW	5 CCIW	6 CCIW	7 CCIW	8 CCIW	9 CCIW	10 CCIW
	11 CCIW	12 CCIW	13 CCIW	14 CCIW	15 CCIW	16 CCIW	17 CCIW
	18 CCIW	19 CCIW	20 Depart CCIW 0900 hrs.	21 NTA Monitor	22Arrive CCIW 1005 hrs.	23 CCIW	24 CCIW
	25 CCIW	26 CCIW	27 CCIW	28 CCIW	29 CCIW	30 CCIW	31 CCIW
APR	1 CCIW	2 Depart CCIW 1040 hrs.	3 Field Trials	4 Field Trials	5 Field Trials	6 Arrive CCIW 1100 hrs.	7 CCIW
	8 CCIW	9 CCIW	10 Depart CCIW 0830 hrs.	11 Regional Sediment	12 Regional Sediment	13 Arrive CCIW 1330 hrs.	14 CCIW
	15 CCIW	16 CCIW	17 Depart CCIW 0900 hrs.	18 Field Trials	19 Arrive CCIW 1305 hrs.	20 CCIW	21 CCIW
	22 CCIW	23 CCIW	24 Depart CCIW 0900 hrs.	25 NTA and Wave Rider	26 NTA and Wave Rider	27 Arrive CCIW 1110 hrs.	28 CCIW
MAY	29 CCIW	30 Depart CCIW 0830 hrs.	1 Seismic Survey	2 Seismic Survey	3 Arrive CCIW 1750 hrs.	4 CCIW	5 CCIW
	6 CCIW	7 Depart CCIW 0905 hrs.	8 Met. Buoys	9 Met. Buoys	10 Met. Buoys	11 Arrive CCIW 2100 hrs.	12 CCIW
	13 CCIW	14 Depart CCIW 1030 hrs.	15 Regional Sediment	16 Regional Sediment	17 Regional Sediment	18 Regional Sediment	19 Regional Sediment
	20 Regional Sediment	21 Regional Sediment	22 Regional Sediment	23 Regional Sediment	24 Regional Sediment	25 Regional Sediment	26 Regional Sediment
	27 Regional Sediment	28 Regional Sediment	29 Regional Sediment	30 Regional Sediment	31 Regional Sediment	1 Regional Sediment	2 Regional Sediment
JUNE	3 Regional Sediment	4 Regional Sediment	5 Regional Sediment	6 Regional Sediment	7 Regional Sediment	8 Arrive CCIW 2015 hrs.	9 CCIW
	10 CCIW	11 CCIW	12 Depart CCIW 0925 hrs.	13 Geophysical Survey	14 Geophysical Survey	15 Arrive CCIW 0145 hrs.	16 CCIW
	17 CCIW	18 CCIW	19 Depart CCIW 0850 hrs.	20 NTA Monitor,Arr CCIW 1410 hrs.	21 CCIW	22 CCIW	23 CCIW
	24 CCIW	25 CCIW	26 CCIW	27 CCIW	28 CCIW	29 CCIW	30 CCIW
JULY	1 CCIW	2 CCIW	3 CCIW	4 CCIW	5 CCIW	6 CCIW	7 CCIW
	8 CCIW	9 CCIW	10 CCIW	11 CCIW	12 CCIW	13 CCIW	14 CCIW
	15 CCIW	16 CCIW	17 CCIW	18 CCIW	19 CCIW	20 CCIW	21 CCIW
	22 CCIW	23 CCIW	24 Depart CCIW 0700 hrs.	25 Geophysical Survey	26 Geophysical Survey	27 Geophysical Survey	28 Arrive CCIW 2220 hrs.
AUG	29 In Transit	30 In Transit	31 In Transit	1 In Transit	2 In Transit	3 Depart Port Stanley 1310 hrs.	4 Geophysical Survey
	5 Geophysical Survey	6 Geophysical Survey	7 Geophysical Survey	8 Arrive CCIW 0500 hrs.	9 Depart CCIW 0730 hrs.	10 Geological Survey	11 Geological Survey
	12 Geological Survey	13 Geological Survey	14 Geological Survey	15 Geological Survey	16 Geological Survey	17 Geological Survey	18 Geological Survey
	19 Geological Survey	20 Geological Survey	21 Geological Survey	22 Geological Survey	23 Geological Survey	24 Geological Survey	25 Arrive CCIW 1230 hrs.
SEPT	26 CCIW	27 CCIW	28 CCIW	29 CCIW	30 CCIW	31 CCIW	1
	2	3	4 OFF CHARTER	5	6	7	8
	9	10	11	12	13	14	15
	16	17	18	19	20	21	22
	23	24	25	26	27	28	29
OCT	30	1	2	3	4	5	6
	7	8	9	10	11	12	13
	14	15	16	17	18	19	20
	21	22	23	24	25	26	27
	28	29	30	31	1	2	3
NOV	4	5	6	7	8	9	10
	11	12	13	14	15	16	17
	18	19	20	21	22	23	24
	25	26	27	28	29	30	1
DEC	2	3	4	5	6	7	8
	9	10	11	12	13	14	15
	16	17	18	19	20	21	22
	23	24	25	26	27	28	29

Remote Sensing Section

The Remote Sensing Section is responsible for research and development in the field of remote sensing technology and the application of this technology to water management and lakes research.

The program includes studies using satellite-acquired data (ERTS-1 and SKYLAB), as well as a variety of conventional and novel aircraft systems. In addition, research is also conducted on the optical properties of the water and the problems associated with the optical path from the water to an airborne sensor.

Aircraft Programme

Two aircraft projects were carried out during 1973. One of these was a high altitude surveillance flight of selected areas in Lake Superior in conjunction with the I.J.C. Upper Great Lakes water quality studies. In this project both photographic and infrared imagery were obtained in conjunction with surface and sub-surface water quality and water movement data collections. An example of the infrared imagery is shown in Figure 28. Analyses of these data will provide information on surface thermal patterns as well as turbidity characteristics in the Thunder Bay region, and are expected to be useful in interpreting sources and movements of pollutants.

The second project involved a series of overflights to collect digital infrared imagery of the power plants along the north shore of Lake Ontario. These data have direct application to the thermal plume studies carried out by the Great Lakes Biolimnology Laboratories. Preliminary analysis shows that the digital scanner data provide a good representation of the surface temperature structure of the thermal plume.

Satellite Studies

Digital Analysis of ERTS-1 Data: Computer techniques have been established for the handling and processing of computer-compatible ERTS-1 tapes supplied by both the Canada Centre for Remote Sensing in Ottawa and the EROS Data Center in Sioux Falls, Idaho. This has enabled a 4-vector spectral classification of the reflectance responses from the water masses, comprising the Great Lakes System on the basis of the energy return from the surface recorded by the ERTS Multispectral Scanner on a geographic scale of ~250 ft. Work done thus far on data collected over the Great Lakes and interconnecting river systems has shown that:

a) Distinct and statistically reliable optical reflectance regimes exist on the surface of the water in a manner conducive to mathematical pattern recognition studies.
b) Excellent resolution (of a few hundred meters) is possible in almost all cases on both a per-band and combined-band basis.
c) The presence of turbidity (due to either the presence of suspended particulate matter or to water color differences) acts as an excellent diagnostic aid to evaluation of lake dynamics, particularly in Band 4 (0.5 – 0.6μ). Under certain conditions,

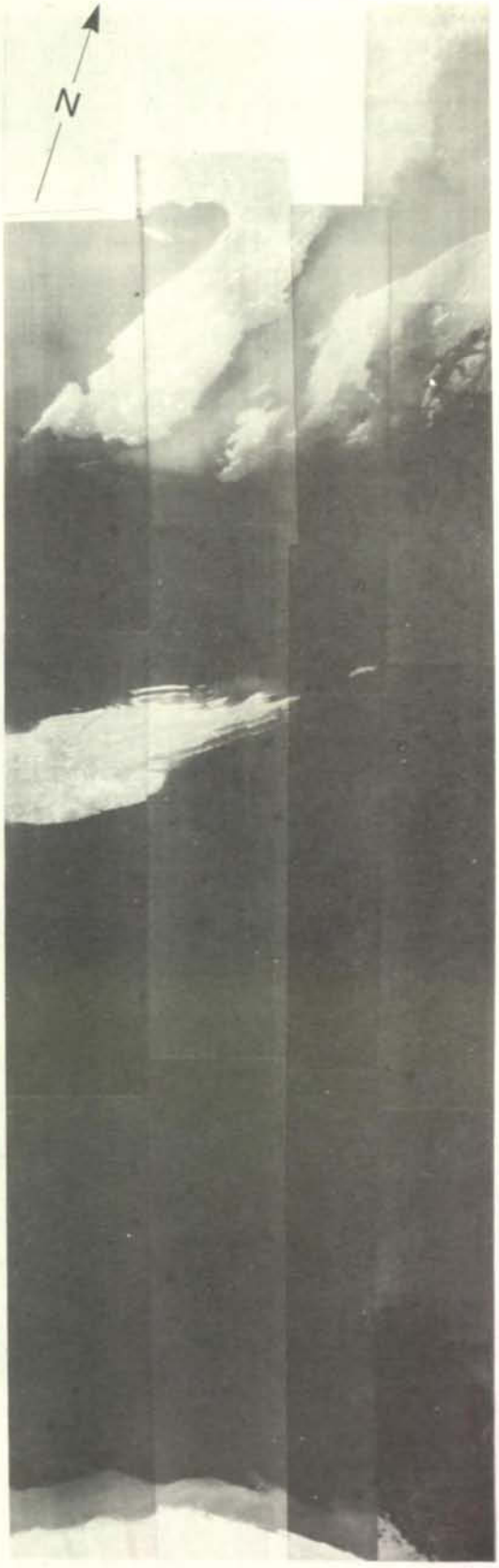


Figure 28. Lake Superior, Thunder Bay to Keweenaw Peninsula. RS 73-11, June 24, 1973, 1730-1830 E.D.T., Lines 5-8, Altitude 34,000 ft.

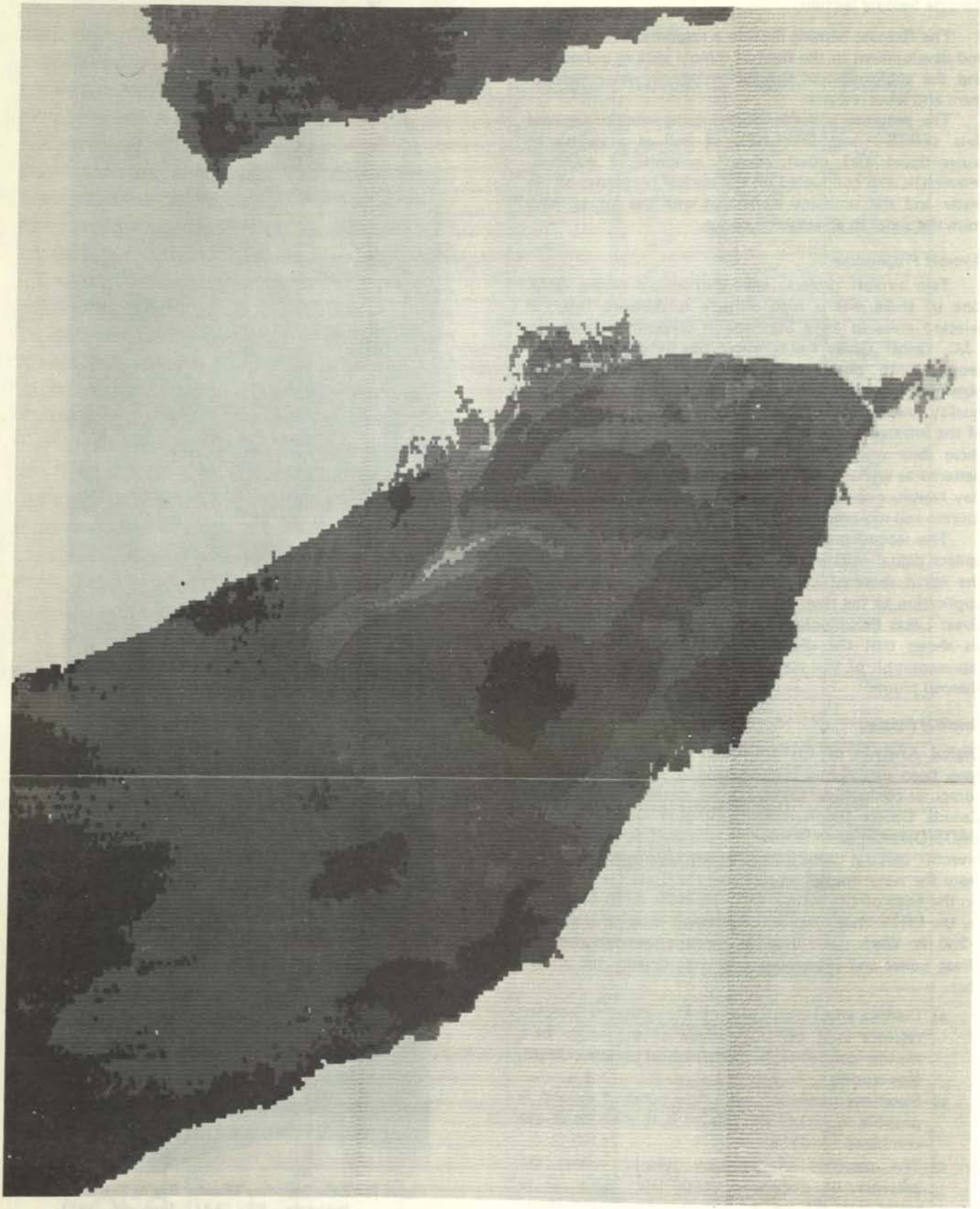


Figure 29. Lake Ontario – ERTS-1 computerized print-out of western Lake Ontario, August 21, 1972, band 4 (0.5-0.6 μ).

ERTS may provide a synoptic review of the internal dynamical features governing the lake behaviour.

Figure 29 illustrates the computerized print-out (maximum spectral resolution; 1/42 maximum spatial resolution) of the western basin of Lake Ontario as recorded by ERTS in Band 4 on August 21, 1972. Figure 30 illustrates the computerized print-out (1/4 maximum spectral resolution; 1/24 maximum spatial resolution) of the sediment transport off Point Pelee as recorded by ERTS in Band 6 (0.7 – 0.8 μ) on March 27, 1973.

During the past year, a number of studies on the interpretation of ERTS data were carried out under contract. In general, these studies involved limnological investigations in small lakes at various locations (Table 9) throughout Canada.

Sun-Glint Studies of Lake Ontario: Using high altitude RB-57 ERTS-Simulation data in conjunction with concurrent CCIW-CCRS intermediate altitude data collected in June, 1972, relationships between lake surface solar reflective properties and dynamics occurring within the lake have been strongly suggested. In particular, a detailed analysis has been performed which shows the role of sun-glint in delineating the dynamics related to upwelling activity.

Data Retransmission via Satellite

The ERTS-1 data collection platform (DCP) program was continued in 1973. During this past field season, the DCP, which relays data from the collector system to a shore receiving station via the satellite, was mounted on a tower in 20 metres of water off Fifty Mile Point in Lake Ontario.

Table 9. Studies of ERTS Data

Study title	Agency
1. Application of satellite imagery to the inventory of the surface and ground water patterns in the Cooking Lake and Gull Lake basins in Alberta, Canada.	University of Alberta
2. Application of satellite imagery to the study of the St. Lawrence Valley area in particular Lake St. Louis and Lake St. Pierre.	Centre de Recherches sur l'eau, Université Laval
3. Application of satellite imagery to water mass delineation of western Lake Ontario.	Erindale College, University of Toronto
4. Application of ERTS imagery to the study of the ice regime on Lake Erie and the reservoir areas above the Churchill Falls power development in Labrador.	H.G. Acres Consulting Services Limited
5. Application of satellite data to freeze-up, break-up and changing configuration of lakes in northern Quebec and Labrador.	McGill University
6. Application of satellite imagery to the study of Big Quill Lake.	Saskatchewan Research Council

Solar radiation and under-water optical parameters were measured. A digital integrator system was designed and constructed at CCIW, as an interface for these parameters. The integrator was a self-resetting type, taking some three days (under average conditions) to fill and reset. This type of integrator can be used with any analog or digital signal in the range of one millivolt to one volt.

The data will be used, along with the lake monitor optical data, to describe the optical conditions of Lake Ontario.

An application of National Oceanographic and Atmospheric Administration has been approved for CCIW to participate in the "GOES" satellite program, commencing in 1974. GOES is a geostationary satellite which will provide opportunities for more continuous data relay.

Remote Detection of Oil

In conjunction with the Environmental Emergencies Branch's Centre of Spill Technology at CCIW, the Remote Sensing Section has undertaken a study into the application of remote sensing technology to the detection of oil spills. Work on a comprehensive state-of-the-art report will be completed by June 1974.

Lake Optical Studies

During 1973, a lake optical program was continued and expanded. A new transmissometer which measures the *in situ* attenuation coefficient, was tested early in the year. Data from this instrument can be expressed as an attenuation coefficient or a percentage transmittance and can provide a vertical profile of these parameters if measurements are made as a function of depth. These measurements are now carried operationally and the data have provided information on water mass characteristics and water movements. The data have also helped locate unexpected biological activity at depths of 20-30 metres in Lake Superior. Figure 31 shows typical data derived from this instrument.

Other optical data collected during the surveillance cruises include upwelling and downwelling irradiance and colour indices. The colour index is simply a ratio of the upwelling irradiance at two wavelengths. The colour indices were measured with an experimental colour index meter designed by the Remote Sensing group. The colour index data obtained from this instrument is encouraging and the main turbid areas and current patterns of Lake Superior are well defined by these measurements. The irradiance measurements using an *in situ* spectrograph have been used as a check on the colour indices and also to examine the characteristics of the *in situ* upwelling and downwelling colour and its relation to limnological parameters.

During the past year, work on a marine Lidar system under contract to York University was initiated. In the early phase of this programme, laboratory measurements in the CCIW indoor towing tanks were performed to assess a number of Lidar system characteristics. Subsequent field trials, on board the CSS LIMNOS in August 1973, in Lake Erie have yielded more information on the present system. In the indoor tanks, penetration ranges up to 20 m have been achieved and in the lake, under typical wave condi-

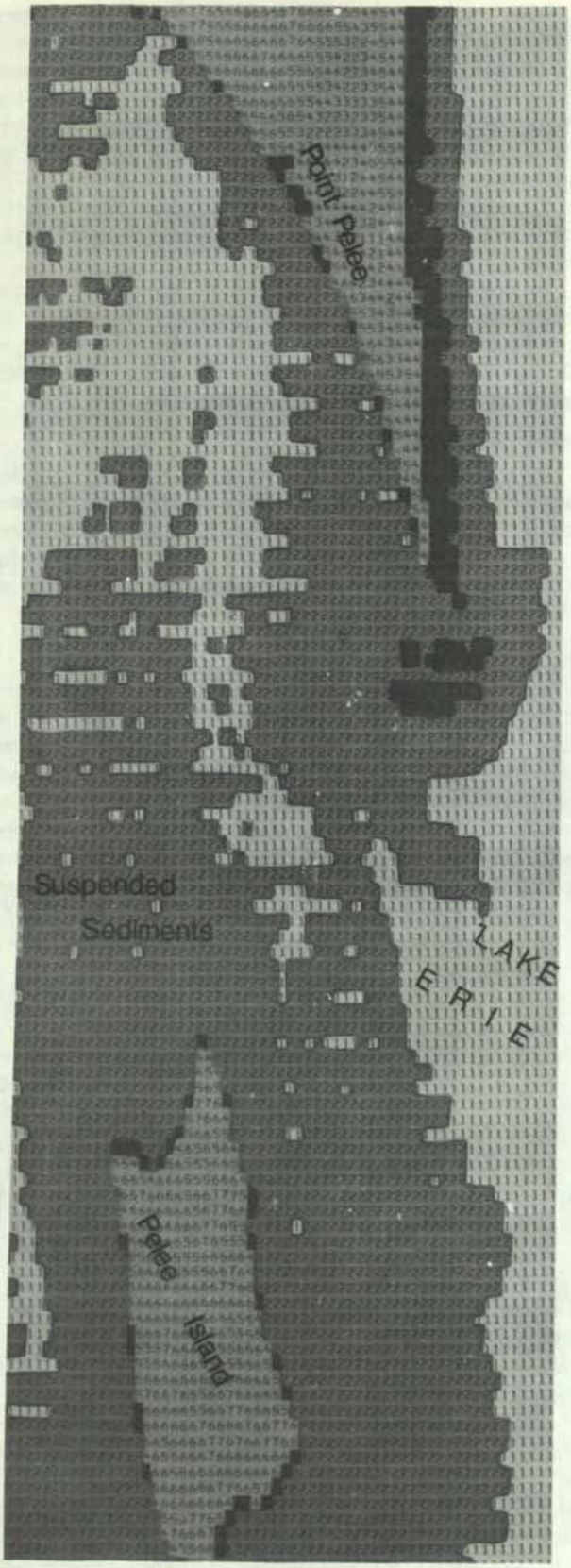


Figure 30. Point Pelee – ERTS computerized print-out of suspended sediments transport in the Point Pelee – Pelee Island area, March 27, 1973, band 6 (0.7-0.8 μ).

tions, penetration depths of up to 8 m have been recorded. Possible future direction of this work may lead to an airborne system which measures the attenuation coefficient at a number of wavelengths.

Data Management Section

The Data Management Section is responsible for planning and operating the CCIW Data Archive (which includes the Canadian IFYGL Data Bank), making data available to users requesting it, providing data processing support for CCIW projects, and preparing special scientific publications and reports.

Three units comprise the section: (1) Computer Applications Unit, which develops and maintains computer software, provides data archiving and management software, provides common user or "library" computer programmes, provides consulting services, and direct project support; (2) Data Archives Unit, which processes and edits certain groups of data (vessel surveys), maintains the CCIW Archive for scientific, socio-economic and engineering data, maintains the Canadian IFYGL Data Bank, and services data requests originating from within the outside CCIW; and (3) Special Projects Unit, which provides direct support to projects within CCIW, and produces descriptive scientific reports for the public and scientific community, for the Great Lakes system.

During the year, a total of five internal projects were carried out, including maintenance of the Canadian IFYGL Data Bank, development of an initial library of common-user computer programs, development and enhancement of a storage/retrieval system for the larger data bases, as well as the development of computer display packages to generate films for micrometeorological studies and the prediction of oil slick movements. In addition, direct programming, technical and clerical support was given to 51 CCIW projects.

The C.C.I.W. Data Archive was reorganized and streamlined during the year and a working group was started in October to design a master plan for the archive and user services. The Canadian IFYGL Data Bank was kept operating at a high level, and acquired a large volume of data, primarily from Canadian IFYGL projects. In addition, 8 official external requests were received for non-IFYGL data, and 53 for IFYGL data, as well as 410 internal data requests. During the autumn, a proposal for a policy on data archiving and data release to users, was submitted to C.C.I.W. management. This policy covered what data was to be archived, general procedures for archiving and when it would be archived. In the area of data release, it covered the availability and accessibility of data in the archive, to C.C.I.W. and other users. Quality controls on data were tightened and streamlined, with the final and more detailed procedures for wider classes of data planned for development in parallel with the master plan for the archive.

A major component of internal software development was in the data management for the archive. This included streamlining and conversion of the STAR and TSAR storage and retrieval systems, and the initial design for a STORET to STAR data conversion package. Assistance was

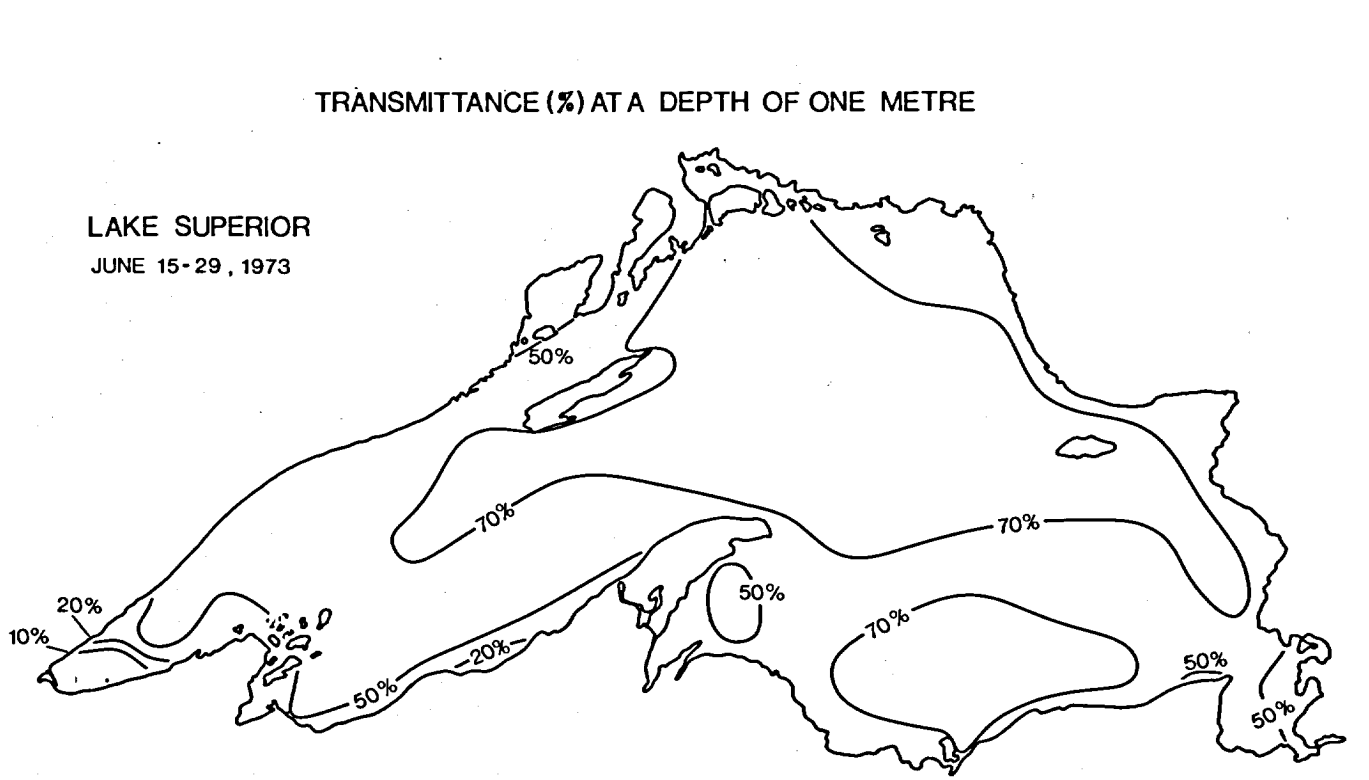


Figure 31. Typical data derived from the Market Model XMS Transmissometer Wratten 45 Filter.

given to the Water Quality Branch for contract programming for a STAR to NAQUADAT conversion package. Additional software was written for the storage of a large variety of data; in the majority of cases, the data were rewritten to conform to the requirements of the standard data management systems: STAR – scientific data obtained from scientific vessels; TSAR – time series data; SAFRAS – geological and socio-economic data. In addition, the first extensive edition of a CCIW Computer Programme Library was produced for users.

An initial set of descriptive reports, one for each of the four Great Lakes immediately adjacent to Canada, was produced. These were the prototypes of reports planned to be issued regularly in 1974, for each vessel cruise.

A large component in the total activities of the Data Management Section, was the provision of supporting services to CCIW projects. This encompassed programming services, clerical assistance, and the provision of technical assistance for scientific projects.

COMMITTEE MEMBERSHIP

Bukata, R.P.	– Secretary to CACRS Working Group on Limnology – Member of Near Shore Zone Task Force, CCIW
Durham, R.W.	– Ad Hoc Committee on Water Quality Objectives for Radioactivity in the Great Lakes – Member – Working Group on Uranium Mining and Milling Effluents – Member
Dutka, B.J.	– Committee D-19. The use of membrane filters in bacteriological examination of water. American Society for Testing and Materials – Committee on Interservice Co-ordination of Analytical Laboratories, Ontario Region – ICW Working Group on Water Quality Networks
Lane, R.K.	– Canadian Co-Chairman, IJC Upper Lakes Reference Group – Member of Canada-Manitoba Lake Winnipeg Limnological Working Group – Chairman, CACRS Working Group on Limnology – Member, Board of Directors, International Association for Great Lakes Research – Member of the Subcommittee on Hydrology (Associate Committee on Geodesy and Geophysics) – General Chairman, American Water Resources Association 1973 Symposium
Lowe, W.E.	– Scientific Operation Division Safety Committee
Prantl, F.A.	– Working Group on Hydrology of the Canadian Advisory Committee for Remote Sensing – Member
Rao, S.S.	– CCIW Great Lakes Surveillance Committee
Thompson, K.P.B.	– Programme Chairman and editor of the proceedings of the International Symposium on Remote Sensing of Water Resources, held at CCIW, June 11-14, 1973. – Member of Programme Committee and Session Chairman of Limnology and Oceanography for the 2nd Canadian Remote Sensing Symposium, to be held at Guelph, April 1974. – Secretary to the CACRS Working Group on Limnology
Weiler, H.S.	– Monitor Surveillance Committee – CCIW – Field Year – Joint Management Team – Department of the Environment EDP Committee

AWARDS

Bukata, R.P. – Co-recipient of NASA Group Achievement Award for contributions to the Pioneers 6, 7, 8 and 9 deep-space probe missions.

SCIENTIFIC SUPPORT DIVISION

The Scientific Support Division provides the major portion of the technical, professional and administrative support for the scientific programmes at the Centre, as well as some applied research and development in instrumentation. It consists of three sections, the activities of which are described below.

SCIENTIFIC SERVICES

This section is comprised of three units: Instrumentation Research and Development, Computer Services and Library Services.

Instrumentation Research and Development Unit

This Unit was created in April, 1973 with the appointment of an engineer and the outfitting of a small wet chemistry laboratory. Its mandate is to develop immersion sensing technology, giving particular attention to the needs of the chemical and biological areas of the work at C.C.I.W.

A major component of this group's effort has gone to the development of what is now called the Robot Experimenter System (REX). Conceived as a new type of water quality monitoring system (K. N. Birch, M. Sci. Thesis, 1973), the system is being designed as an in situ workbench to aid in the development of new sensor technology and, eventually, new and improved sensors. It will consist of a submersible station, made up of apparatus and interface modules; and a shore station, housing a minicomputer. The apparatus modules are being specifically engineered to work under water and under computer control. Designs are now completed on a series of electrode-flow cell modules, an eight point distributing valve and a series of reagent and sample pumps. It is expected that an operational prototype system will be completed by the end of 1974 summer.

A research contract was awarded to Dr. K. B. Oldham of Trent University for developmental work on a novel dissolved oxygen sensor for long-term monitoring applications, plus conceptual development of a humidity sensor and a low speed, current meter based on an electrochemical principle. Early indication is that the concept for the dissolved oxygen probe is practical, but additional work will be needed to realize accuracy and sensitivity at the sub-ppm level.

During the latter part of the field season, Instrumentation R & D sponsored two pilot evaluation trials for commercially available instrumentation. In one of these trials a set of three instruments (a fluorometer sensitive to Chlorophyll a, a Keen ratiometer turbidity meter, and a U.V. absorption meter for dissolved organics) was arranged to continuously monitor the surface water along the track of a ship. The data which resulted showed interesting variation in these optical properties between the usual monitoring stations. In another trial, an InterOcean probe that measured temperature, pH, conductivity, dissolved oxygen and light transmission against depth was evaluated.

Computer Services Unit

The Computer Services Unit has the responsibility for operating and providing software support for the major computer systems at C.C.I.W., as well as a keypunch service and technical consultation in areas pertaining to electronic computers.

The major accomplishment of 1973 was the upgrading of the Control Data (CDC) 3300 computer with 32,768 words of memory and serial batch processing capability, to a CDC 3170 computer with 98,304 words of memory, expanded disk storage, a faster line printer, and the capability of multi-programmed operation (the concurrent processing of several jobs). The proposal for this upgrading was approved in August; site preparation completed in September, and installation of the new hardware occurred in October and November. During this period, extensive software development took place so that, on November 19th, the CDC 3170 computer with the MASTER operating system was placed in regularly scheduled operation. At this time all special system software was available for the transfer of existing programmes. For the remainder of the year both the MASTER operating system and the old system (MSOS) were available each working day so that production work continued while programme conversion took place. On December 31st, MSOS was used for the last time, and full time use of MASTER was initiated in the new year.

During 1973 a total of 33,019 jobs were run under the MSOS system, which utilized 1,767 hours of elapsed computer time and required the mounting of 18,367 magnetic tapes. In addition, 3,761 jobs were run under MASTER, which utilized 76.1 hours of central processor time and required the mounting of 2,602 tapes. A combined total of 36,780 jobs were run during 1973.

In addition to the CDC 3170 computer, the Unit has a DEC PDP-8 computer used to reformat instrumentation tapes to computer-compatible magnetic tape and a larger DEC PDP-15 is used for special applications such as plotting, analog-to-digital conversion, interactive graphics, and the production of motion-picture data displays.

A terminal connected to Multiple Access Limited in Toronto was operated during the year for the running of jobs which were too large for the in-house facility. However, with the expansion to the CDC 3170 system, this service is no longer required and it was terminated at the end of December.

Library Services

The Library support of C.C.I.W.'s expanding research programme was hindered somewhat this year by the great increase in the cost of publications, which necessitated trimming our journal subscriptions and book purchases. Inter-library loan requests increased to 3,470 during the year. In computerized information retrieval, several new scientists were assisted in compiling computer interest profiles and many retrospective searches were conducted

for C.C.I.W. scientists on several data bases during the year. The library staff compiled a bibliography of C.C.I.W. staff publications and published it, as well as Volume 5 of our Collected Reprints.

ENGINEERING SERVICES

The Engineering Services Section provides engineering support services on request to all other sections, groups, and divisions at C.C.I.W. These services range from innovative design and development engineering, through various equipment modification and improvement programmes, to preventive and corrective maintenance performed on the substantial and increasing C.C.I.W. environmental instrument inventory. This support is centred around a professional design engineering capability in the technological fields related to inland waters instrumentation and equipment, and also features technical drafting, equipment testing, calibration and machine shop prototype manufacture.

Shown in the Summary Table 10 is a listing of those C.C.I.W. instruments, equipments, or environmental data-gathering systems which required during 1973 sufficient engineering support to be considered as a major engineering activity or project. This listing comprises a book value of several million dollars worth of equipment. A brief description of the engineering support given to the larger programmes in 1973 is provided here. Also shown are photographs illustrating some typical instrumentation or equipment installations.

Table 10. Summary of Engineering Systems, Projects, and Instrumentation

Moored Metbuoy Systems, with Sensor.
Moored Current Measuring Buoys (approx. 20 locations).
Shoreline BT Stations (quantity 7 systems installed).
Air/Water Interaction Instrumentation (2 Towers/Turbulence & Profiling).
Moored FTP System. Technical Evaluation Programme.
Wind/Wave Flume Data-Acquisition System. Definition Phase.
Monitor Printout Unit Refurbishment Programme (quantity 10).
Recorder System for Micromet Application.
In Situ Fluorometer (Improvement Programme).
Environmental Data Storage Modules (Study & Survey).
Programmed Fluorescent Dimming System (for EPS Bioassay).
Modified Timer (for 1973 ERTS Satellite Program).
Nearshore Monitoring Facility (System Definition/Preplanning).
Ship's EBT Systems (various – approx. 10 plus spares).
Submersible Electronics Package Design.
Auto-Programmer for CO_2 Monitor System (Quinte/Burlington).
Digital Timecode Generator Module (quantity 6).
Acoustic Bottom-Detector/Camera System.
Solid-State Temperature Sensor Module.
Auto-Programmer for DO-Profiling Winch System (Quinte).
Electromagnetic Current Sensor (Procurement Programme).
Digital Integrator (for 1973 ERTS Satellite Programme).
C.C.I.W. Acoustic Release Units.
Sediment Transport/Tracer System (quantity 1).
C.C.I.W. Data-Translator (for Plessey/Geodyne Tapes).
Sediment Settling Tube Pressure Recording System (quantity 2).
Solid-State Depth Sensor Module.
FRB Fish Counting System.
Towed Temperature-Profiling Digital System.
Solid-State RH Sensor Module.
Ship's "Data Acquisition Systems" (quantity 2).
Aquatic Biota Photo Stimulation System.
C.C.I.W. Towed Body (Batfish) System Engineering.
Water Re-aeration Flume (Hydraulics).
Instrument Carriage and Data Acquisition – Wind Wave Flume (Hydraulics).
Frazil Ice Flume with Wave Maker (Hydraulics).
New Corers – MKII Triple Corer, Mini-Shipek Corer, Water-Jet Beach Corer, Soft Mud Sampler.
Horizontal Electric-Drive Core Extruder and Core Slicer.
Oil/Water Emulsification Hydrophil Balance.
Ship's Pumping Systems – Heavy Duty Water Monitoring.
Reverse Osmosis Membrane Apparatus.
Interstitial Water Squeezers and Electrode Potential Cells.
MKII Plankton Incubator Using Carbon 14 Technique.

Moored Temperature-Profiling Buoy Systems

The engineering support applied to these systems in 1973 was in three main phases. The first phase involved the analysis and elimination of the residual system problems noted during IFYGL (1972). The special Fixed Temperature Profiling (FTP) cable assembly received design improvements in conjunction with industry and consultants; extensive in-house cable endurance and flex tests were run (Figure 32); improved logic was incorporated in the FTP electronic digitizers; and sensor alignment problems were solved. The second phase (mid-year) was a multi-month field technical evaluation programme in Lake Huron which was successful. Finally, a winter operational moorings pro-

Figure 32. Moored FTP system being deployed.

gramme was conducted with an "inverted under-ice" buoy system configuration . . . . a first for C.C.I.W. Post-'73 utilisation of these profiling systems in British Columbia lakes and elsewhere is expected to increase considerably.

Air/Water Interface (Micromet) System

During 1973 the C.C.I.W. instrumentation system used for boundary-layer studies (which in 1972 was wholly deployed offshore at Niagara) was substantially re-configured and deployed in the nearshore Hamilton area. Two towers mounted the sensor instrumentation (Figure 33), power and data cables were laid to the beach, where a trailer site held the data-logging instrumentation. Although storms and accidents damaged the tower structures, useful time-series data were recorded. Also the boundary-layer measuring was extended to the 1000 feet height, using specially modified tethersonde radiotelemetry instrumentation.

C.C.I.W. Acoustic-Release Units

Longstanding problems with C.C.I.W.'s various acoustic-releases, used for freeing moorings on command, were technically analysed during the year, their faults diagnosed, and a technical-upgrade programme implemented with industry and successfully performed on the best-designed unit (Figure 34). Other releases not offering potential for long-term satisfactory operation were phased out from C.C.I.W. inventory. Extensive winter under-ice deployment of these improved releases followed.

Moored Metbuoy Systems

These now well-proven C.C.I.W. systems for over-lake meteorological measurements received extensive use during 1973 in Lake Superior, Huron and Ontario, Lake of the Woods, Bay of Quinte, the St. Lawrence, in both summer and winter (Figure 35). The necessary maintenance and testing of the 22 instrumented systems is contracted to Canadian industry.

Dissolved-Oxygen Auto-Profiler

In connection with the Bay of Quinte limnocorral experiments, an automatically controlled winch profiler was designed, which sequentially profiled a dissolved oxygen probe through the water column in each corral in turn once per hour. A view is shown of the special winch engineering for this system (Figure 36).

Simulated Radiation System

During the year a second auto-controlled light simulation system for lab use was manufactured and installed in the E.P.S. bioassay laboratory for studying the effects of simulated daylight on algae specimens. Of interest was the overall development sequence, where Canadian industry, with little difficulty, produced the second needed system in 1973, after C.C.I.W. staff had developed the first prototype in 1972.

Temperature/Depth Profiling (EBT) Systems

This equipment area is one of the many where equipment mix and diversity requires and consumes far too much technical effort. Accordingly in 1973 emphasis was put on logistic rationalization, with separate programmes conducted to upgrade and standardize the various sensing probes and winches of this system. The EBT probes were then improved and standardized (Figures 37 and 38). The prototype EBT winches used on Limnos and Martin Karlsen are being replaced by advanced design heavy-duty units. Three more winch systems are also being prepared for use on launches.

C.C.I.W. ERTS-Satellite Radiation Monitoring System

Engineering Services participated in the establishment of this tower-based radiation monitoring system by developing solid-state digital-integration facilities for the various solarimeters used. This system represented the second application of ERTS Satellite technology at C.C.I.W.

Moored Current Measuring Buoys

About 150 deployments of C.C.I.W. self-recording current meters at inland waters moored stations were provided in 1973 in support of various water-movements studies. All refurbishment, preparation, testing and calibration of this equipment is contracted to Canadian industry. Between 200 and 300 field-data and test-data tapes were routinely translated during this work.

Auto-Sequencer for CO_2 Monitor

Engineering support was provided in 1973 in the creation of a tower-based automatic atmospheric CO_2 monitor system for lake use. This system featured considerable piping, valves, pumps, solenoids, gas sources, equilibrator, etc., as well as the CO_2 analyser itself. The different system modes-of-operation each required a pre-set cycle of activation of these components, and to control and time the operations correctly, a solid-state diode-matric sequencer assembly was designed and built, as shown in Figure 39.

Integrated Electronic Instrument Packaging Technique

Analysis of C.C.I.W. electronic engineering development activities of recent years had shown very considerable effort spent in evolving specially packaged electronic assemblies for specific projects, using various sub-assembly physical formats. To provide more rapid prototypes of electronic equipment for C.C.I.W. programmes some effort was applied in 1973 to rationalizing the overall approach to the packaging problem. For this work an integrated series of standard packages has emerged (Figures 40, 41, 42 and 43), where the same standard components, parts, integrated circuit boards, etc., are consistently used, whether for submersible electronic packages, for rack-mounted chassis assemblies, or for smaller bench-type instruments. Higher development productivity should stem from this approach.

Acoustic Fish Population Density Monitoring

Engineering support was given early in '73 to modifying and testing G.L.B.L.'s measurement system for assessing the fish biomass component. This relatively simple acoustic sounding system was used in Lake Ontario with promising results. Later in the year, significant design effort was

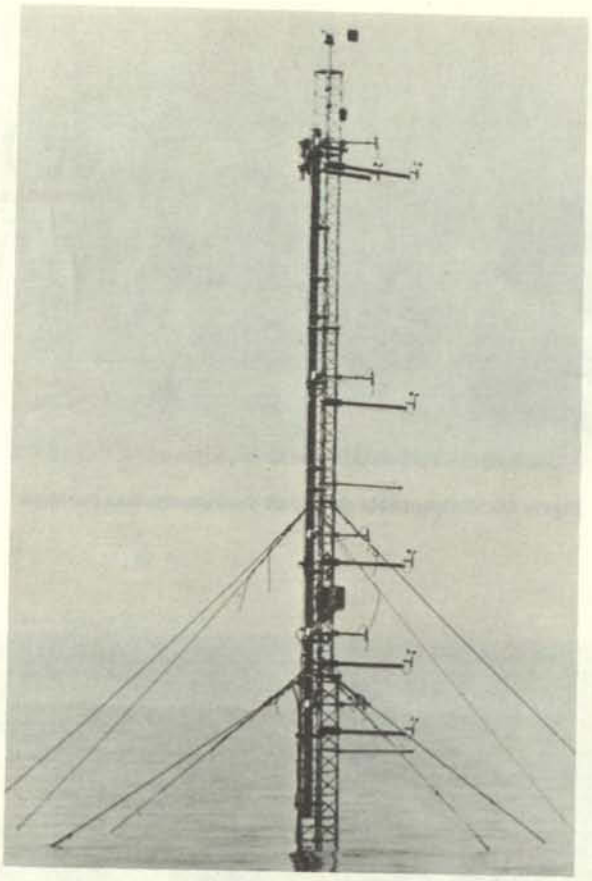


Figure 33. Air/Water Interaction Programme profiling subsystem.

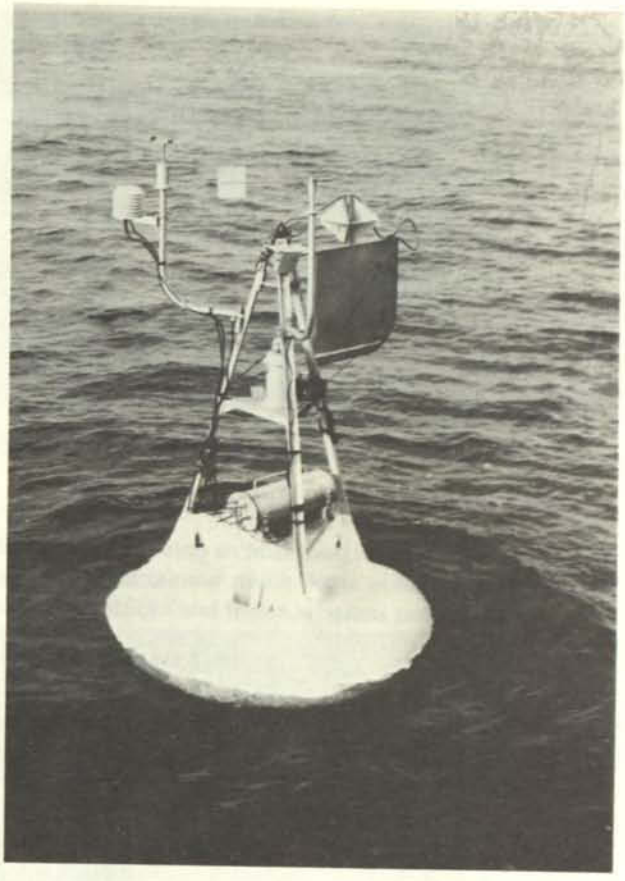


Figure 35. Metbuoy system with sensors (winter mooring).

Figure 34. Acoustically triggered underwater release unit.

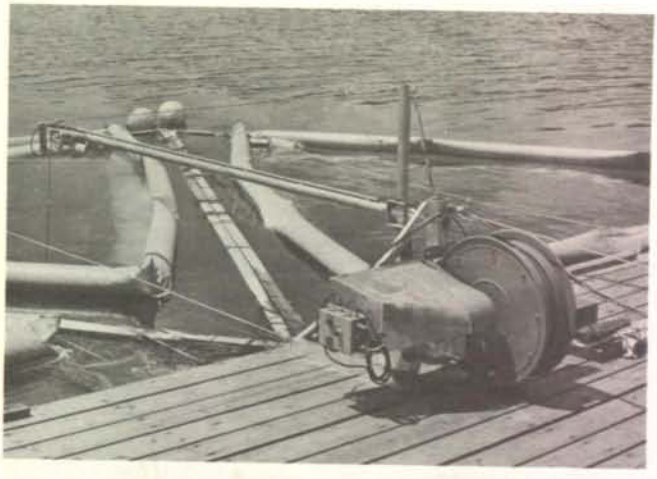


Figure 36. Dissolved oxygen profiling winch installed at limnocorrals.

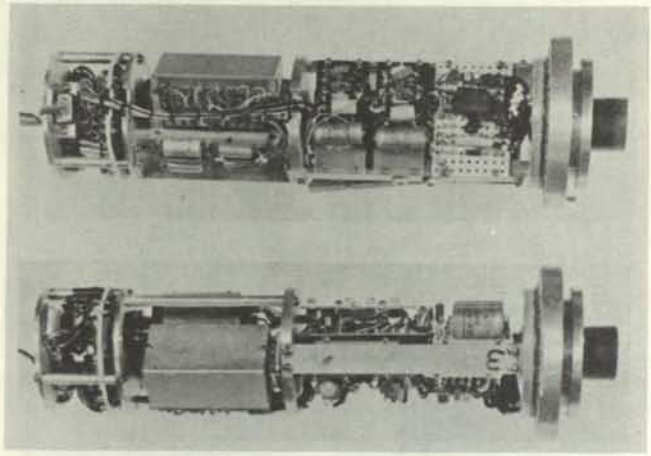


Figure 37. EBT probe (1971 model, prior to rework).

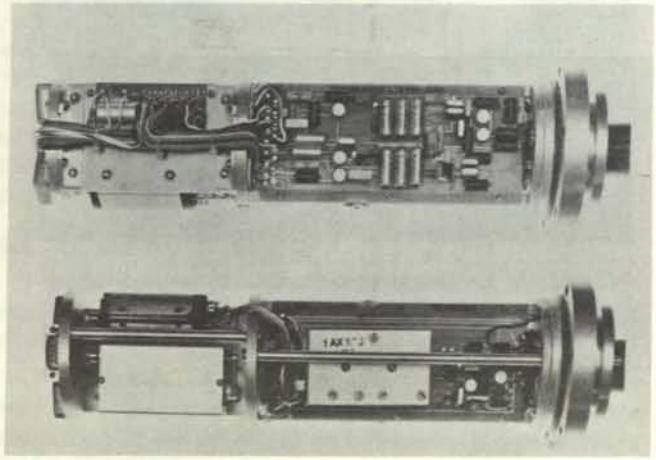


Figure 38. Reworked/repackaged EBT probe (1973).

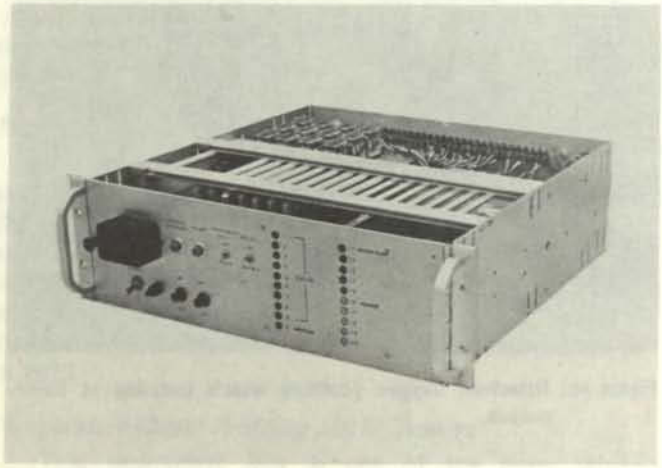


Figure 39. Auto-sequencer for CO_2 monitor system.

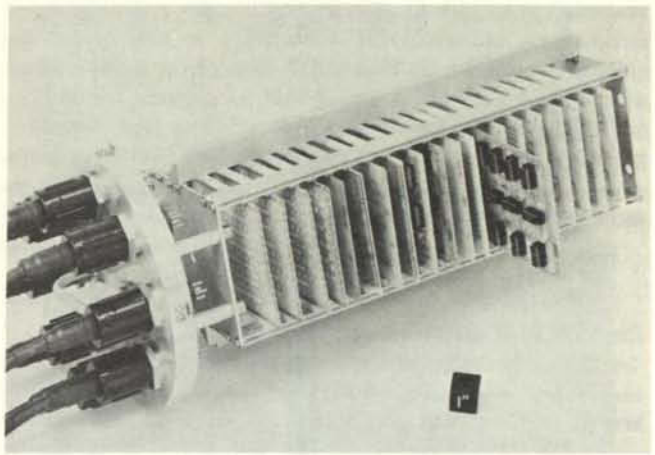


Figure 40. Submersible electronic instrumentation package.

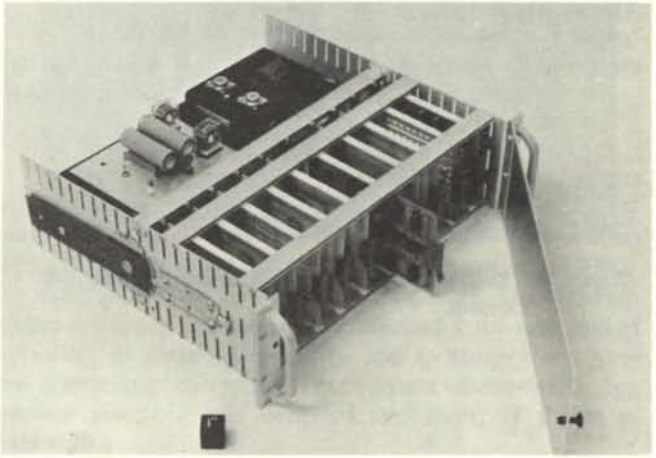


Figure 41. Rack-mounted electronic instrumentation package.

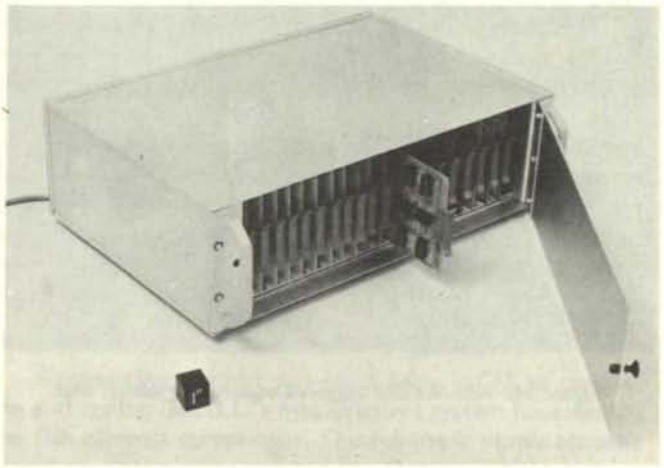


Figure 42. Lab-type bench instrumentation package.

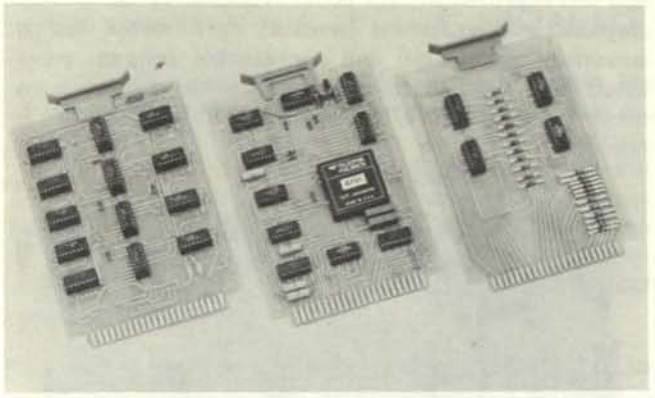


Figure 43. Standard integrated circuit PC card modules.

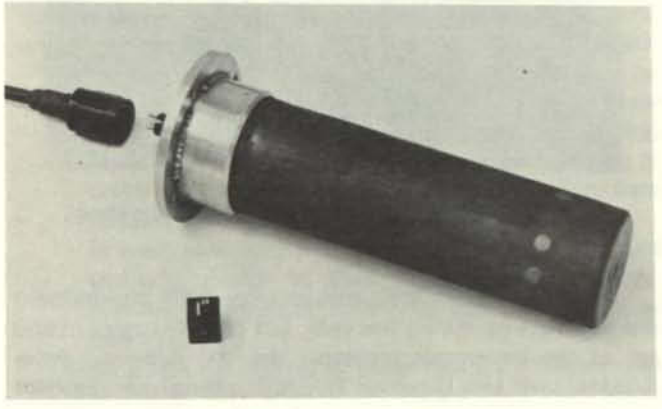


Figure 44. Electromagnetic water velocity sensor module.

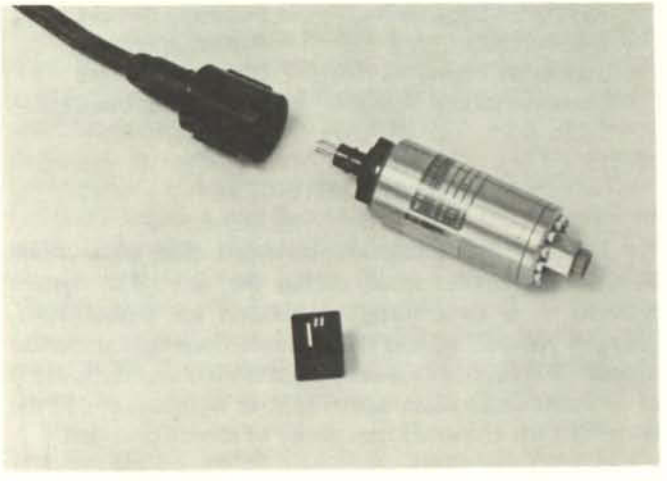


Figure 45. Underwater pressure sensor module.

Figure 46. Platform direction sensor module.

directed to evolving an improved acoustic fish echo analysis system for obtaining much more accurate data on inland waters fishstocks and their variations and distribution.

Underwater Cable Systems

C.C.I.W., with its many inland waters measuring systems, has continuing heavy investment in specially engineered underwater cable systems. In fact, present cable assembly inventory totals over $150,000. Although all cable assembly manufacture and special testing (such as hipoting, pressurizing, TDR, stressing and X-raying) is done by local industry, considerable engineering support in terms of cable assembly design definition and procurement specification is provided each year. In 1973, as a routine activity, seven separate cable design specifications were engineered, and about 20 cables of $40 K value procured for this year's programmes.

Environmental Sensor Engineering

Some limited work was done in 1973 towards the target of having in C.C.I.W. operating inventory, a range of relatively standard, easily interchangeable sensor modules, use of which could substantially ease the considerable effort presently required to synthesize and assemble environmental monitoring systems. Figures 44, 45 and 46 show certain prototype solid-state sensor modules for measuring some of the specific environmental parameters such as water speed, ambient pressure, relative humidity, temperature, atmospheric pressure, fluorescence, conductivity, platform direction, wave amplitude, etc.

Aquatic Biota Photo-Stimulation System

Design engineering commenced late '73 for the development of a flexible controlled illumination system used in studying the responses of biotic specimens by G.L.B.L. This system will feature wide light intensity range, varying radiation incidences, and different chromaticity modes.

Reverse Osmosis Membrane Apparatus

A special membrane casting apparatus was designed and manufactured by Engineering for the Water & Wastewater Research Subdivision. Figure 47 shows the system

which consists of:

- a water bath with temperatures adjustable within -10° to 50°C to an accuracy of ± 1/2°C,
- a temperature controlled plate for casting of membranes,
- a gelation cold temperature bath with mechanised feed,
- manufacture and installation of membrane pressure cells consisting of 2 bands of six dynamic cells and two static pressure cells.

Since volatile materials such as acetones and ethers are now being considered in the testing solutions for manufacture of membranes, the system has been modified to give total explosion proofing.

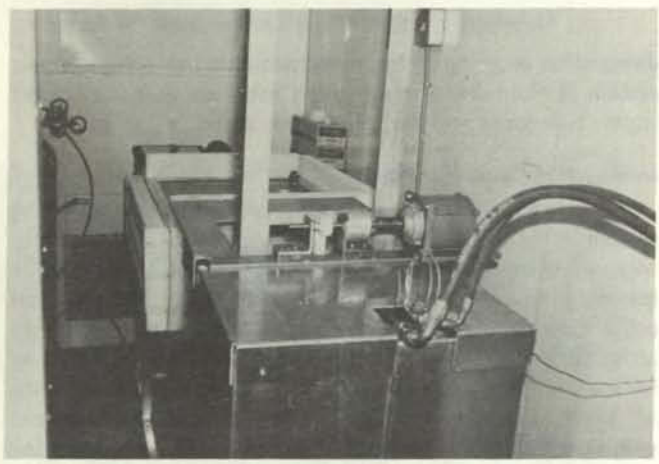


Figure 47. Reverse osmosis membrane manufacturing apparatus.

Assistance to Hydraulics Division

The design and project control of a 104-foot long tilting re-aeration flume was done by Engineering (Figure 48). This flume is a recirculating type with a 60 cm wide trough and is now used for research into the process of atmospheric re-aeration in open channels (see report of Hydraulics Division). An ice flume has also been designed for use in the newly constructed cold room. Engineering Services designed and constructed the apparatus to generate continuous sinusoidal waves at adjustable frequencies and amplitudes with adequate damping, as well as methods to prevent ice forming on the equipment of the flume.

Maintenance, Repair, and Calibration of C.C.I.W. Instrument Inventory

As in previous years, a large portion of Engineering Services support to research programmes at C.C.I.W. took the form of maintenance of the substantial and increasing inventory of environmental instruments and electromechanical equipment, totalling more than 1200 items. The term "maintenance", of course, encompasses incoming inspection; preventive maintenance; equipment modification and improvement; corrective maintenance such as fault diagnosis and equipment overhaul; performance testing; instrument calibration; and considerable contract supervision. The C.C.I.W. common-user inventory to be maintained increased in 1973 to approach 3 million dollars in value.

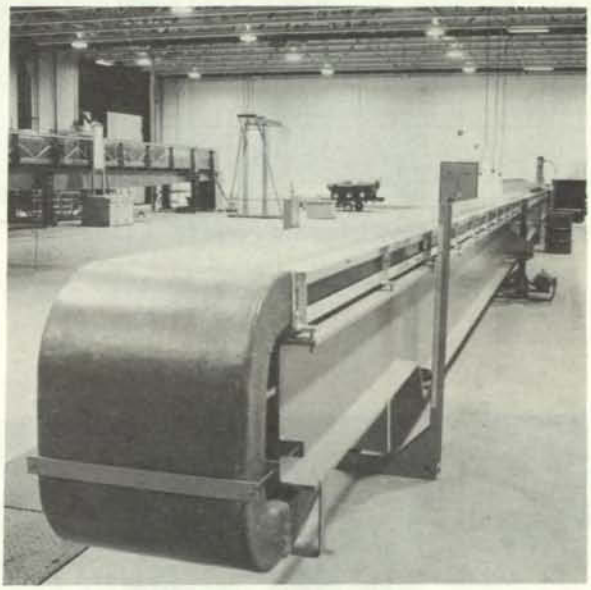


Figure 48. Hydraulics Division's tilting re-aeration flume.

Because the C.C.I.W. maintenance staff complement did not increase during the year, but both the amount and age of the instrument inventory did, the increased maintenance load was handled by augmenting our contract maintenance programmes with Canadian industry. During the year, approximately $250,000 in maintenance type contracts were placed with industry and technically monitored by Engineering Services staff, embracing such standard environmental instrumentation items as:

Current Meters	Digital Data Loggers
Temperature Probes	Teletypes
Resistance Digitizers	Humidity Sensors
Fluorometers	Radiation Sources
Special Winches	Digital Test Units
Chart Recorders	Cable Assemblies, etc.

STAFF SERVICES

A new Centralized Procurement and Accounting System was implemented during the year. The system provides three basic integrated services viz. procurement, financial accounting, and their required typing and clerical support. This system has relieved scientists and technicians of an increasingly heavy administrative workload and at the same time has enhanced the quality of service provided.

SOCIAL SCIENCES RESEARCH

It is the responsibility of this group to review and develop balanced water resources management policies and programs, specifically as they relate to the regional and the national program responsibilities of CCIW and its research and regional activities. Disciplines of economics, sociology, geography and political science are represented, and these different perspectives are combined to formulate and carry out socio-economic studies. More specifically, the research objectives are:

- to provide a comprehensive and detailed socio-economic data base, covering the Great Lakes Basin, in support of quantitative analyses for policy formulation, and for the assessment of the economic impact of proposed water management policies on the regional economy.
- to investigate and assess the costs and benefits of existing practices, procedures, and operational systems used in water resources management, and to recommend more suitable alternative solutions.
- to investigate and analyse public and officials' perceptions of, and attitudes towards water resources issues in general, and specifically as they relate to problems encountered in the Great Lakes Basin water management. To recommend changes in water management policies so as to incorporate notions of public perceptions and attitudes.
- to analyse legislation, institutional arrangements and practices insofar as they affect specific water resources management problems, and to recommend improvements.
- to assess the impact of water resources research, its diffusion and innovative applications, on water resources management.
- to develop analytical and systems modelling techniques to allow quantitative estimates of the complex interrelationships between human activities and water quality, and to assist in forecasting the changes in these interrelationships.

The year 1973 was an active year for this group. A new Head was appointed, and there was an increase in staff, as well as several staff changes. Each professional staff member undertook several individual research projects, and also participated in joint projects with other divisions, departments, and government agencies. Staff members participated in work of the International Joint Commission's Upper Lakes Reference Group, the International Joint Commission's Land Drainage Reference Group, the Canada-Ontario Great Lakes Shore Damage Survey, the National Library/Treasury Board Committee for Application Centres for Scientific Information. Staff members also participated in the work of several of the committees of Organization for Economic Co-operation and Development, a preliminary Economic Study on the Extension of the Navigation Season in the St. Lawrence Seaway, the Steering Committee for the Ontario Government's Lakeshore Capacity Study, an International Joint Commission Research Advisory Board working group (Social Sciences, Economics and Legal Aspects), and as observers at meetings of the U.S. Great Lakes Basin Commission.

Basic and applied research was conducted in the following major program areas:

Economic Baseline Studies

The main thrust in this field has been to carry out research for the two IJC Reference Groups: "Upper Lakes" and "Land Drainage". Specifically, Social Sciences Research is responsible for Canadian co-chairmanship of Working Group A (Upper Lakes Reference Group). This involves collecting background information on the Upper Lakes Basin and its population, and later, a study of the interrelationships between broad geographic characteristics and water quality. To these ends, studies are presently underway to determine population, land use, and economic activities in the Upper Great Lakes Basin. Dynamic modelling techniques are being developed for the integration of the many variables for forecasting developments and effects on pollution levels.

Various studies on the impact of agricultural activities on water quality were undertaken. This resulted in the production of a map showing the distribution of cattle feedlots in the Great Lakes Basin, and in a report analysing the trends in livestock and poultry farming in the basin and their effects on water quality (Figure 49).

As part of the federal-provincial Great Lakes Shore Damage Survey, Social Sciences Research is responsible for the production of an inventory of ownership and uses of properties along the shoreline of the lakes. The great quantities of data resulting from this survey are stored in a computerized data bank.

Much effort has been spent on responsibilities under the Canada-U.S. Agreement, specifically in the preparation and implementation of Tasks B2 and B5 of the Land Drainage Reference Group Study Plan. For the first task, information is being collected concerning the nature and location of specialized land uses in the Basin; for example, liquid and solid waste disposal sites, land fill sites, high-density non-sewered residential areas, etc. The objective of Task B5 is to provide an internally consistent and comprehensive set of forecasts for all sectors and activities of land uses which, directly or indirectly, affect the drainage of pollutants into the Great Lakes. Such socio-economic parameters as population, industrial levels, technological developments and legal frameworks will be considered.

In addition, a study plan for socio-economic research as part of the Limnology Study for Lake Winnipeg has been proposed. The mutual relationship between man and the lake will be explored. This will include a study of present and future populations, industrial impact, production shifts, recreation habits, etc. Lake Winnipeg is especially important since its Basin covers more than 40,000 square miles and is affected by all five Canadian Prairie metropolitan centres and virtually all Canadian Prairie agriculture.

Economic Impact Studies

Under this program, the economic impact of the management of waste heat discharges is being studied. The effects upon the economic system of price increases associated with controlling waste heat discharges will be investigated.

Environmental Contaminants

Research on the uses in the economy of various toxic substances was continued. Papers on Selenium, Cadmium, Beryllium, and Antimony were edited, while a similar paper on Lead has reached the draft stage. Data collection for a document on Phthalates has begun. These papers provide background information for a natural sciences research and control program, and later, for an analysis of the social costs of toxic substances in the Canadian economy. Such factors as incidence of diseases, therapeutic expenditures and loss of livelihood play important roles in the balance of costs and benefits. Most of the effort during this period went into the development of analytical techniques for this study.

Perception and Attitude Studies

A study is now underway, in co-operation with the International Joint Commission, to evaluate the public hearing process as used by the IJC. This is part of a larger study of public participation in water resources management.

A review and evaluation of the use of attitude studies in environmental management was completed. Tentative hypotheses were developed concerning attitude formation on water resource issues.

The attitudes of municipal officials towards the use of renovated waste water and other alternatives to conventional waste treatment were surveyed, and a report on the findings is being prepared.

Legislative and Institutional Studies

A comparative study of the administrative and legal framework within which municipal sewage treatment facilities are financed throughout Canada was begun. Interviews have been held with officials across the country, and relevant policies and legislation are being examined.

The legal and administrative processes governing the location and management of manure disposal sites in the Great Lakes Basin were surveyed.

The legal basis for potential public participation in the management of Canada's water resource is being analysed, particularly in relation to the provisions in the Canada Water Act.

Dynamic Modelling

Acquisition of a computer terminal has resulted in a greater opportunity to use more sophisticated techniques of analysis, specifically the application of dynamic modelling techniques, and quantitative analyses. Through the terminal, various data banks and program packages can be used; for example, DYNAMO, a software package for the building of dynamic models; SPSS (Statistical Package for the Social Sciences) and other programs on file with York University's Institute for Behavioural Research (including the Institute's Data Bank); and DATA BANK and MASSAGER, the program packages for economic analysis. The basic software for the CANDIDE (Canadian Disaggregated Interdepartmental Econometric) model of the Canadian economy has been acquired.

Work was also begun on a mathematical model of the economics of alternate means of phosphate load reduction. Some preliminary tests of this model for the OECD were conducted, using data from the Great Lakes.

CCIW Lecture Series

The seminar series for the Centre has been revised, and Social Sciences Research is now organizing a series of five or six major lectures per year. The objective is to provide the scientific staff at CCIW, at neighbouring universities and research institutes, and in other government agencies in southern Ontario with a series of lectures focussing on unifying principles in multi-disciplinary environmental research. The lectures deal with common backgrounds, assumptions, analogies in systems, and directions of philosophies and policies as the determinants of environmental management. They will be held approximately every six weeks and well-known speakers have been invited to participate. The first lecture, entitled "Climatic Change: Prospects for Man", was given by Dr. Kenneth Hare.

Information Systems

Access to several computerized information systems was acquired during this year. The most useful of these is WATDOC (Water Resources Data Systems Document Reference Centre), which includes data bases in the fields of law, pollution, and environment, as well as a news clippings service dealing with all matters in Canadian newspapers pertaining to water (Figure 50). Preparations have been completed for access to a number of major American scientific literature data bases, so that, early in 1974,

Figure 50. WATDOC information retrieval system in operation.

MILES 50 0 50 100
KILOMETRES 80 0 80 160

PREPARED BY
SOCIAL SCIENCES RESEARCH (C.C.I.W.) 1973

LEGEND

AVERAGE NO OF CATTLE PER FEEDLOT BY COUNTY 1971

- 0
- 1 - 55
- 56 - 80
- 81 - 100
- 101 - 120
- 121+

COUNTY MODEL

CATTLE DENSITY PER FEEDLOT

NUMBER OF FEEDLOTS AT A GIVEN DENSITY

LIST OF COUNTIES

1) ALGOMA
2) BRANT
3) BRUCE
4) DUFFERIN
5) DURHAM
6) ELGIN
7) ESSEX
8) FRONTENAC
9) GREY
10) HALDIMAND
11) HALIBURTON
12) HALTON
13) HASTINGS
14) HURON
15) KENT
16) LAMBTON
17) LEEDS
18) LENNOX & ADDINGTON
* 19) LINCOLN
20) MANITOULIN
21) MIDDLESEX
22) MUSKOKA
23) NIPISSING
24) NORFOLK
25) NORTHUMBERLAND
26) ONTARIO
27) OXFORD
28) PARRY SOUND
29) PEEL
30) PERTH
31) PETERBOROUGH
32) PRINCE EDWARD
33) SIMCOE
34) SUDBURY
35) THUNDER BAY
36) TIMISKAMING
37) VICTORIA
38) WATERLOO
* 39) WELLAND
40) WELLINGTON
41) WENTWORTH
42) YORK

* NIAGARA REGION 1971

Figure 49. Distribution and concentration of cattle feedlots in the Great Lakes Basin of Canada.

scientists have access to more than two million recent multi-disciplinary literature references through terminals at CCIW. Negotiations with the U.S. Department of the Interior have led to the formulation of an exchange agreement covering references to water research literature. Another important development is the use of CANSIM (Canadian Socio-Economic Information Management System). This Statistics Canada Data Base is one of the largest data banks in North America.

Social Sciences Research also provides one of Environment Canada's representatives on the National Library/ Treasury Board Committee for Application Centres for Scientific Information, a group of various government departments interested in computerized documentation.

WATER QUALITY BRANCH

ANALYTICAL METHODS RESEARCH SUBDIVISION

The objective of the Analytical Methods Research Subdivision (AMR) is to develop or improve analytical methods for the identification and measurement of chemical and biological pollutants in inland waters.

The analytical research is initiated in response to a stated need by:

1. any of the IWD regional water quality laboratories;
2. any division of the CCIW;
3. a national or international committee in which the Department of the Environment is cooperating.

In addition, the AMR scientists may propose and initiate any approved analytical research project that would render analysis more accurate, faster or less expensive, extend the detection limit or broaden the present knowledge of water pollutants.

Analytical research requests must be clearly defined as to the objectives and relevance. On the basis of such definitions, the AMR staff provides an estimate of the duration of the project in man/years.

AMR Groups

There are presently five teams in the AMR subdivision specializing in the areas of automation of analysis, atomic absorption spectroscopy, electro-chemistry (selective-ion electrodes, polarography, potentiometry), gas chromatography, mass spectrometry and high-speed liquid chromatography. Presently in formation is another team to handle the development of analytical methods for biological pollutants.

Publications

During the year the AMR staff was involved in 24 research projects. The completed work resulted in 10 publications and 12 scientific presentations at national and international conferences.

Among the publications are: (See publications list for full references).

— Determination of Submicrogram Levels of Phenols in Water, by P. D. Goulden and P. Brooksbank.

The method comprises an automated distillation step followed by colour development with either 4-Aminoantipyrine (4AAP) or 3-Methyl-2-benzothiazolinone hydrazone (MBTH) at a rate of 10 samples per hour with a limit of detection of 0.2 milligrams per litre.

— Automated Solvent Extraction for the Determination of Trace Metals in Water by Atomic Absorption Spectrophotometry, by P. D. Goulden, P. Brooksbank and J. F. Ryan.

The method described in this paper is a solvent extraction method, completely automated, capable of handling 40 samples/hr with a detection limit of 0.5 ug/l. It is based on complexing the metal with ammonium pyrrolidine dithiocarbamate (APDC) and the subsequent quantitative extraction of the complex with methyl isobutyl ketone (MIBK). The MIBK phase is then separated and aspirated into the flame of an atomic absorption spectrophotometer.

— Automation of Direct Potentiometry, by I. Sekerka and J. F. Lechner.

The paper discusses the application of ion selective electrodes for the simultaneous automated measurements of fluorides and ammonia at a rate of 20 samples per hour.

— Potentiometric Determination of Nitrilotriacetate in Water and Sewage by I. Sekerka, J. F. Lechner and B. K. Afghan.

The method is based on potentiometric titration of separate aliquots of sample solution with thallium (III) and cupric ions using platinum redox electrode and calculating the NTA contents from the difference of the two titrants consumed. The double titration is required by the fact that T1 (III) forms a 2:1 ratio complex with NTA and 1:1 complexes with other chelating agents such as EDTA, CDTA, EGTA, etc. Cupric ion forms 1:1 complexes with all tested chelates. The advantage of the new procedure over the existing polarographic procedure is that it allows on-site measurements by means of simple electrode titration and thus eliminates the need of taking samples to the laboratory with the inherent sample preservation problems.

— Analytical Research at the Canada Centre for Inland Waters, by S. Barabas.

The article provides information on the scope, objectives and means of the Analytical Methods Research Subdivision within the broader context of the Inland Waters' water quality objectives.

— An Improved Method for the Determination of Trace Quantities of Phenols in Natural Waters, by B. K. Afghan,

P. E. Belliveau, R. H. Larose and J. F. Ryan.

The procedure uses solvent extraction in place of distillation to concentrate and separate phenols from interferences. The preconcentration of phenols is effected by extraction into n-butyl acetate or iso-amyl acetate and the final readout is by either spectrophotometry (with 4-aminoantipyrine), differential UV absorption or molecular fluorescence depending on the requirements of the analysis as to the sensitivity and the phenol differentiation.

– Confirmation of Lindane Identity in Environmental Samples Using Gas/Liquid Chromatography and High Speed Liquid Chromatography, by R. H. Larose.

The determination of lindane in environmental samples is usually performed by gas-liquid-chromatography. Unfortunately, this method is not too accurate, especially in the case of animal samples such as fish, where fatty substances cause much interference. A method has been developed which permits removal of all coextractives from lindane using high speed liquid chromatography. Fractions are collected from the liquid chromatograph for further analysis by gas chromatography. The procedure takes less than five minutes and recoveries of more than 90% are obtained. The detection limit for water samples is 5 ug/l.

– Automated Determination of Arsenic, Antimony and Selenium in Natural Waters, by P. D. Goulden and P. Brooksbank.

A method is described for the determination of sub-microgram levels of antimony, arsenic and selenium in natural waters. Stibine, arsine and hydrogen selenide are produced from the samples in an automated system and passed to a tube furnace mounted in the light path of an atomic absorption spectrophotometer. The use of a tube furnace as a covalent hydride decomposition device gives an increase in sensitivity over a conventional hydrogen-argon entrained air flame of at least two orders of magnitude. The method will allow the analysis of 40 samples an hour with a limit of detection of 0.1 ug/l for arsenic and selenium and 0.5 ug/l for antimony. With a dual-channel spectrophotometer simultaneous determinations of As and Se levels have been made on a large number of natural water samples.

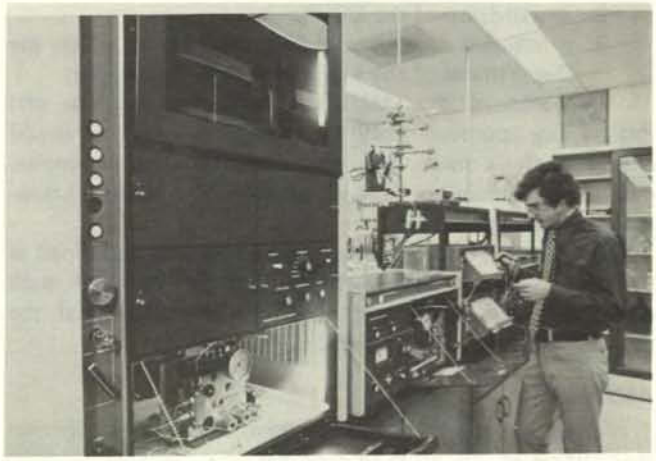
– Automated Phosphate Analysis in the Presence of Arsenate, by P. D. Goulden and P. Brooksbank.

The arsenate interference in the determination of phosphate in natural waters is eliminated by reduction with thiosulfate to arsenite in an acidic medium prior to the addition of the molybdate reagent.

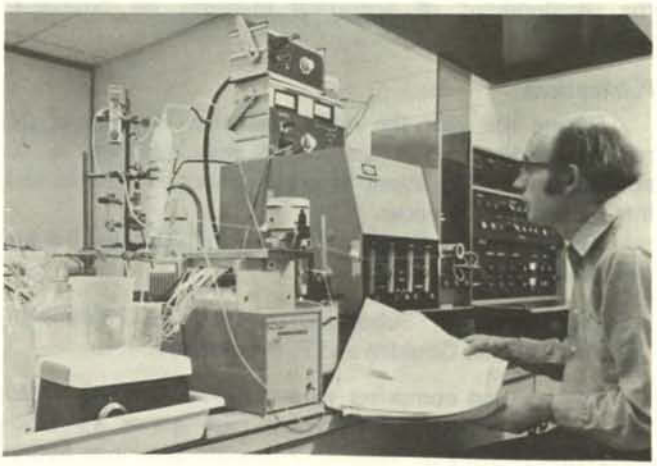
– Automated Determination of Fluoride Ion in the Parts per Milliard Range by I. Sekerka and J.F. Lechner.

The method allows the detection of as little as 2 parts per billion fluoride with a relative standard deviation of less than 2% and the recovery in the range of 96-107%.

Mike Comba (foreground) and Dr. Frank Onuska check the settings of their Mass Spec/Gas Chromatograph for the identification of pesticide residues.



Dr. Aaron Wolkoff identifies the peaks of some 20 phenol compounds by high-speed liquid chromatography.



Dr. Peter Goulden observes the flow rates in the simultaneous analysis of selenium and arsenic by atomic absorption spectroscopy.

Other Projects Completed in 1973

- Determination of Citric Acid in Water and Sewage Samples, by B. K. Afghan and J. F. Ryan.
- Simultaneous Determination of Na^+, K^+ and NH_4^+, by Automated Direct Potentiometry, by I. Sekerka and J. F. Lechner.
- Potential Interferences in the Determination of Soluble Iron in Natural Water with TPTZ, by P. D. Goulden, P. D. Bothwell and J. P. Emery.
- Combustion of Covalent Hydrides in a Tube Furnace, by P. D. Goulden and P. Brooksbank.
- Determination of Nanogram Quantities of Formaldehyde by Twin-Cell Polarography, by B. K. Afghan and J. F. Ryan.
- Automated Simultaneous Determination of Water Hardness, Conductivity and pH, by I. Sekerka and J. F. Lechner.
- Organochlorine Pesticide Photoalteration Products and Their Identification by Means of Gas Chromatography, Mass Spectrometry and Nuclear Magnetic Resonance, by F. I. Onuska and M. Comba.

Work in Progress

- Differenciation and Measurements of Phenols by Reverse-Phase High Speed Liquid Chromatography (A. W. Wolkoff and R. H. Larose).
- A Rapid Method for Chlorophyll Analysis (P. D. Goulden and P. Brooksbank).
- Determination of Copper, Lead, Zinc and Cadmium in Natural Waters by Twin-Cell Polarography (B. K. Afghan and J. F. Ryan).
- Determination of Dissolved Organic Carbon (DOC) in the Parts-per-Billion Range (P. D. Goulden and P. Brooksbank).
- Determination of Total Sulfur and Total Sulfides (I. Sekerka and J. F. Lechner).
- Mass Spectrometric Characterization of 14-oxathiins (F. I. Onuska and M. Comba).
- Determination of Hydrocarbons in Water by High-Speed Liquid Chromatography (A. W. Wolkoff and R. H. Larose).

WATER AND WASTEWATER TREATMENT RESEARCH

The Water and Wastewater Treatment Research Subdivision generates scientific information that can be used to control and manage the quality of Canada's water resources. To meet its responsibilities, the subdivision undertakes studies in the Canada Centre for Inland Waters, laboratories and, in addition, initiates, administers and co-ordinates a number of studies conducted within the consulting and university scientific communities. Some subdivision activities are initiated from within. Others are undertaken on request, and some are assigned to the subdivision as part of the federal government's commitment to support specific water quality control research under both the Canada-U.S. and Canada-Ontario Agreements.

Development of Improved Reverse Osmosis Membranes (H.K. Johnston)

Static and dynamic reverse osmosis membrane test cells were designed within the subdivision and manufactured at the Canada Centre for Inland Waters. Dynamic systems of 6 cells each are currently in operation. These cells employ both series and parallel flow patterns. Membrane casting facilities were designed and manufactured permitting careful control of all casting parameters. Cellulose acetate reverse osmosis membranes, which exceed the performance of commercially available products, are prepared within subdivision facilities.

Studies on viscometric behaviour of concentrated cellulose acetate solutions have led to a theory which allows *a priori* production of casting dope formulations to prepare efficient reverse osmosis membranes. These new concepts might permit similar development of other cellulosic derivatives.

Development of Reverse Osmosis Membranes Capable of Withstanding Extremes in pH Without Undergoing Hydrolysis (H.K. Johnston)

The top and/or bottom sides of cellulose acetate membranes are being treated both before and after shrinkage. The basic approach is to chemically modify the membrane surfaces, thereby giving greater chemical resistivity while increasing the thickness of the bound water layer through a reduction in the wetting angle. Methods being studied include:

Irradiation from a Co^{60} γ cell to produce surface-free radicals for copolymerization, γ radiation induced in situ copolymerizations, ozone, and ultraviolet irradiation at different wavelengths, both in the presence and absence of different oxidizing chemicals such as chlorine.

The Application of Reverse Osmosis Membranes to the Improvement of Industrial Waste Effluents (H.K. Johnston)

The quantitative removal of thirteen different heavy metals by reverse osmosis has been studied by the use of static cells. Correlation of the separations with the basic physico-chemical characteristics of the different metals is underway. A vapor phase membrane copolymerization cell has been designed and constructed. This cell will be used to produce high-flux membranes with extended lifetimes through their ability to operate efficiently while exhibiting little pressure-induced compaction.

Treatment of Waste Treatment Plant Effluents by Reverse Osmosis - Canada-Ontario Agreement (H.K. Johnston)

A complete research pilot plant has been designed and assembled to permit an evaluation of on-site reverse osmosis efficiency under a variety of controllable operating conditions. The design has been based on a modular concept to permit easy assembly/disassembly and modification. The entire laboratory is mounted in a self-contained 18-foot trailer. Laboratory tests have been carried out using static and dynamic test systems to evaluate the efficiency of removal of a variety of nitrogen and phosphorus containing materials under various conditions of pH and concentra-

tion. Parallel laboratory and pilot plant investigations will include studies on the removal efficiencies of P, N, $FeCl_3$, Al_2SO_4, $CaCO_3$, B.O.D.$_5$, C.O.D., T.S., T.O.C., T.C., colour and coliforms.

The Removal and Destruction of Polychlorinate Biphenyls (PCB's) (J. Lawrence)

Methods of separating from water PCB's and ultimately destroying them are being studied within subdivision laboratories. The absorption of PCB's onto activated carbon, polyurethane foams and other suitable media is one of the removal methods being studied. PCB destruction methods being considered are: (a) radiation - sunlight and lasers; (b) high temperature incineration; (c) anodic oxidation and (d) ozonation.

The Removal of Asbestos Fibres from Contaminated Water Sources (J. Lawrence)

This project aims to develop a method for substantially reducing the numbers of chrysotile and cummingtonite fibres in municipal water supplies. The study has been undertaken because of growing concern about the possibility that asbestos fibres may, in high concentration, cause a health hazard. Fibres in various water samples are being treated then counted under an electron microscope.

Removal of Trace Metals from Wastewater by Zeolite (A. Netzer)

Experiments were undertaken to determine removal rates of aluminum, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, silver and zinc from aqueous solutions. All the zeolite studies were conducted within the pH range 3-11. Removal rates greater than 99.5% were observed.

Removal of Trace Metals from Wastewater by Lime and Ozonation (A. Netzer)

Experimental studies showed that ozone treatment, followed by precipitation, will remove from aqueous solutions trace metals as hydroxides or oxides. Solutions containing aluminum, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, silver and zinc were studied. Removal rates greater than 99.5% were observed.

To explore the feasibility of applying lime and ozonation treatment on a large scale, a pilot study was undertaken. Results permitted the establishment of general guidelines for determining optimum operating values of various process parameters. They also indicated that removal of trace metals from wastewater by lime and ozonation is feasible.

Removal of Trace Metals from Wastewater using Discarded Automotive Tires (A. Netzer)

The use of worn and discarded automobile tires to remove trace metals from wastewaters was investigated. Experiments indicate that shredded rubber tires will remove trace metals from aqueous solutions by reaction with the sulfur in the rubber. Solutions containing aluminum, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, silver and zinc, were investigated. Removal rates greater than 99.5% were observed.

Removal of Trace Metals from Wastewater by Adsorption on Sand (A. Netzer)

Experiments to determine the merit of using sand to remove trace metals from water and wastewater were undertaken.

Removal rates from solutions of aluminum, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, silver and zinc from aqueous solutions by adsorption were studied within the pH range 3-11. Results have been obtained in terms of initial concentration and pH.

Removal of Trace Metals from Wastewater by Adsorption on Activated Alumina (A. Netzer)

Removal of aluminum, cadmium, chromium, cobalt, copper iron, lead, manganese, mercury, nickel, silver and zinc solutions using activated alumina as an adsorbent was investigated over the range of pH 3-11. Removal rates in excess of 99.5% were observed.

Research into Novel Vessel Waste Treatment Systems - Canada-U.S. Agreement (A. Netzer)

Experiments were conducted to evaluate possible novel physical-chemical methods treating marine sewage on board ships. Coagulation with various inorganic chemicals along with polymeric flocculant aids and adsorption on to powdered or granular activated carbon were investigated. The effect of aeration on the system was also studied.

Results indicate that reductions of B.O.D., T.O.C. and suspended solids in excess of 80% can be attained with the proper dose of activated carbon, coagulant and flocculant. Further studies indicate that subsequent conventional disinfection by chlorine or ozone can reduce bacterial counts to acceptable levels, prior to discharge.

The processes studied are economically attractive and highly efficient. Preliminary economic analysis indicated low capital investment and minimum operating costs. In addition, it appears that the processes can be scaled to meet most requirements, are resistant to shock loads, are independent of ambient temperature, require little space and can be fully automated.

Treatment of Combined Sewer Overflows - Canada-U.S. Agreement (A. Netzer)

A comprehensive study of a high-rate wastewater treatment concept for abatement of pollution from combined sewer overflows (C.S.O.) is being carried out under contract by several consultants. This project is co-ordinated by the Water and Wastewater Treatment Research Subdivision. Two pilot plants have been constructed. The first pilot plant is based on air floatation and hydrocyclones, while the second includes microscreen and ozonation. The objective of these pilot plants is to determine the size of the various equipment and the major operation parameters.

Oxy-Chlorination of Organic Pollutants - Contract (A. Netzer)

A study to determine the products formed during

hypochlorous acid treatment of organic compounds (such as phenols and aromatic compounds which often pollute water supplies) is being conducted at the University of Waterloo under a research contract administered and co-ordinated by the Water and Wastewater Treatment Research Subdivision. The study is designed to establish whether highly chlorinated products of potential biological toxicity can arise under the conditions employed in the chlorination and superchlorination of municipal water supplies, sewage effluents and industrial waters.

The study has been initiated in response to concern about the possibility of hydrocarbon pollutants, (e.g., Bunker C and other types of fuel oils) forming polychlorinated aromatic hydrocarbons such as polychlorinated biphenyls, as a result of chlorination.

The organic compounds being examined are those found as contaminants of water supplies. The study includes product identification and synthesis.

Iron and Manganese Removal from Rural Water Supplies - Contract (A. Netzer)

A contract, undertaken by James F. MacLaren Limited, to study removal of iron and manganese from small rural water supplies is being co-ordinated by the subdivision. The objects of this study are: to evaluate new and promising processes; to assess real capabilities by field trials; to examine and evaluate existing municipal facilities and to scan commercial-industrial facilities for useful ideas.

Two ozone-filtration systems have been installed; one in New Brunswick, the other in Ontario. Samples are collected and analyzed at the Canada Centre for Inland Waters. The cartridge-type filter is constructed of greensand.

Induced Biodegradability by Laser Irradiation (B.G. Oliver)

The purpose of this project is to investigate the feasibility of using high intensity light from lasers to convert materials which are resistant to biological degradation to biodegradable forms. Photoalterations of organic molecules have been observed using ultraviolet light from a laser and a mercury arc lamp. Present studies are focussed on classifying the organic molecules which can be degraded with light, those which exhibit an increased rate of breakdown at higher light intensities, and those which will decompose under the influence of light when photosensitizers are added to the system.

Heavy Metal Concentration Points in Conventional Activated Sludge Waste Treatment Plants (B.G. Oliver)

This project is complete. The conclusions are that much of the heavy metal entering activated sludge treatment plants is removed by the process and is concentrated in the sludge. There is concern about the fate of heavy metals in treatment plants that receive some industrial wastewaters. This is because the resulting sludges are sometimes disposed of on crop-growing soil and heavy metals might be concentrated by either crops or animals that consume the crops. (See EPS effort).

Inland Waters Directorate—Ontario Region

WATER PLANNING AND MANAGEMENT BRANCH

In September, the Inland Waters Directorate established a Toronto Liaison Office to ensure even closer working relationships with Ontario colleagues and other federal departments with regional headquarters in Toronto. Office space was made available by the Ministry of the Environment at 135 St. Clair Avenue West and is shared with the Regional Office of the Environmental Protection Service.

The Head of the Inland Waters Directorate, Toronto Office, is Mr. Derek M. Foulds, who is also in charge of Water Planning and Management activities in Ontario. These activities include the Great Lakes-St. Lawrence Study Office in Cornwall directed by Mr. D.F. Witherspoon; the engineering staff directed by Mr. W.P. Persoage at Burlington; and a sub-office in Niagara Falls which was transferred to the Branch from the Water Survey of Canada in November.

The Branch carries out extensive studies related to water management problems in Ontario and is responsible for providing support to the International Joint Commission in various operational activities governing the control of the levels and outflows of the Great Lakes. Its members serve in various capacities on several Engineering Boards and Boards of Control established by the Commission, and also on a number of joint Canada-United States International Committees.

Great Lakes - Levels and Flows

Record high lake levels occurred on some of the Great Lakes during 1973 as a result of extremely high water supplies which greatly exceeded those associated with the previous record levels of 1952. In the unregulated lakes, St. Clair and Erie exceeded previously recorded maximum levels by as much as 9 inches, and lake Michigan-Huron reached the highest level since 1886. In the regulated Lakes, Superior levels approached but did not exceed the prescribed maximum; Ontario did exceed the prescribed maximum by about 15 inches but did not surpass the 1952 record.

Extraordinary action was taken to alleviate high water level conditions on the lower lakes. In response to an application from the United States Government and expressions of concern by the Government of Canada, the International Joint Commission directed its Lake Superior Board of Control to deviate from the existing regulation plan. Accordingly, Lake Superior outflows were regulated to provide relief from critical high water levels downstream without causing undue detriment to Lake Superior interests. In spite of this action, high Superior outflows combined with very high Lake Huron levels, caused problems in the St. Marys River.

Lake Ontario supplies averaged one million gallons per minute more than in the previous record year (1952) and without regulation the lake would have exceeded the previous record level by 15 inches. The Ontario outflows exceeded the previous maximum by about 10% in the period following the spring flood on the Ottawa River. By the end of the year, lake levels were close to average. The St. Lawrence River Board of Control has requested studies on how regulation may be improved.

Considerable time was spent responding to public inquiries on lake levels, making presentations to shoreline and water use groups and giving interviews to radio, TV and newspaper representatives on the subject of high lake levels. To assist in this activity, forecasts of the possible range of Great Lakes and Montreal Harbour levels for the ensuing six months were prepared every month and incorporated into a news release which accompanies the monthly publication of the Marine Sciences Directorate.

Branch members participated during the year in the International Great Lakes Levels Board study of the feasibility of further regulating the levels of the Great Lakes. Through a considerable effort, the final report to the International Joint Commission was completed in December. Seven Appendices to the report are in the final stages of preparation and should be completed by May, 1974.

On the Niagara River, Branch representatives participated in several water use studies for the Commission's International Niagara Board of Control and the International Niagara Committee which was established by the Governments of Canada and the United States to determine the amounts of water available for purposes of the Niagara Treaty of 1950. Included were hydraulic studies of the effects of the temporary closure of the Welland Canal during the 1972-1973 winter season and of placement of earth fill in the Upper Niagara River at Fort Erie. A related study, currently in progress, involves the degree, if any, to which water level variations in the Chippawa Grass Island Pool above the Falls could influence flow out of Lake Erie. Results of the last two studies may influence the Lake Levels Board's conclusions. The Board is currently studying the effects of allegations of environmental effects related to the use of an ice boom which is installed at the outlet of Lake Erie every winter season.

Branch representatives are currently engaged in an investigation of possible measures which may be desirable or necessary to preserve or enhance the beauty of the American Falls at Niagara. The study is being carried out for the I.J.C. by the American Falls International Board. In June, a panel of experts in landscape architecture and aesthetics discussed alternatives and related problems at a seminar in Niagara Falls, Ontario. A brochure on the subject was prepared and more than 100,000 copies were distributed to the public. At year-end, a first draft of the final report was completed for consideration by the Board.

Great Lakes - Erosion and Flooding

Serious flooding and erosion problems occurred in certain areas of the lower lakes. As a result, the Governments of Canada and Ontario embarked on an intensive study of the affected shorelines including aerial photography and mapping of the eroded shorelines, the determination of erosion rates, an inventory of property values and a survey of the damages which resulted. The Water Planning and Management Branch provided a representative on the federal-provincial steering committee for the project and a project engineer who headed the stage-damage field survey operations which were completed in December, 1973.

A federal interdepartmental task force, chaired by the Director, Canada Centre for Inland Waters, Burlington, was created to review all available information on shore erosion in the Great Lakes-St. Lawrence system to aid in the development of federal policy on shoreline management. With the assistance of representatives from the Ministry of Transport, Department of Public Works, and Lands Directorate of Environment Canada, D. W. Brown of Water Planning and Management Branch prepared a report which compiles and analyses all current information on the problem.

The Branch is active in:

1. The preparation of a report by a Working Group involved in the study of Water Quality in the Upper Great Lakes;
2. Producing forecasts of water surface temperature in the Lake Ontario to Montreal reach of the St. Lawrence River relating to scheduling the end of navigation and the installation of ice booms;
3. Estimation of heat losses in the South Shore Canal for the St. Lawrence Seaway Authority; and
4. The preparation of guidelines in conjunction with other services for environmental studies by proponents of federal projects, such as Pickering Airport, and Sault Ste. Marie Harbour.

WATER QUALITY LABORATORY AND NETWORK

The role of the Water Quality Laboratory and Network (Ontario Region) is (1) to operate a water quality network in the Ontario Region and (2) to operate an analytical chemistry laboratory to support regional and national water management programmes.

In addition to the Analytical Services Section and the Special Services Section which were already in existence, the Water Quality Branch (Ontario Region) now includes a Monitoring and Surveys Section to undertake field programmes.

Analytical Services Section

This section consists of a Ships Support Laboratory, an Inorganic Analysis Laboratory and an Organic Analysis Laboratory. During the year these laboratories performed more than 200,000 tests on more than 25,000 samples supporting 72 different projects in cooperation with various federal and provincial governments, universities and other agencies.

Some of the major projects supported are listed below.

(1) Great Lakes Monitor Programme

The Section participated in 21 cruises, including six on Lake Superior, two on Lake Huron, eight on Lake Ontario and five on Lake Erie. Some 78,400 tests were conducted, about 48,100 of which were done on board ship, on 7,300 water and suspended particle samples taken during these cruises. The Technicon AutoAnalyzer equipment on board ship was replaced by the improved AutoAnalyzer II systems, which performed well throughout the year.

(2) Water Quality Monitoring and Survey Programme

The Section continued to support the Water Quality Branch monitoring and survey programmes in Ontario and Quebec. A total of 596 water samples from Ontario and Quebec were received and analyzed during the year.

(3) St. Lawrence and St. Marys River Studies

These studies were supported by the analysis of 424 samples collected by the Monitoring and Surveys Section. Some 2,700 tests were conducted in field laboratories and samples were brought back to the laboratory for further analysis.

(4) NTA Programme

This programme involves analysis of municipal water supply samples taken from selected sites across Canada, as well as continued analysis of samples from Hamilton Harbour, Lake Ontario, groundwaters in Manitoba and Eastern Ontario, and marine waters from Vancouver and Halifax Harbour.

(5) Other Projects

The section also supported such studies as the Point Source Study in Marathon, Ontario, carried out by the Great Lakes Biolimnology Laboratory and Lakes Research Division, the Precipitation Chemistry Programme carried out by the Monitoring and Surveys Section, and many other projects being carried out by scientists at CCIW and elsewhere.

(6) Quality Control

The internal quality control programme was extended during the year so that now approximately 15-20% of all analyses are done for quality control purposes. In addition, the section participated in the quality control programmes operated by the Special Services Section and supported those programmes by analysis of samples for certain storage and other tests.

The section participated in several split sample programmes, including separate split sample projects with the Ontario Ministry of the Environment, the Environmental Research Associates Division of Korab Marine Limited, and with Procter and Gamble (the latter with regard to NTA). Also, the Organic Analysis Laboratory was involved with the Fisheries Inspection Branch and the Guelph Pesticide Residue Laboratories in the analysis of a number of fish check samples for PCBs and chlorinated hydrocarbon pesticides.

Special Services Section

The Special Services Section plays a national role in the overall coordination of activities of the four regional Water Quality laboratories. These include (1) maintaining and updating the analytical manual, (2) method development as requested by the regional laboratories, (3) operation of the quality control programme, and (4) other assistance and advice to the regional laboratories regarding analytical procedures.

The objective of the Quality Control programme is to help ensure the continuation of a high standard of analytical quality among the regional laboratories and other laboratories which have contributed data to NAQUADAT and to other programmes of interest to the Inland Waters Directorate. There are currently 40 participants, including 13 federal, 14 provincial and two municipal government laboratories as well as two universities and nine private companies.

The quality control functions include the National Quality Control Programme which last year undertook laboratory intercomparison studies of major ions, physical properties, pesticides and trace metals among the 40 participants; an Inter-Regional Quality Control Programme in which natural samples are distributed once a month to the four WQB regional laboratories (Vancouver, Calgary, Burlington, Moncton) for a full analysis; and guidance and analysis of data with regard to the various split sample exchanges carried out between the Analytical Services Section and other laboratories.

The method development section carries out the evaluation and development of analytical methods to recommend the best method and instruments for new tests

Table 11. St. Lawrence River Data Summary–1973*

PARAMETER	MAY	JULY	SEPTEMBER
TOTAL PHOSPHORUS mg/l-P	.020	.020	.019
TOTAL SOLUBLE NITROGEN mg/l-N		.28	.29
NITRATE + NITRITE mg/l-N	.124	.062	.052
CHLORIDE mg/l	24.6	27.0	26.5
IRON, EXTRACTABLE mg/l	.075	.047	
DISSOLVED OXYGEN mg/l	11.9	8.2	8.7
pH	8.2	8.0	8.2
FECAL COLIFORM MF/100 ml	3	3	3
FECAL STREPTOCOCCUS MF/100 ml	2	2	3
HETEROTROPHS Standard Plate Count 7 day 20°C	3380	2350	2050

*Means of 69 stations

which will be carried out by the regional laboratories. It functions as a service to the regional laboratories and undertakes investigations primarily at their request. If a method cannot be found that will fulfil a need for the regional laboratories without undertaking a basic research project, the project is referred to the Analytical Methods Research Subdivision.

During the year, a number of development projects were completed, including:

(1) A GLC method for detecting as little as 0.05 ug/l of coprostanol and cholesterol, which will be used as an indicator of fecal pollution in a number of projects.

(2) A simple and sensitive GLC method for detecting as little as 0.01 ug/l of pentachlorophenol for routine use by the regional laboratories.

(3) A method to analyse 14 organophosphorus pesticides in water, which is now in use in the regional laboratories for monitoring run-off waters after forest spraying.

(4) A survey of methods for PCB quantitation to select the best available method, which is now being adapted to routine analysis for the automatic calculation of PCB levels.

(5) A method to analyse 21 metals in sediments by bomb digestion followed by atomic absorption spectrophotometric analysis.

Table 12. St. Marys River Data Summary - August, 1973*

PARAMETER	AUGUST 27	AUGUST 28	AUGUST 29	AUGUST 30	AUGUST 31
TOTAL PHOSPHORUS mg/l-P	.004	.005	.005	.006	.007
TOTAL SOLUBLE NITROGEN mg/l-N	.40	.38	.42		
NITRATE + NITRITE mg/l-N	.245	.229	.229	.251	.227
CHLORIDE mg/l	1.3	1.0	1.3	1.1	1.0
IRON, EXTRACTABLE mg/l	.024	-	.017	-	.006
DISSOLVED OXYGEN mg/l	9.4	9.4	9.5	9.5	9.4
pH	8.2	8.2	8.2	8.2	8.2
TOTAL COLIFORM MF/100 ml	83	78	124	188	228
FECAL COLIFORM MF/100 ml	5	3	6	13	7
FECAL STREPTOCOCCUS MF/100 ml	2	3	3	10	6
HETEROTROPHS Standard Plate Count 7-day 20°C	1600	2500	2200	2300	2400

*Means of 34 stations

(6) A simple method for confirmation of heptachlor in the presence of PCBs using solid matrix derivation techniques.

Monitoring and Surveys Section

The Monitoring and Surveys Section was established during 1973 with a section head and a senior technician operating three major programmes through most of the year; the Water Quality Surveys Programme, the Precipitation Chemistry Programme and the Water Quality Monitoring Programme. In addition, a Toronto liaison office was established at the offices of the Ontario Ministry of the Environment in Toronto and is regularly visited by Section personnel.

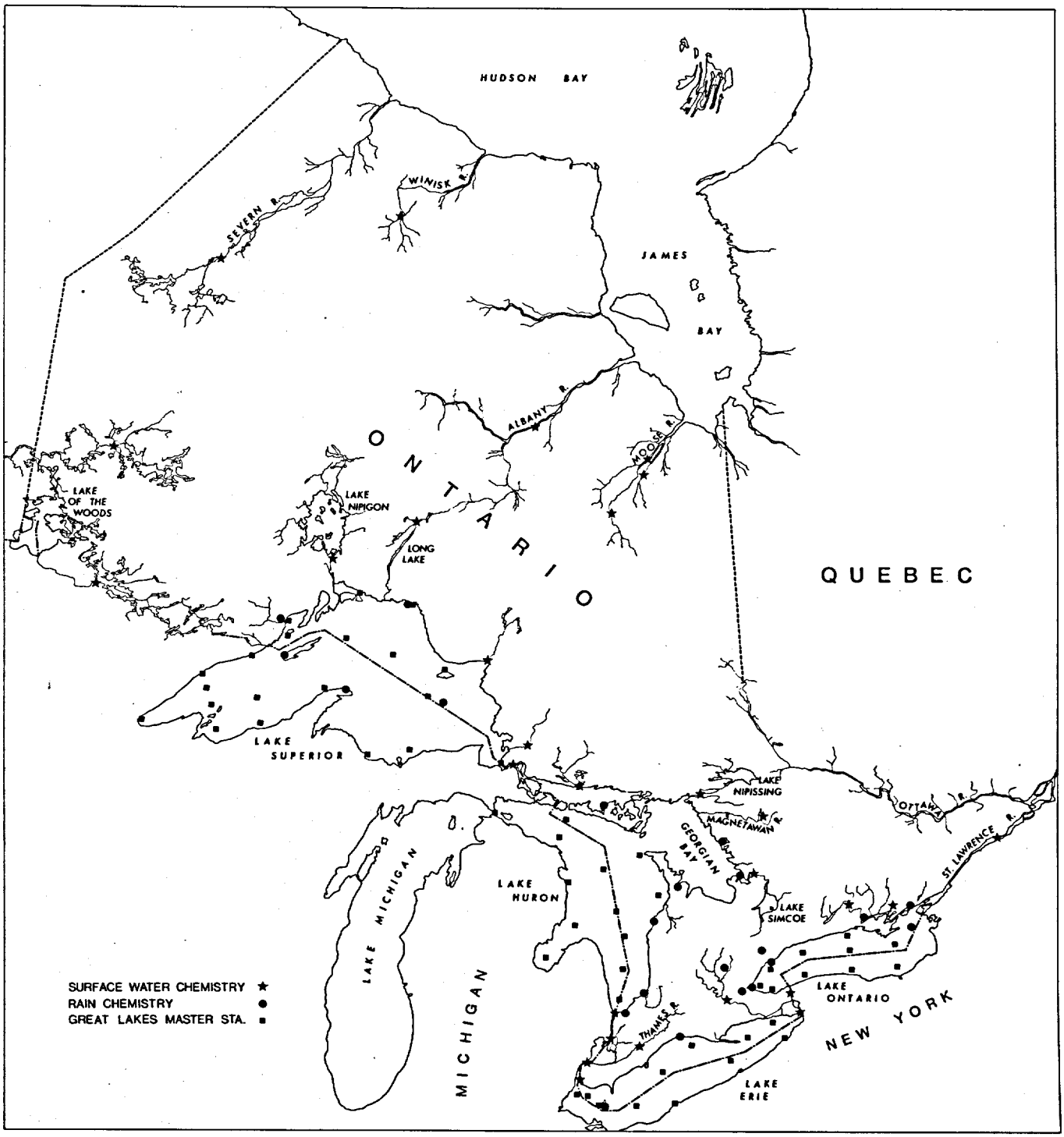


Figure 51. Water Quality Branch Ontario Region network stations.

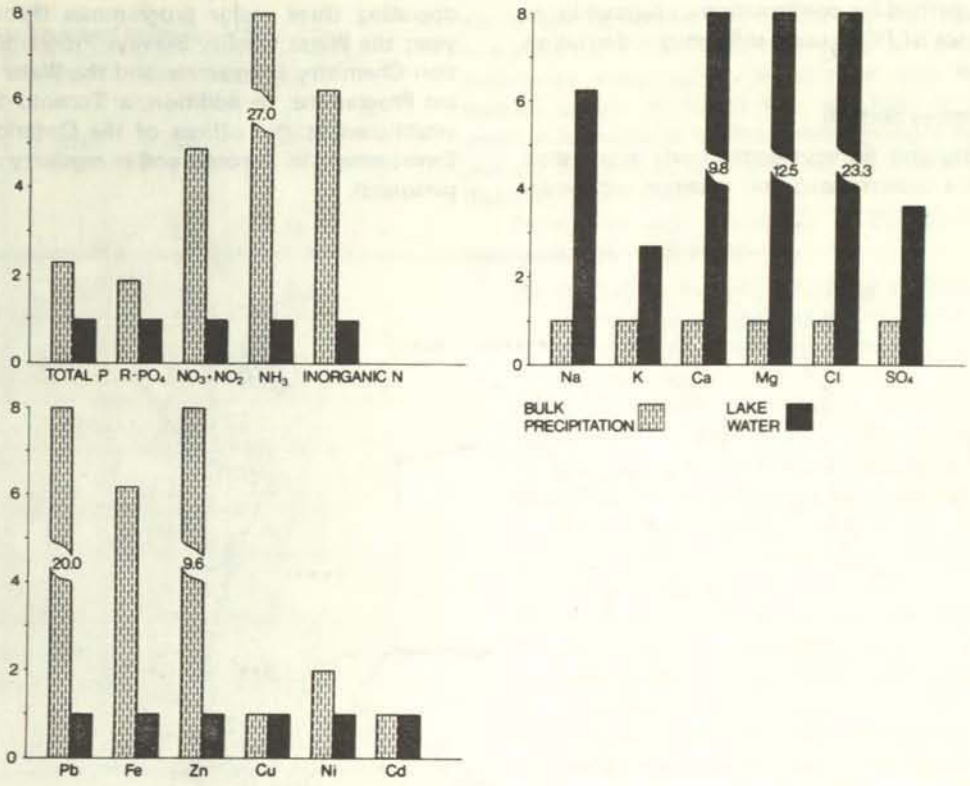


Figure 52. Ratios of concentrations of various constituents in precipitation and in lake water, Lake Ontario Basin.

Water Quality Surveys Programme

This programme involved water quality surveys on the St. Marys River and the St. Lawrence River which were coordinated with surveys carried out by the Ontario Ministry of the Environment, and which were supported by the Analytical Services Section as well as by the Microbiological Unit and the Technical Operations Section of Scientific Operations Division, and by the Marine Sciences Directorate at CCIW.

The objectives of the Water Quality Surveys were to determine the present water quality of the interconnecting channels, to supply historical or baseline data by which future deterioration or improvement can be measured, and to identify any transboundary movement of pollutants. The information will help evaluate the effect of improvements in wastewater treatment facilities provided for in the Canada-U.S. Agreement on Great Lakes Water Quality, 1972.

Three five-day surveys were carried out on the St. Lawrence River during the field season. In each survey a total of 69 stations in 31 ranges were sampled daily. Field laboratories were set up to determine nutrients, pH, dissolved oxygen and conductivity as well as to prepare samples for later bacteriological tests. Table 11 summarizes some data forwarded to the IJC from the project.

Two similar surveys were carried out on the St. Marys River, one in August and one in November. A total of 34 stations in seven ranges were sampled daily in the August survey; the November survey was similar, but had to be partly curtailed due to weather conditions. Table 12 summarizes some results from the August survey.

Precipitation Chemistry Programme

Responsibility for the operation of this programme was transferred this year from the Lakes Research Division to the Monitoring and Surveys Section. The programme has now increased to comprise 22 stations in the Great Lakes Basin; the stations are shown on Figure 51. In addition, a programme of rain collection and analysis was initiated on the major survey vessels, the Martin Karlsen and the Limnos. Samples taken on the Karlsen are analysed immediately for certain parameters, while those taken on the Limnos are preserved and analysed later.

During 1973 the emphasis of this programme shifted to the Upper Lakes basin in response to the requirements of the Upper Lakes Reference Group on the pollution problems of Lake Huron and Lake Superior. Eight new stations were established in these two basins during 1973. Most of the samples collected by the two survey vessels during 1973 were collected on Lake Superior.

Some of the results of this project are illustrated in Figure 52 which shows the relative concentrations of a number of constituents in precipitation and in lake water for the Lake Ontario basin. In this chart the lower of each pair of concentrations is set equal to 1. The chart shows that precipitation accounts for significant inputs of

nutrients and some metals but negligible inputs of major ions.

Water Quality Monitoring

The Water Quality Branch operates a national base line monitoring programme consisting of fixed sampling stations throughout Canada from which samples are regularly taken and analysed for a wide variety of constituents. The programme is designed to assess the quality of lakes and rivers and to determine trends in water quality. There are about 600 sampling stations in the national programme with the Water Quality Laboratory and Network (Ontario Region) responsible for the operation of the stations located in Ontario.

As shown in Figure 51, there are presently 104 stations in the Ontario Region, of which 22 are precipitation stations. Of the remaining 82 stations, 28 are river samples collected by the Water Survey of Canada or by lay collectors and the rest are on the Great Lakes and are sampled from survey vessels.

WATER SURVEY OF CANADA

The Ontario Region of the Water Survey of Canada is primarily responsible for the inventory of water quality of the Water Resources in Ontario. The District Office is located at Guelph, with sub-offices at Ottawa, North Bay, Niagara Falls and Sault Ste. Marie. District operations from the Niagara Falls Office were transferred to Guelph during the year, and Mr. V. J. M. Johns was transferred to the Water Planning and Management Branch.

Operations of the network in the western and north-western part of the Province are presently carried out by the Manitoba District of the Western Region, Inland Waters Directorate. In addition to the water quality planning and monitoring programmes, the Ontario Region, in co-operation with the United States Corps of Engineers, are responsible for monitoring programmes on interconnecting channels in the Great Lakes and specifically in the Niagara River where considerable work is done for the International Niagara Board of Control.

Operation and maintenance of water level stations on the Great Lakes is carried out for the Marine Sciences Directorate, and a limited sampling programme is also carried out for the Water Quality Branch.

A review of the functions of the various sections in the Ontario Region is as follows:

Field Operation Section

This section has three prime work areas:

1) Hydrometric Gauging Stations.
2) Great Lakes Water Levels.
3) Sediment Surveys.

A *Hydrometric Network* of approximately 370 active gauging stations was operated in 1973. An extensive field programme of collecting discharge measurements to determine or verify water level-discharge relationships was carried out. This included a total of approximately 3,000 measurements and 16 new gauging installations. Water level data extraction from the recorder charts was made with the D-Mac Pencil Follower and data was processed on the I.B.M. 370-55 computer at the University of Guelph Computer Centre. Sampling programmes on behalf of the Water Quality and Groundwater Divisions were also completed. One hundred and sixty-three water quality samples and six groundwater discharge measurements were collected and forwarded to the respective group involved.

A total of *41 Water Level Stations* located on the *Great Lakes* and St. Lawrence River were maintained for the Tides and Water Levels Section, Marine Sciences Directorate, Ottawa. A Telex Data Retrieval system is now installed and operating at at least one location on each of the Great Lakes. Three Tele-Announcing systems were installed at other existing stations during the year.

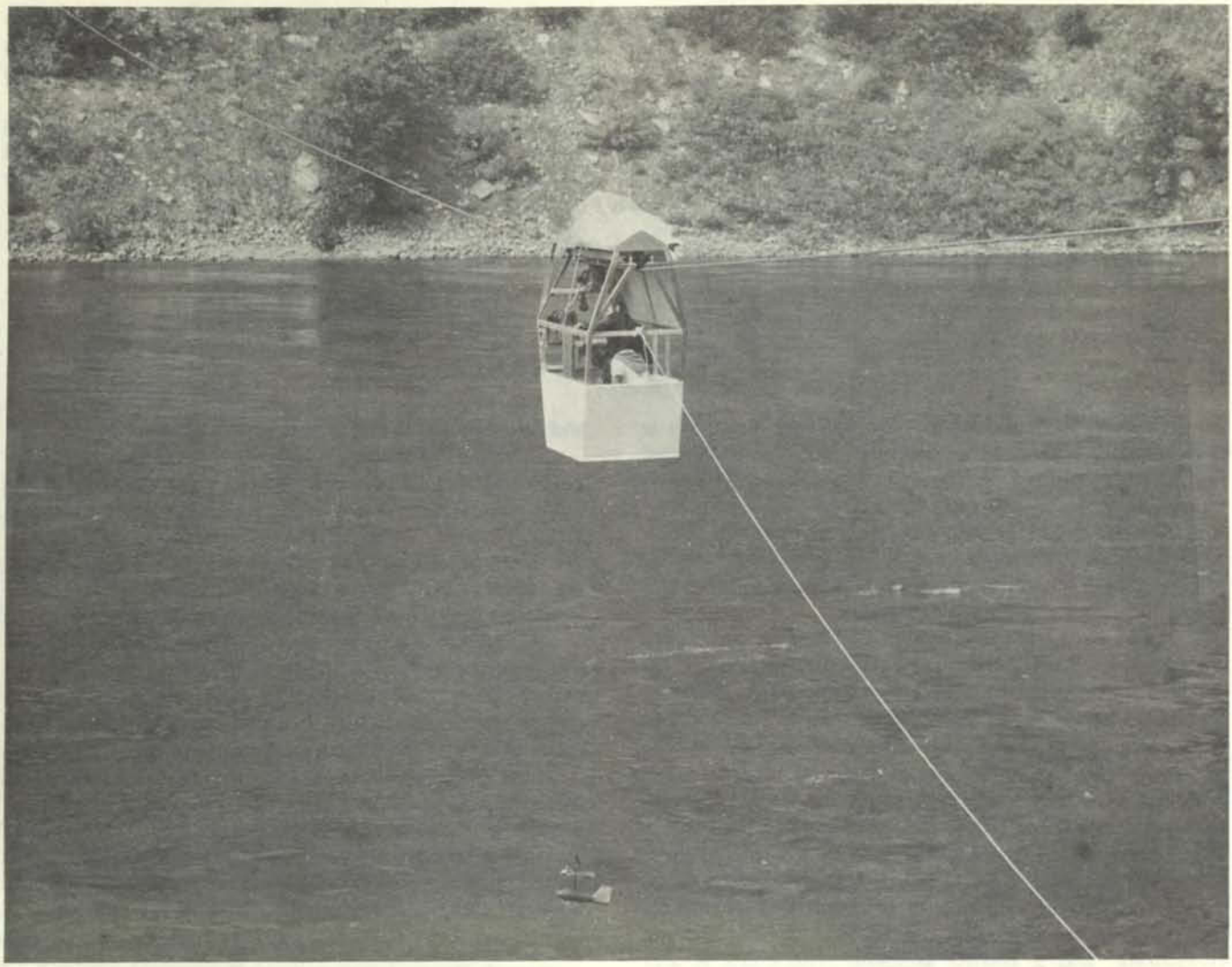
A complete *Sediment Sampling* programme was completed on 12 stations in the Regional network. During the year 3,500 bottled samples, 16 suspended sediment discharge measurements, and five bed material samples were collected. Sediment discharge computations for 1972 data were computed and approved for four stations by District personnel, the remainder being computed by the Sediment Section in Ottawa. A good portion of the summer work period was concentrated on two reservoir sediment surveys in the Toronto region – Clairville and Finch Reservoirs. Staff of both the Provincial Conservation Authorities Branch and Water Survey of Canada conducted the surveys.

Special Studies and Surveys Section

In 1973 several measurement programmes were carried out on the interconnecting channels of the Great Lakes. The programmes completed were:

1) Discharge measurements of the Niagara River at Fort Erie, at the International Railway Bridge section.
2) Calibration of the Leading Edge Flowmeter at Fort Erie.
3) A joint programme with the U.S. Corps of Engineers to measure discharge, storage and wave propagation as related to flow in the St. Clair River.
4) Calibration of the regulating weir in the Welland Canal at Port Colbourne.

Installation of the Niagara River Aerial Cableway was completed in September, 1973. The purpose of the cableway is to provide a direct measurement of the flow past the Ashland Avenue Gauge and to verify power plant discharge ratings. Joint discharge measurement programmes with the United States Corps of Engineers were also carried out.



This battery-powered, self-propelled aerial cablecar was installed on the Niagara River above the Robert Moses Power Plant is September 1973. It will provide a platform from which it is possible to measure the discharge out of the Maid-of-the-Mist Pool. A Gurley-type velocity meter suspended above a 100-pound sounding weight is used to measure the average velocity and depth across the metering section. The weight and meter are raised and lowered by an electrically powered winch. (Photo courtesy of the Power Authority of New York State).

Niagara River Studies and Control

This unit participated in the functions of both the International Niagara Committee and the International Board of Control.

Regular inspections were made to ensure that power diversions were made in compliance with the terms of the "1950 Niagara Diversion Treaty." On only one occasion was the flow deficient and that was a deliberate action of the International Control Structure Superintendent in the successful attempt to rescue ten people stranded on he Niagara River.

New operating procedures for the Chippawa Grass Island Pool were put into effect in March, 1973. The new procedures provide higher river profiles during low flow periods and lower river profiles during high flow periods.

The Leading Edge Flowmeter, which was installed to provide better control of the International Control Structure downstream, operated and collected data for a number of months during 1973. A number of "bugs" have been eliminated from the system and rating of the Flowmeter will be continued.

Data Control Section

This section is comprised of two main working groups:

1) Hydrometric Data Compilation and Quality Control.
2) Data Review.

In 1973 our major publication "SURFACE WATER DATA – ONTARIO 1972" was compiled, quality checked, printed and distributed to various streamflow data users throughout Ontario. Requests were handled for more than 22,000 station-years of data, excluding miscellaneous data such as river cross-sections, velocity profiles, etc. As part of

our participation in the International Field Year on the Great Lakes, streamflow data for 37 discharge stations providing inflow into Lake Ontario was forwarded to the IFYGL Data Bank at Canada Centre for Inland Waters for further distribution to participants, particularly the agencies involved in the Terrestrial Water Balance study of Lake Ontario.

The Data Review Section, which is involved in the review of all data collected to 1970, has completed approximately 30% of the total review programme. The initial phase of the programme was concentrated in the Northernmost basins, with review reports written for all hydrometric stations involved. Work involved the examination and revision, if necessary, of the data.

Network Planning and Forecasting Section

This section became operational in August, 1973. A start has been made on studies of regional water flow patterns to investigate the possibility of estimating (flood peaks, average flows, low flows) from existing data.

An Inter-District Seminar is planned for January, 1974 for the purpose of identifying hydrologic forecasting agencies that are now in operation, and to analyse the techniques which have been implemented to date across Canada.

Other projects completed by this unit were:

1) Implementation of a network planning classification of Ontario Region stations.
2) A review of 5 station records to be used in a UNESCO Study on large floods.

Environmental Protection Service

Environmental Protection Service

The Environmental Protection Service (EPS) was formed to ensure that the Federal Government's legislation, regulations and guidelines concerned with the quality of the environment are approached in a fashion consistent with national policy and enforced under appropriate circumstances. The Environmental Protection Service is involved in the development of guidelines and regulations, in the identification and solution of pollution problems, problem surveillance and monitoring, and the development and demonstration of waste treatment technology. It draws on expertise from the Resource Missions of the Department for the criteria necessary to develop meaningful regulations, guidelines, and codes of good practice and for the conduct of research required to support EPS responsibilities.

TECHNOLOGY DEVELOPMENT AND DEMONSTRATION DIVISION

The Technology Development and Demonstration Division, Technology Development Branch, Water Pollution Control Directorate, is charged with the conception, development, and implementation of technical development programs as related to water pollution control for industrial and municipal wastewaters across Canada. The Division not only undertakes bench and pilot scale studies in their laboratories but also participates in field demonstration projects at industrial sites.

To fulfill the mandate of the Technology Development Branch, EPS established a program at the Wastewater Technology Centre at the Canada Centre for Inland Waters (CCIW). The Wastewater Technology Centre (WTC) is located in a two-storey building at the North end of the CCIW site. The building houses laboratories, and provides 1,395 m^2 (15,000 sq. ft.) of working area for a wide variety of modular wastewater and sludge treatment process equipment.

The Wastewater Technology Centre bases its program priorities on the requirements of the Abatement and Compliance Branch of the Water Pollution Control Directorate, plus inputs from the various Regional Branches of EPS and Provincial Environmental organizations.

In August, 1971, the Government of Canada and the Government of the Province of Ontario signed an agreement to ensure that the water quality of the Great Lakes is restored and protected. This "Canada/Ontario Agreement on Great Lakes Water Quality" was signed in response to the recommendations of the International Joint Commission (IJC) concerning pollution of the Lower Great Lakes and in anticipation of the Canada/United States Agreement on Great Lakes Water Quality. The purpose of this Canada/Ontario Agreement was to permit Canada and Ontario to effectively carry out their obligations under the International Agreement. An additional important provision of the Agreement was for the conduct of a research program with a view to reducing costs of programs to achieve the specific water quality objectives set out in the Agreement. Thus, late in 1971, research programs were initiated on chemical removal methods, sludge handling, sludge disposal and other matters related to the process of nutrient removal from sewage. A major portion of the effort of the Wastewater Technology Centre has been directed toward the solution of these nutrient removal problems.

The staff of the Wastewater Technology Centre is organized into four main sections. These are the Process Development Section, Demonstration Section, Laboratory Services Section and Facilities Services Section, all supported by administrative personnel.

PROCESS DEVELOPMENT SECTION

The Process Development Section comprises four units organized along process lines: (1) biological processes, (2) physical processes, (3) chemical processes and (4) soil processes.

Biological Processes Unit

This group is responsible for carrying out developmental work on biological processes used to remove components such as BOD, suspended solids and toxicity from municipal and industrial wastewaters. A bioassay group, responsible for determining the fish toxicity of untreated waste streams and treated process effluents, is part of the biological processes unit.

Biological Treatment of Kraft Bleachery Effluent

A joint Federal/Industrial project initiated in 1973, involves the operation of a pilot-scale two-stage activated sludge system treating a Kraft bleachery effluent from the pulp and paper mill of Eddy Forest Products Limited, Espanola. The main objective of the program is to evaluate

the fish toxicity removal capabilities of the high rate activated sludge system. For comparative purposes, a single-stage conventional activated sludge process is being operated in parallel with the two-stage system.

The Kraft bleachery effluent being treated is the total effluent from a six-stage bleachery processing hardwood and/or softwood. The bleachery effluent is neutralized and pumped to the pilot-scale activated sludge systems at flow rates ranging from 2.27 to 22.7 l/min (0.5 to 5.0 lgpm). Performance of both systems is being monitored by conducting analytical and bioassay tests on 24-hour composite samples. These tests provide information for the determination of engineering design parameters and a measurement of the toxicity removal efficiency of each system.

Optimization of Biological Nitrification

A nitrification/denitrification pilot plant (22.7 l/min, 5 lgpm) program was carried out in conjunction with McMaster University in 1972 to investigate the feasibility of using continuous microbial denitrification for nitrate removal from municipal wastewater under cold temperatures.

Results from this study established that the critical link in a low temperature biological nitrification/denitrification system was in the nitrification step. Consequently, a pilot plant program was initiated in 1973 to examine various flow and process configurations for biological nitrification systems. Demonstration of process effectiveness under a range of operating conditions typical in Canada, is a further objective of this study.

Two pilot plant systems (Figure 1) have been constructed and are being operated as parallel systems using municipal wastewater as substrate. The two systems have been constructed so that six modes of operation can be studied; a bio-disc will also be used to study the nitrifying capabilities of a fixed film reactor. To provide a complete nitrogen balance, nitrified effluent will be denitrified in packed column reactors or a stirred tank reactor; denitrified effluent will be subjected to aerobic stabilization to remove excess methanol, the carbon source for denitrification. Preliminary experimental studies initiated in October, 1973, have been completed and the detailed experimental design is being formulated.

Biological Treatment of a High Strength Pulp and Paper Mill Effluent

Bench-scale studies were undertaken to investigate the possibility of using an activated sludge process for the treatment of the total mill effluent from a neutral sulfite semi-chemical (NSSC) pulp and paper operation. Samples for the study were obtained from Domtar's NSSC mill at Trenton. Untreated wastewater used in the original phase of the study had BOD_5 and total dissolved solids concentrations of approximately 7,000 mg/l and 25,000 mg/l respectively; these values have now increased to approximately 14,000 mg/l and 50,000 mg/l as the result of modifications in the water reuse program of the mill.

A single-stage and two-stage activated sludge reactor are being used in the laboratory studies (Figure 2). The major objectives of the study are to determine (a) whether an activated sludge system will reduce the BOD_5 to an acceptable level; (b) the fish toxicity removal capabilities of the activated sludge system; (c) sludge yield and oxygen requirements of the mixed liquor; and (d) the characteristics of sludge generated to provide information for sludge handling and ultimate disposal. Results indicate that an acceptable effluent BOD_5 level can be attained; however, additional information is required before any conclusions can be drawn.

Aircraft De-Icer Treatability Study

A study was conducted at the WTC to investigate the feasibility of treating a combination of de-icing fluid and airport wastewater using an activated sludge process. The results were to provide information for the design of treatment facilities at the new airport at St. Scholastique, Quebec and for assessing treatment alternatives at other airports across Canada.

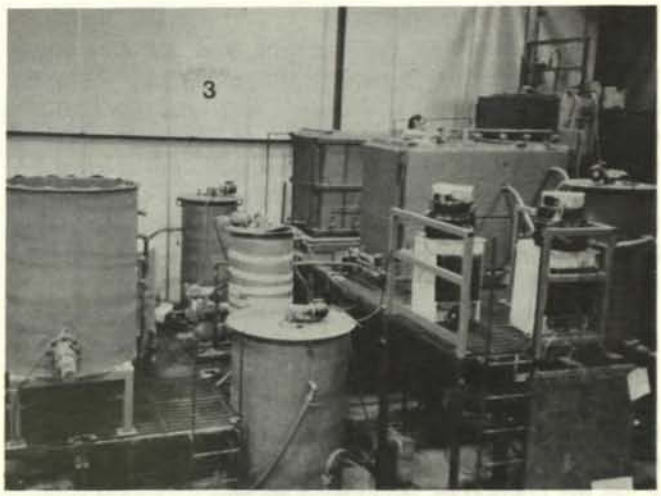


Figure 1. Biological nitrification/denitrification pilot plant.

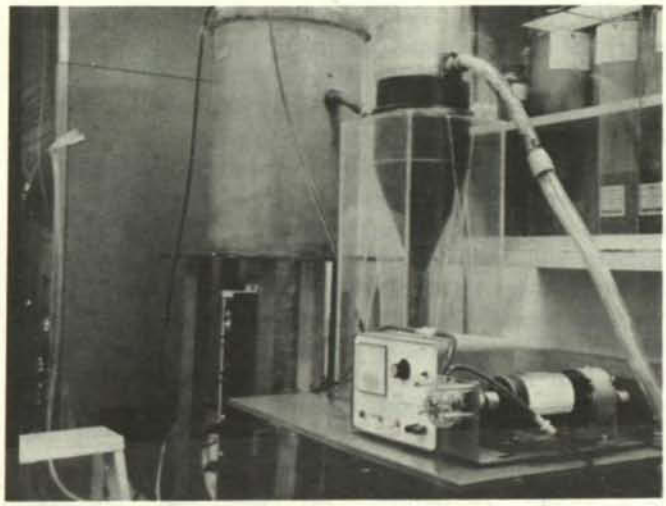


Figure 2. Single-stage activated sludge reactor treating NSSC effluent.

The first part of the program consisted of a bench-scale activated sludge study to determine the optimum loading condition and to obtain design parameters for the treatment of de-icing fluids and municipal sewage at low temperatures. A 91 l/min (20 lgpm) pilot plant was operated at the optimum organic loading to verify the results from the laboratory-scale study and to determine whether there were any operational problems. The second part of the program, consisting of bioassay studies, was carried out to determine whether the aircraft de-icing fluids and process effluents were acutely toxic to rainbow trout.

The experimental results showed that an activated sludge system treating a combination of de-icing fluid and municipal sewage at less than 10°C will produce an effluent having a BOD_5 and Suspended Solids concentration of 20 mg/l and 25 mg/l respectively at a loading of 0.15 kg BOD_5/kg MLSS.day. Growth of filamentous micro-organisms and the resulting sludge bulking condition dictated selection of the low loading condition. The bioassay results showed that, at this loading, the concentration of de-icer in the feed solution would be such that the effluent from the activated sludge process would meet fish toxicity requirements.

Physical Processes Unit

This group carries out research and development work on physicochemical treatment processes for the removal of deleterious and toxic constituents from industrial and municipal waste streams. Active areas of concern include the development of design and operational criteria for the dewatering of municipal waste sludges, investigation of physical-chemical treatment (PCT) processes for small communities and the treatment of wastes from base metal mining and metal plating industries.

New Brunswick Acid Mine Drainage Treatment Project

In 1972, a joint Federal/Provincial/Industrial study was initiated for the development of mine and mill wastewater treatment technology in the base metal mining industry. As a result, two waste treatment pilot demonstration plants have been established at the Brunswick Mining Company site in northeastern New Brunswick. The first plant on stream was a versatile pilot plant which incorporates state-of-the-art technology for the treatment of acid mine waters. Unit processes include neutralization and precipitation, sedimentation, sludge handling and effluent polishing. Effluent metal concentrations obtained for several mine waters using state-of-the-art technology were as follows:

Mine water	Pb*	Zn	Cu	Fe
BMS # 12	0.3	0.42	0.04	0.36
Heath Steele	0.3	0.55	0.10	0.78
BMS # 6	0.3	0.52	0.06	0.54

*all values in mg/l

In support of the field program, bench-scale development studies were carried out to assess the feasibility of alternative procedures and effluent polishing techniques. Excellent results were obtained with sand filtration, MgO reactor filters and polymer scavenging processes. Sand filtration and scavenging by polymers are presently under investigation in the pilot plant.

A second significant pollution problem also existed with the milling of the high sulphur content ores. Reduced sulphur compounds (thiosulfate and thionates) generated in the grinding and separation processes were escaping the mill in the tailings pond overflow. This caused a significant pH depression in the receiving water when naturally occurring bacteria oxidized these thiosalts to sulphate. Studies carried out at the Centre established the feasibility of two treatment processes: biological oxidation using a "bio-disc" and chemical oxidation in a stirred tank reactor using ozone. Sulphur precipitation also showed promise. Biological oxidation rates were approximately 29×10^{-4} and 11×10^{-4} kg thiosulfate per m^2 (6×10^{-4} and 2.2×10^{-4} lbs/ft^2) of reactor surface per hour at 20 and 2°C, respectively. The ozone reaction required approximately 30-40 minutes consuming 0.4 mg (lbs) of ozone per mg (pound) of thiosulfate oxidized. A "bio-disc" biological oxidation pilot plant is presently being constructed to demonstrate the technology and provide design data.

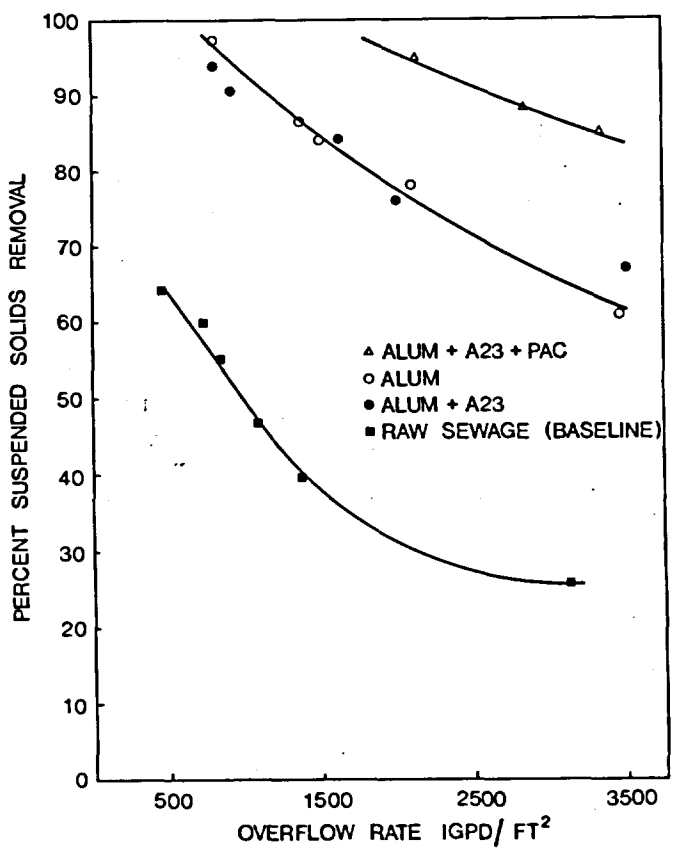


Figure 3. Settleability of chemically treated domestic sewage.

Table 1. Comparison of Percent Removals for Different Treatment Conditions

OPERATING CONDITIONS / PARAMETERS	BASELINE no chemicals added	200 mg/1 ALUM July 16-Aug 1	200 mg/1 ALUM 0.5 mg/1 A-23 Aug. 6-Aug. 31	200 mg/1 ALUM 0.5 mg/1 A-23 100 mg/1 PAC Oct. 3-Nov. 2
Total Organic Carbon (TOC)	13.4 (15.3)	30.9 (11.4)	45.7 (11.5)	48.6 (12.1)
Biochemical Oxygen Demand (BOD_5)	43.5 (13.0)	79.5 5.6	88.3 (2.2)	87.7 (4.0)
P	21.9 (14.3)	91.3 (4.2)	90.4 (11.2)	95.6 (3.2)
Suspended Solids (SS)	55.9 (16.6)	88.6 (4.1)	92.6 (4.4)	95.2 (2.4)
Al	–	37.4 (23.1)	63.7 (19.7)	83.9 (16.0)
Zn	–	81.2 (10.0)	83.3 (7.8)	71.1 (18.2)
Cu	–	87.6 (4.2)	90.2 (4.0)	88.2 (10.5)
Fe	–	76.6 (5.8)	76.1 (11.0)	90.4 (5.1)

Standard deviations are shown in brackets.

Table 2. Physical Characterization of Primary Sludge

	200 mg/1 ALUM		200 mg/l ALUM + 0.5 mg/l A-23* + 100 mg/1 PAC**	
PARAMETERS	MEAN	STANDARD DEVIATION	MEAN	STANDARD DEVIATION
Concentration (g/1)	20.163	5.7	35.752	4.8
Volatile (%)	50.2	9.6	66.4	3.2
ρ Suspension (g/cm^3)	1.0057	0.0017	1.0079	0.0012
ρ Solids (g/cm^3)	1.73	0.28	1.39	0.11
Moisture Cake (%)	75.9	3.5	78.3	1.3
C.S.T. (Secs)	29.7	13.5	33.1	9.0
Resistivity (Sec^2/g)	2.797×10^9	1.14×10^9	0.982×10^9	0.42×10^9
Viscosity Filtrate (Centistokes)	1.47	0.22	1.04	0.04
pH	7.36	0.22	7.16	0.22
Filtrate Conductivity ($MMHOS/cm^2$)	1.16	0.24	1.25	0.15
Total Organic Carbon (mg/1)	115	81.2	109	33.6

* Polymer
** Powdered Activated Carbon

Table 3. Sludge Production – Primary Treatment

CONDITION	SLUDGE VOLUME l/day (l gal/day)	TOTAL PHOSPHORUS mg/l	SS mg/l	VSS mg/l	SLUDGE WEIGHT kg/day (lbs/day)
Baseline	224 (49.3)	428.3	65,000	37,000	12.7 (28.0)
Lime pH 9.5	440 (96.9)	1435.1	120,500	26,200	51.4 (113.0)
Lime pH 9.5 Sludge Recycle	614 (135.0)	647.9	17,000	23,300	65.8 (144.7)
Lime pH 11.2	991 (218.0)	415.7	75,300	15,100	71.5 (157.2)
Lime pH 11.2 Sludge Recycle	991 (218.0)	444.1	100,900	15,200	100.0 (220.0)
200 mg/l Alum	1778 (391.2)	239.6	18,800	9,900	33.2 (73.0)
200 mg/l Alum + 0.5 mg/l Polymer	1347 (296.4)	567.8	32,200	18,100	43.0 (94.7)
200 mg/l Alum + 0.5 mg/l Polymer + 100 mg/l PAC	1414 (311.1)	458.8	34,700	22,600	48.7 (107.1)

SS = Suspended Solids
VSS = Volatile Suspended Solids
PAC = Powdered Activated Carbon

Physical/Chemical Treatment for Small Communities

Under the "Canada/Ontario Agreement on Great Lakes Water Quality," a study was initiated to investigate and develop physical/chemical treatment processes for small communities. These small isolated sewage treatment plants, serving rural communities of a few hundred people or less, typically present unique design and operational problems which are usually not encountered in large plants even though the treatment process employed may be basically the same in both instances. Many of the problems are directly related to the fact that small plants receive little maintenance and supervision. For satisfactory performance, the treatment system must obviously be highly dependable. Problems are also caused by highly variable organic and hydraulic loads under which small plants must operate. Characteristically, high surges of sewage over short periods and little or no flow at other times are experienced.

Pilot plant studies which have been carried out for the past year include the following unit processes: chemical clarification, air flotation, powdered activated carbon, pressure filtration, granular activated carbon in downflow packed beds or upflow expanded beds, and recarbonation. Results from a series of tests to evaluate alum and polymer (A-23) and powdered activated carbon (PAC) addition to raw sewage are presented in Figure 3 and Table 1. Studies are continuing.

Sludge Dewatering Process Development Studies

The "Sludge Treatment Process Development Program" which was initiated in early 1972 under the terms of the Canada/Ontario Agreement, was aimed at the characterization of sludges with respect to physical (Table 2) chemical and biological properties and the correlation of these properties to efficiency of various sludge dewatering processes. The program was also to determine the effect of the various inorganic chemicals used in phosphorus removal on the present biological sludges (Table 3). The overall objective was to develop an understanding of sludge dewatering, either by sedimentation or filtration and to establish design criteria and methodology for the selection of process units based upon a knowledge of the influence of physical, chemical and biological properties of sludge on dewatering performance.

A study on "Chemical Treatment for Phosphorus Removal – Impact on Effluent and Sludge Properties" is a part of the overall sludge treatment development program. It was initiated in April, 1973, to investigate the following: phosphorus, carbon and suspended solids removal; heavy metal removal; sludge production; process operational characteristics; raw sewage settling; activated sludge settling; raw primary sludge characteristics; waste activated sludge characteristics and chemical conditioning. Many of the experimental studies have been completed. Studies

presently in progress include the addition of a chemical precipitant (lime) to the raw sewage of a primary treatment plant and the addition of a chemical precipitant (ferric chloride) to the aeration basin of an activated sludge process.

A second directly related study examines some sludge dewatering process units such as vacuum filtration, basket and solid bowl centrifugation, air flotation, thickening and plate and frame pressure filtration. Developing methodology criteria for the selection of process units, based upon a knowledge of the influence of physical, chemical and biological properties of sludge on dewatering performance, is the goal of this study. For this purpose mobile sludge dewatering test facilities will be used.

Chemical Processes Unit

This group carries out developmental work using chemical processes for the removal of undesirable and potentially harmful constituents from effluent waste streams. Of immediate concern and involvement is the removal of phosphates by chemical means.

Full-Scale Phosphorus Removal Studies

During 1973, the Chemical Processes Unit conducted full-scale phosphorus removal studies at Canadian Forces Bases (C.F.B.) Petawawa, Trenton and Uplands.

Alum addition to the primary was investigated at the Petawawa wastewater treatment plant. The response of the two-stage digestion process to the alum sludge was closely monitored. It was observed that the digester was capable of accumulating most of the phosphorus added to it for a period in excess of sixty days. As shown in Figure 4, this accumulation resulted in an improved supernatant quality.

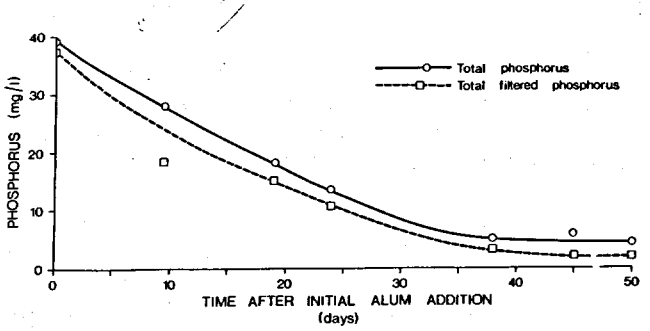


Figure 4. Effect of alum addition on digester supernatant phosphorus levels.

A full-scale study at C.F.B. Uplands compared the relative phosphorus removal efficiencies of alum and ferric chloride. Primary and secondary addition systems were evaluated for each chemical. The effect of Canada's detergent reformulation program (i.e., reduction of detergent P_2O_5 from <20% in 1972 to <5% in 1973) was clearly evident during the Uplands investigation. Figure 5 compares the average diurnal total phosphorus concentrations for the two years. The mean daily phosphorus loadings to the treatment plant were 26.0 kg (57.3 lb) and 11.4 kg (25.1 lb) for 1972 and 1973, respectively, or a loading reduction of 56%. Since the Base population remained relatively static over the data collection period, much of this reduction can be attributed directly to detergent reformulation.

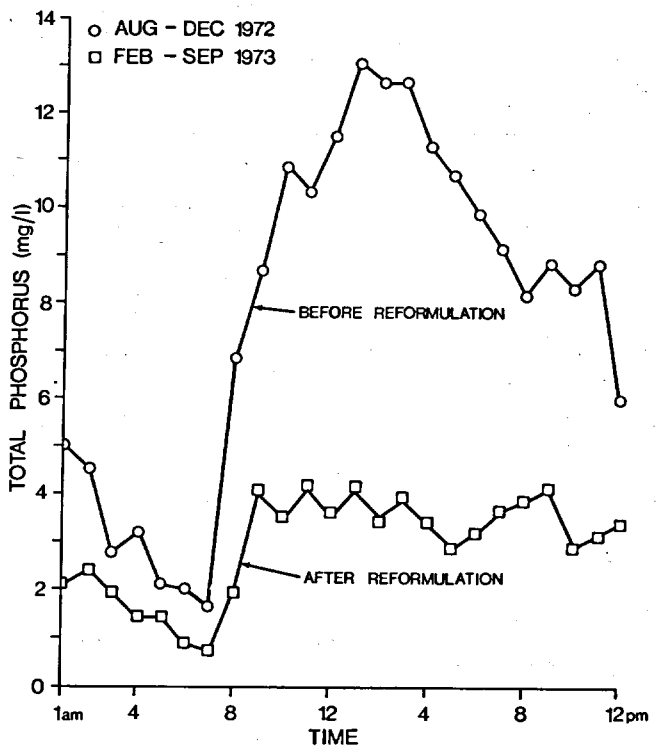


Figure 5. Diurnal variation of total phosphorus in raw wastewater at C.F.B. Uplands.

A field station is being set up at the C.F.B. Borden wastewater treatment plant in order to carry out pilot-scale studies on the sludge dewatering, incineration and chemical recovery. Multiple-hearth and rotary kiln incineration of alum, ferric chloride and lime sludges will be investigated during 1974. The feasibility of recovering and recycling lime/iron from the incinerator ash will be explored. The pilot-scale incinerator and calciner that will be employed are shown in Figures 6 and 7.

Utilization of Industrial Wastes and Wastes By-Products for Phosphorus Removal

In this study funded under the Canada/Ontario Agreement on the Lower Great Lakes, 141 Ontario and Quebec companies were contacted regarding waste products with potential utility for phosphorus removal. An inventory of waste products was compiled and several different types of waste material produced by 48 separate companies were evaluated for phosphorus removal efficiency by jar testing procedures. Several wastes with varying degrees of usefulness were identified — i.e., pickle liquors, reclaimed $FeSO_4 \cdot 7H_2O$, mill scale, spent mine acid, carbide lime, stack precipitator dusts, dross, red mud and certain bag-house dusts and slags.

The geographical location of some of these waste materials is shown if Figure 8. As part of this project, full-scale phosphorus removal studies at a local wastewater treatment plant (Dunnville, Ontario) using pickle liquor were closely monitored with respect to heavy metals levels in the various plant streams. For all metals, with the exception of iron, there was no increase in metal transport through the plant in going from baseline to pickle liquor addition conditions. There were, however, significant increases in all metal concentrations in the mixed liquor, aerobic digester and waste sludge solids.

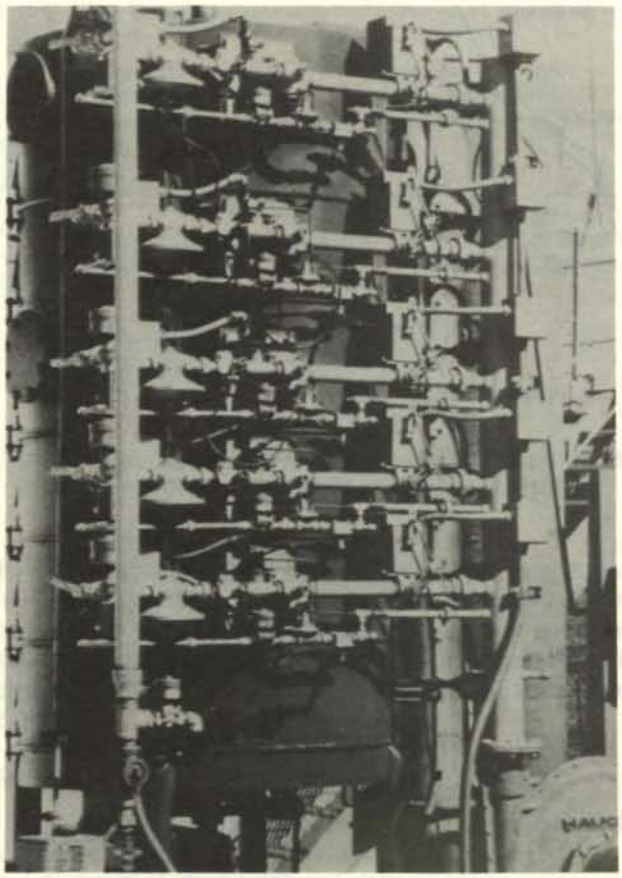


Figure 6. Multiple hearth incinerator, detail of burner system.

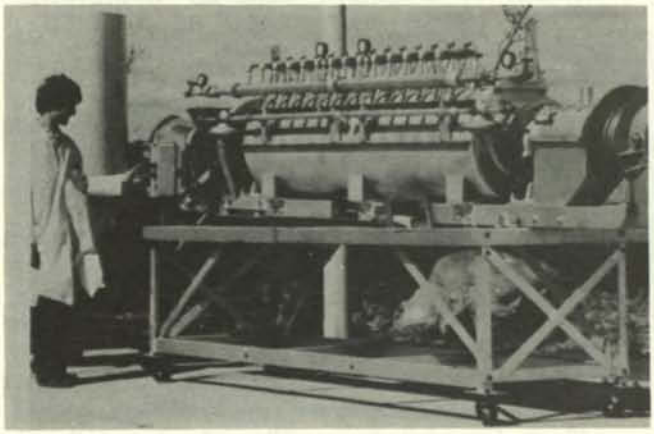


Figure 7. Rotary kiln calciner – overall view.

Tertiary Phosphorus Removal and Limiting Nutrient Studies

Pilot-plant experiments were carried out on the treatment of a stabilization pond effluent at Canadian Forces Station (C.F.S.) Lac St. Denis. The pilot plant was a 45 l/min (10 lgpm) chemical treatment system consisting of alum coagulation, flocculation, tube-settling and mixed media filtration components. Various alum and polymer feed conditions were evaluated over the 10-month period of continuous operation. Algal assays were carried out on the receiving water, Lac Depatie, to determine the limiting nutrient and to ascertain the effect of treated and untreated pond effluent upon algal growth. Phosphorus was shown to be the probable limiting nutrient in Lac Depatie and the tertiary phosphorus removal system reduced the phosphorus loading to the lake to an extent which should significantly reduce eutrophic conditions. As illustrated in Figure 9, treatment of the stabilization pond effluent greatly reduced its algal growth potential.

Water Quality Control Experiments on the Welland Canal

In May, 1973, the Saint Lawrence Seaway Authority (SLSA), treated a five-mile section of the abandoned Fourth Welland Canal with alum at an overall dosage of 5 mg/l as Al. The feasibility of this approach to water quality control had been established by experimental-basin studies carried out by the Chemical Processes Unit in 1972. The full-scale treatment involved distributing and mixing over 500 tons of liquid alum via a barge system as shown in Figure 10.

The water quality of the Fourth Canal was closely monitored during 1973 and it was observed that the alum precipitation significantly reduced the total and dissolved phosphorus levels of the canal water and consequently controlled water quality problems associated with summer algal blooms. The short-term effects of alum additions (i.e., reduction of phosphorus, and turbidity and increase in water transparency) are evident in Figure 11.

Other Projects in Progress (Funded Under the Canada/Ontario Agreement)

A) *Development of Predictive Models for Phosphorus Removal:* The objectives of this on-going project are:

(i) To establish a data bank, statistically analyse and derive trends from the "Treatability Data" collected as part of Canada/Ontario Agreement on the Lower Great Lakes.

(ii) To develop and verify statistical and chemical models for phosphorus removal on municipal wastewater.

B) *Effect of Citrate and Carbonate Based Detergents on Phosphorus Removal:* The objective of this project is to evaluate the effect of citrate and sodium carbonate based detergents upon phosphorus removal processes and to

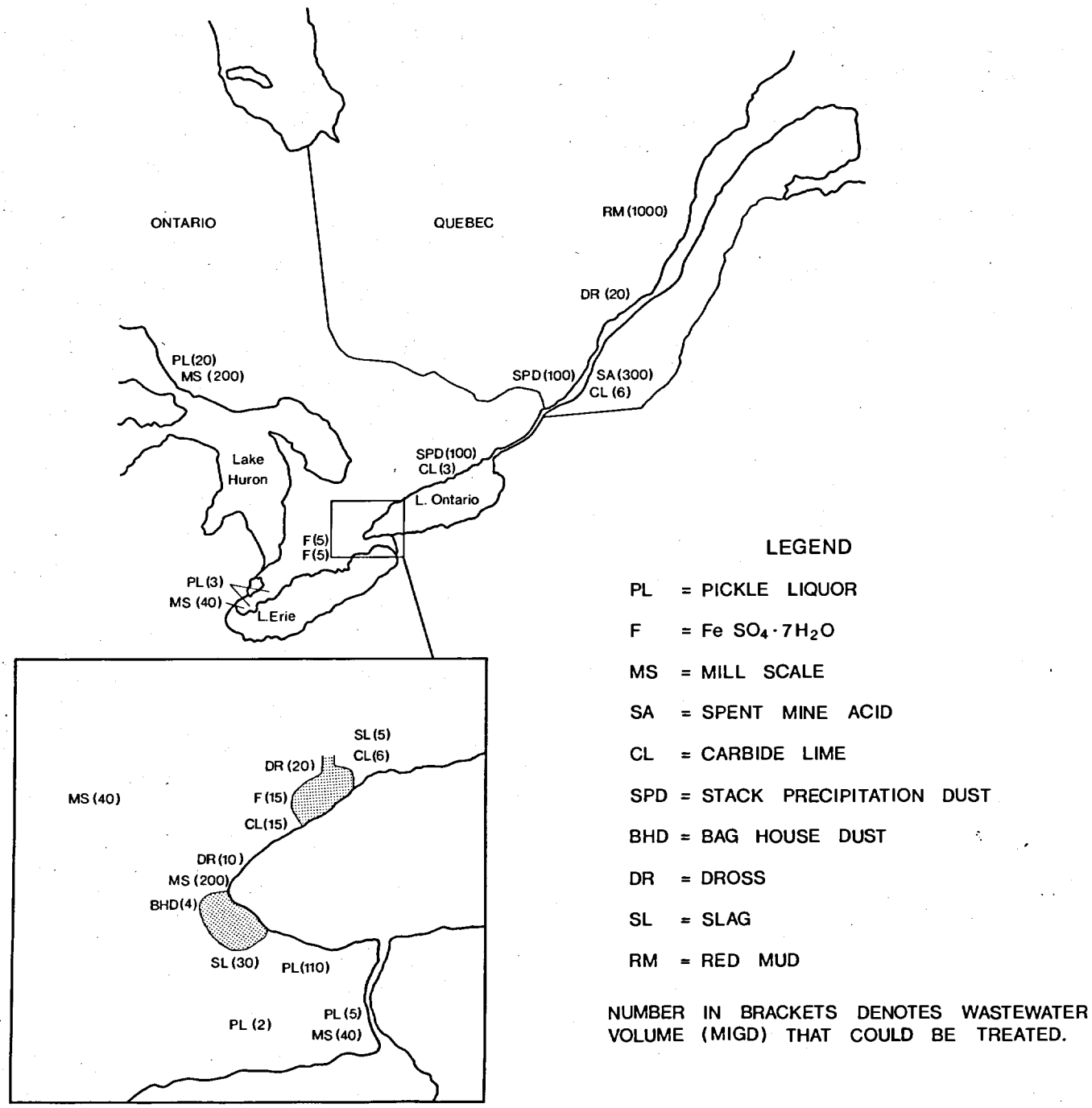


Figure 8. Geographical location of potentially useful industrial waste sources.

determine their general effect(s) on wastewater treatment plant operation. A citrate based detergent was evaluated for (i) potential phosphorus removal interferences by jar testing with ferric chloride, alum and lime, and (ii) biodegradability, potential metal transport and phosphorus removal interference by controlled full-scale detergent additions to an activated sludge plant at Waterdown. A carbonate based detergent was evaluated for potential phosphorus removal interferences on lime systems via jar testing and on a pilot 91 l/min primary lime treatment plant.

C) *Polychlorinated Biphenyls (PCB's) in Domestic Wastewater:* In order to assess the magnitude of the polychlorinated biphenyl (PCB) problem in the Lower Great Lakes a project was initiated with the following objectives:

(i) to determine, by sampling of selected Ontario wastewater treatment plants, the concentrations

of PCB's in raw and treated wastewaters and in primary, activated and digester sludges,

(ii) to determine the extent of PCB degradation within a conventional activated sludge treatment plant,

(iii) to determine PCB levels in typical combined and storm sewer discharges.

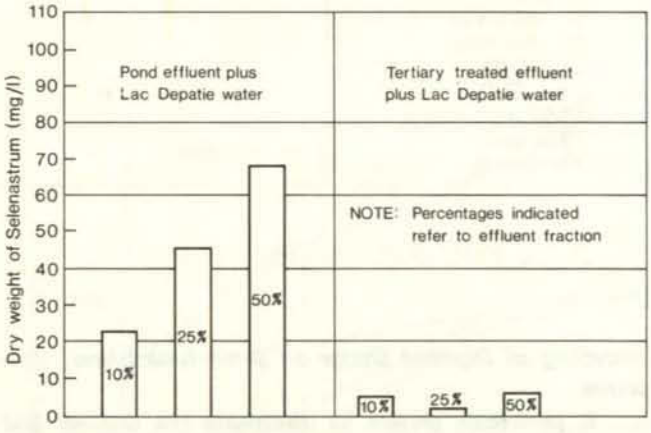


Figure 9. Effect of pond and tertiary treated effluents on the growth of Selenastrum in Lac Depatie water.

To-date, study results indicate that PCB levels in raw wastewaters are generally low (<3μg/l.). Effluent levels are consistently less than 1μg/l and with secondary treatment <0.1 μg/l. Relatively high PCB levels were encountered in digester sludges with some concentrations being in excess of 2,000 μg/l.

Soil Processes Unit

The chief area of responsibility of this group is in investigating methods suitable for the disposal of effluents and chemical sludges using soil systems. Areas of concern consist of characterizing the leachate from the sludge soil system and the role different soil systems play in removing various constituents.

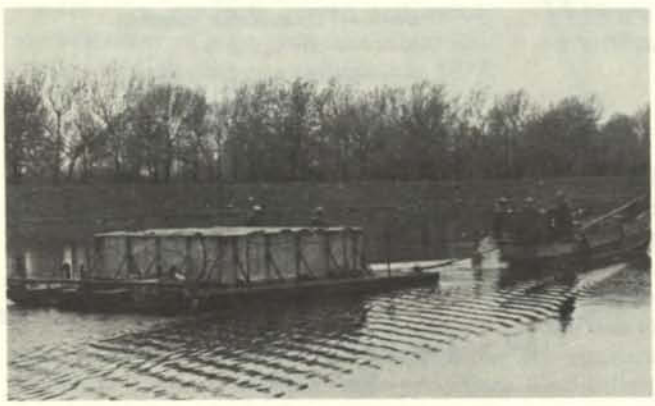


Figure 10. Alum application barge used on Fourth Welland Canal.

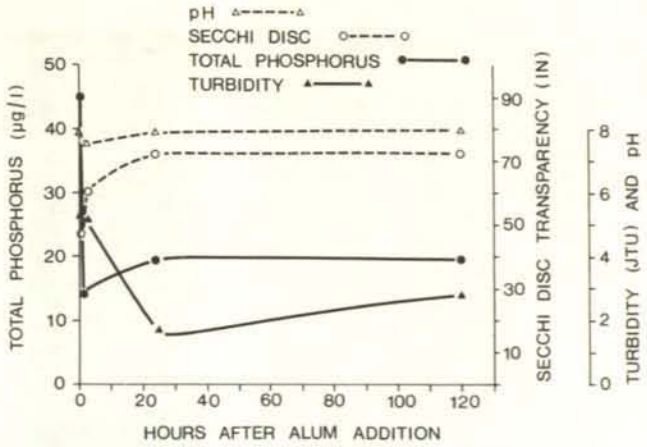


Figure 11. Short-term effects of alum treatment at section of the Fourth Canal immediately north of townline cut.

Biochemical Characterization of Chemical Sewage Sludges

Studies begun in 1972 concerning the biochemical characterization of chemical sewage sludges were continued in 1973. Digested sludges from four primary and secondary waste treatment plants practising phosphorus removal were characterized over an extended period of time in order to assess constituent variability trends. Between the four plants (Newmarket, North Toronto, Point Edward and Sarnia) the three most commonly used chemicals (lime, alum and ferric chloride) which are used for phosphorus removal are employed. Typical parameters investigated are summarized in Table 4. Significant variations in the concentrations of constituents in the sludges were observed over a one-year period.

Reclamation of Acid Mine Tailings

The objectives of this study were to ascertain if it was possible to reclaim and stabilize tailings resulting from mining operation. Mine tailings have pH values of approximately 2, while digested lime sludges from phosphorus removal systems have pH values of approximately 7.5. It was felt that lime sludge application to acid mine tailings would have a neutralizing effect. Bench-scale studies were initiated in 1973 to investigate this problem solution approach.

Liquid and dry lime sludges with and without sawdust added as a bulking agent were mixed with the top 6" layer of 18" deep mine tailings held in 1-foot diameter acrylic containers. After preliminary trials, liquid and dry lime sludge application rates as shown in Table 5 resulted in significant pH increases in the surface layers of the mine tailings in the various test containers. Figure 12 illustrates some of the preliminary data obtained.

Disposal of Chemical Sewage Sludges on Land Lysimeter Studies

The continued work from 1972 on this project saw two soil systems – Lisbon – loamy sand and Guelph – silt loam – established in the 66 lysimeters. In the spring, orchard grass (Frode variety) was planted on the lysimeter surfaces and three digested chemical sludges (alum, lime

Table 4. Biochemical Characterization Parameters Investigated for Chemical Sludges

PHYSICAL	NUTRIENTS	MINERALS	HEAVY METALS	PESTICIDES	PETROLEUM HYDROCARBONS
TS	TKN	Ca	Cu	PCB-Arochlar 1254	Total Lipids
TDS	NH_3	Mg	Zn	Heptachlor	Petro – HC
TVS	Org. N	Na	Ni	Heptachlor-expoxide	n – alkanes
DVS	Total P	K	Cd	Aldrin	Fatty acids
pH	Sol.-P	SO_4	Cr	p,ṕ – DDE	
Conductivity	Org.-P	Cl	Fe	Lindane	
	Total C		Mn	γ – chlordane	
	Org. C		Al	α – chlordane	
	Inorg. C		Pb	o,ṕ – DDT	
				p,ṕ – DDD	
				Dieldrin	
				Thiodan–I	
				Thiodan–II	

TS = Total Solids
TDS = Total Dissolved Solids
TVS = Total Volatile Solids
DVS = Disolved Volatile Solids

and iron-treated) were applied. Annual sludge application rates of 300, 600 and 900 KgN/ha were employed.

During the year, grass cuts from the various lysimeters and leachate analyses were carried out in order to establish nutrient and other constituent mass balances. The chemical composition, nutrients, heavy metals and minerals uptake were monitored to determine biochemical degradation of sludge constituents as well as their availability to the grass planted. Figure 13 summarizes the dry matter (D.M.) yields of orchard grass for various chemical sludges applied to the two soil systems under investigation. For reference purposes, yields from both soils when subjected to artificial fertilizer application (NPK) at a rate of 336 kgN/acre are shown.

Table 5. Lime Sludge Application Rates*

LIQUID SLUDGE		DRY SLUDGE	
Cubic Meters per Hectare	Lime Requirement**	Tons per Hectare	Lime Requirement
1.5×10^3	3.5	145	3.0
3.0×10^3	7.0	290	6.0
4.5×10^3	10.5	435	9.0

* Based on $CaCO_3$ content in the sludge
** Lime Requirement = 7.5 kg $CaCO_3$/t of tailings

Utilization of Dewatered Sludges

This project, dealing with the disposal on land of dewatered chemical sludges, was initiated and supported under the terms of the Canada/U.S. Agreement in 1973.

To-date, two soil systems – one, a heavy clay, the other a light sand – have been collected and repacked to natural field density in 48, 2-feet square polyethylene reactors with a soil depth of 30 inches. The experiments designed involve four application rates of three dewatered chemical sludges on the two soil systems in duplicate.

Recycling of Digested Sludge on Sand, Iona Island, Vancouver

A pilot-scale project to investigate the disposal and recycling of primary digested sludge on sands has been in operation at Iona Island, Vancouver, since 1972. The main objectives of the study are:

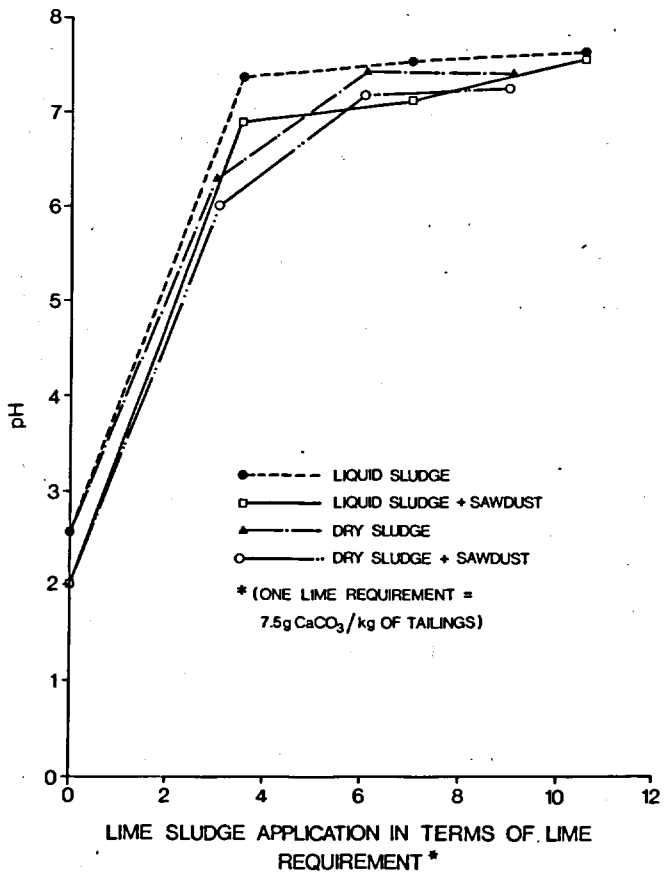


Figure 12. Surface (0-6") pH of acid mine tailings after four months of lime sludge application (Sept.-Dec. 1973).

(1) To investigate the optimum sludge application rate for efficient nutrient recycling on sand;
(2) To determine the biodegradation rate of digested sludges on land;
(3) To investigate the extent of accumulation of metals in soil, toxicity to plants and leaching of nutrients and bacteria to groundwater.

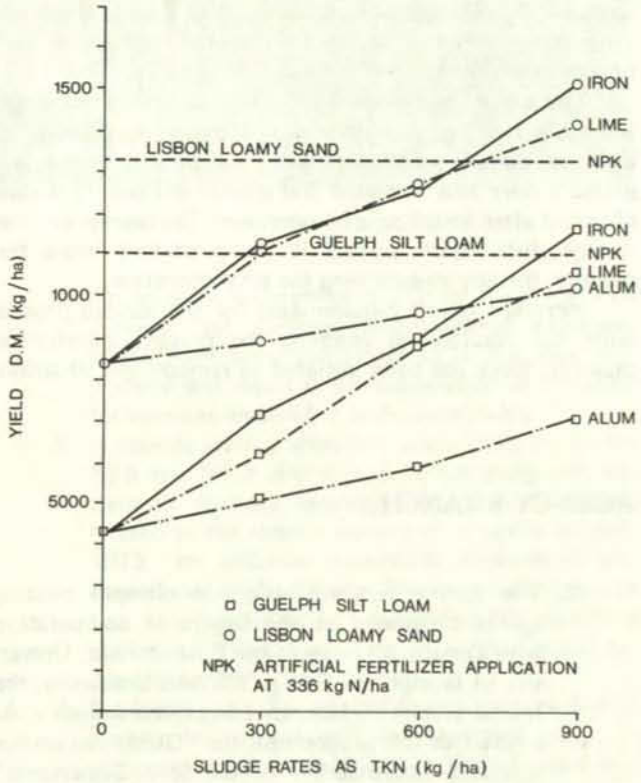


Figure 13. Total dry matter (D.M.) yield of orchard grass, 1973 (4 cuts).

Sludge was added to four plots of 0.61 hectare each at rates of 0, 260, 475 and 1030 tons per hectare. A grass crop was established on all plots and three cuts were made during 1973. Percolates from all plots are being monitored regularly for nutrients, metals and bacteria. A successful establishment of grass crop on sludged sand is exemplified in Figure 14. Studies are continuing in 1974.

Demonstration Section

The Combined Sewer Sub-committee of the Technical Committee on the Canada/Ontario Agreement on Great Lakes Water Quality developed a research strategy to be followed within the framework of the Canada/Ontario Agreement in addressing the problem of combined sewer overflows. The purpose behind this research strategy was to adapt and modify the EPA Storm Water Management Model for application to Canadian conditions. To facilitate this task within the budgetary and time frame available, a number of projects were proposed by the Sub-committee.

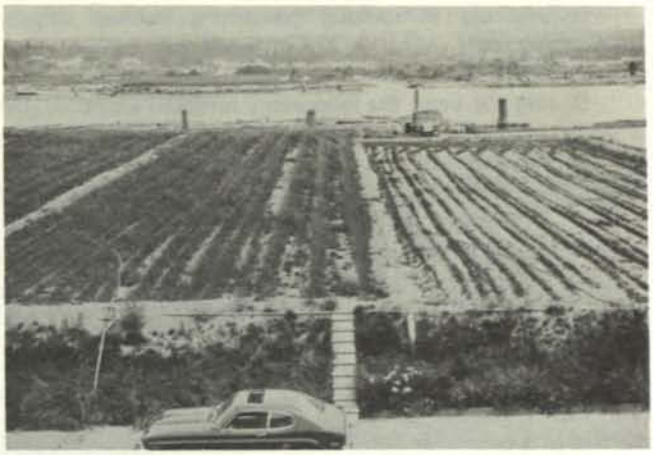


Figure 14. Grass crop on sludged sand – Iona Island.

The terms of reference for the development of a storm water management model were prepared and a call for research proposals was sent out by the Department of Supply and Services under the Canada/Ontario Agreement on Great Lakes Water Quality.

Mobile Laboratories

Specifications, drawings and purchase orders were prepared for two mobile analytical and one mobile bioassay laboratory.

Mobile Pilot Plants

Early in the year, two 45' moving vans were purchased and modified for equipping as mobile pilot plants. A 25-ton flat bed trailer was specified and purchased to transport a multi-hearth incinerator from site to site to study the feasibility of recovery of precipitation chemicals used for phosphorus removal.

Laboratory Services Section

As in the previous year, this Section continued to supply the bulk of the analytical support required by the WTC projects. Approximately 31,000 samples were received from 29 projects requiring about 90,500 analyses of which 40,000 were metals. Although the parameters measured were largely confined to various forms of carbon, nitrogen and phosphorus plus heavy metals, sample types varied considerably including sewages, soils, grasses, sludges, lysimeter leachates and wastes from paper and base metal mining operations.

Because of the variety of sample types, considerable time was spent in proving and adapting techniques suitable for their general analysis, particularly for soils and sludges. Specific investigations were carried out for the following parameters:

1. Nickel and chromium in digester sludges,
2. Calcium in digester sludges and soils,
3. Phosphate in acid mine drainage containing high concentrations of iron,
4. Iron in plant tissue, and

5. Sulphate in samples containing reduced sulphur species.

During the year, the laboratory initiated a comparative analysis study on heavy metals in digester sludges among laboratories interested in the sludge disposal programs. This program now has ten participating laboratories, including federal, provincial and university groups. The laboratory also participated in the National Interlaboratory Quality Control Program initiated by Water Quality Branch of the Environmental Management Service for the analysis of nutrients and metals in water.

Facilities Services Section

The Facilities Services Section operates and maintains the various pollution control units in the Wastewater Technology Centre and ensures that services for new processes are assembled to meet design criteria generated by the Process Development Section.

During 1973, the nitrification/denitrification pilot plant was rebuilt, the physical-chemical pilot plant modified to suit new program needs and the various sludge dewatering process units were made operational.

Completion of the outside facilities now allows for the improved operation of a 13.6 m^3/day (30,000 Igpd) extended aeration process, with sludge wasting, effluent sampling and influent control. A pilot ozonation process for domestic and industrial wastes as well as two — 4.5 m^3/day (10,000 Igpd) reverse osmosis units were assembled. One reverse osmosis model is of the spiral module type using cellulose acetate film, while the other uses hollow nylon fibres.

The supply of raw sewage for various process investigations has been greatly improved with the installation of back up pumping and automatic switch gear. Flow and pressure were also increased and greater uniformity is now obtained after installing a comminutor. The permanent raw sewage distribution system is being utilized more frequently, thereby streamlining the total operation.

Increased power requirements for the various process units has resulted in reaching the present transformer capacity. Work has been initiated to remedy this situation.

ENVIRONMENTAL EMERGENCY BRANCH

The Environmental Emergency Branch (EEB) which is part of the Environmental Protection Service has national responsibilities for protective and preventive activities where an environmental threat results from an accident in which a hazardous chemical is released into the environment. EEB is represented at CCIW by the Centre of Spill Technology (COST), formerly known as the Hazardous Material Spill Countermeasures Unit.

CENTRE OF SPILL TECHNOLOGY

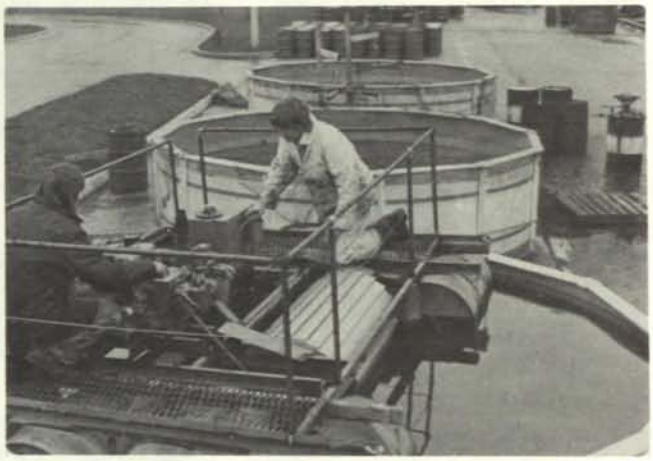
The Centre of Spill Technology's working staff presently includes three research engineers, one geographer and two technicians. The projects conducted by this group encompassed local, regional and national problems.

Many of the projects have been undertaken in liaison with other groups and scientists at the Centre, with industrial companies, with university consultants and with other government agencies. The following projects were either completed or in progress in 1973:

1. Testing, evaluation and development of oil spill equipment including skimmers, pumps, transfer systems and booms was initiated. The programme was carried out in Hamilton Harbour and Lake Ontario. The MSD supplied vessels and coxswains for the field operation. Several oil spill systems including the JBF "DIP" and Lockheed Cleansweep have been evaluated and reports written this past year.
2. The testing and evaluation of oil spill treating agents continued at the Centre in co-operation with Ontario Ministry of the Environment, University of Guelph, Sir George Williams University, the Inland Waters Directorate and private industry. As a result of this programme, the "Guidelines on the Use and Acceptability of Oil Spill Dispersants" was issued in August, 1973. The work is continuing and guidelines on the use of gelling and sinking agents should be issued in 1974.
3. In conjunction with the Northwest Region — EPS, the problems associated with the restoration of land contaminated by oil and petroleum products are being investigated. Field restoration work in areas of western Canada will be undertaken in 1974.
4. At the request of the Department of National Defence, COST reviewed the oil spill problems at CFB Esquimalt, B.C. and presented recommendations (1) for oil spill contingency planning and (2) for oil spill countermeasures equipment and techniques.
5. At the request of the Pacific Region — EPS, COST is studying the problem and preparing recommendations for oil spill countermeasures at the Port of Vancouver. This study will be completed in early 1974.
6. Jointly, with the IWD, projects related to (1) Properties of Oil (2) Behaviour of Oil Spills (3) Oil Tagging and (4) Mode of failure of oil containment booms, are underway.

Evaluating "DIP" 2001 in South Slip of CCIW.

7. An on-going programme is a study of the methods available for cleaning and restoring shorelines which have been contaminated by oil. This programme will result in the preparation of a manual for agencies involved in such undertaking.
8. A remote sensing specialist, under contract to the EEB, was hired and is now co-operating with the Centre's Remote Sensing Section in all aspects related to the remote sensing of oil spills. In early 1973, an airborne microwave experiment was carried out at the Centre. This experiment was to test the feasibility of microwave in detecting spilled oil. MSD and Technical Operations co-operated in this work.
9. Engineering studies related to the microbiological degradation of oil spills on land and water, in co-operation with the WWTC – EPS are underway.
10. The planning of "Operation Preparedness" involving all DOE services at the Centre was initiated in 1973. The purpose of this study is to develop an "Action Plan" to deal with oil spills on the St. Clair River. In 1974, COST will be involved in the field testing and developing of the countermeasures.
11. Planning was initiated on the Beaufort Sea project which includes work on the detection, clean-up and disposal of oil spilled under Arctic conditions. A field programme will be undertaken in 1974.
12. A laboratory and field evaluation of the commercially available oil spill absorbents was undertaken in 1973. This programme will continue in 1974.
13. This year the Environmental Emergency – Technical Handbook was issued to assist operations personnel in cleaning up and handling of spilled oil.
14. Other areas of involvement were: (1) Participation with the U.S. Coast Guard on an oil spill equipment evaluation in Alaska; (2) Seminars across Canada on Dispersant Guidelines; (3) Outlining Research and Development work to the EPS' Regional Environmental Emergency Co-ordinators and (4) Observations on the field evaluation programme of the P.A.C.E. – Steltner oil containment boom.



Performance testing of Lockheed "Cleansweep" R2002.

Testing of absorbents at CCIW.

Fisheries and Marine Service

Fisheries Research and Development Directorate

GREAT LAKES BIOLIMNOLOGY LABORATORY

GLBL conducts research programmes on the relationships among wastewater inputs, water quality and aquatic resources in the Great Lakes. Excess nutrient loadings, increased primary production and altered species composition at all trophic levels constitute cultural eutrophication, which continues to be examined both regionally and locally using a variety of approaches. Studies began on a large scale in 1973 on the upper Great Lakes and planning was completed for studies on the effects of land use activities on water quality in the Great Lakes. Both of these activities, guided by IJC Reference Groups and the Great Lakes Water Quality Board, have required considerable participation by GLBL staff. All field work on Lake Superior and portions of the work on Georgian Bay were completed in 1973 as part of the IJC Upper Lakes Reference Study. Studies on the impact of toxic substances, waste heat and dredging activities were initiated in 1973 also under terms of reference of the Canada-United States Agreement on Water Quality in the Great Lakes.

The work of the Great Lakes Biolimnology Laboratory is composed of three main programmes. These are, 1) Descriptive Biolimnology and Surveillance, 2) Environmental Toxicology, and 3) Ecosystem Metabolism Studies. The programmes represent different but complementary approaches to the total array of problems, with each programme differing in its needs for subdisciplinary expertise and logistic support.

Coordination of activities with other units at CCIW is facilitated in several ways, including the CCIW Management Committee and its subcommittees (for example, Vessels Assignment), Scientific Council for Coordination and the Environmental Quality Coordination Unit.

Descriptive Biolimnology and Surveillance

This programme is based on the examination of communities of algae, zooplankton, zoobenthos and fish (i) to determine damage to aquatic resources, and wherever possible causes, (ii) to establish baseline descriptions of aquatic resources against which future changes, for better or for worse, can be compared and (iii) to develop, prescribe and apply surveillance techniques on a sound statistical and economical basis.

Biolimnology of the Upper Lakes

The major activity in 1973 was the sampling programme for the Upper Lakes Reference Report. Samples were collected for lakewide surveys of chlorophyll *a* concentration, primary production, phytoplankton and zooplankton species composition and abundance. A benthos survey of Lake Superior and Georgian Bay was carried out in conjunction with a programme of sediment surveys in those areas.

Chlorophyll *a* concentrations in Lake Superior were determined at about 100 stations on six cruises from May to November, 1973. Average concentrations in the top 20 metres increased from 0.85 mg/m^3 in May to a maximum of 1.45 mg/m^3 in October. Vertical profiles obtained at 20 deep-water stations indicated that concentrations of chlorophyll were similar down to at least 100 m during unstratified conditions while during stratified conditions, especially in early August and September, there were frequent maximum concentrations of biomass just below the thermocline. The presence of these concentrations could be located by examining transmissometer traces. Primary production was determined by incubation of water samples with $^{14}CO_2$ in shipboard incubators and at several *in situ* moorings. Average values of carbon fixation obtained from approximately 50 stations ranged from 1.0 mg/m^3/hr in June to a maximum of 2.7 mg C/m^3/hr in September. In the relatively clear waters of Lake Superior the level of optimum primary production was 10-15 m.

On the July cruise, Dr. J. Verduin, Southern Illinois University, Carbondale, Illinois, joined the cruise and made estimates of CO_2 uptake by measurements of changes in pH. These values agreed with incubator measurements of ^{14}C uptake. Both sets of values are considerably higher, up to 10 times, than previous estimates of primary production in Lake Superior. The primary production values for the Superior are 2 to 3 times lower than those for Lake Huron exclusive of Georgian Bay and Saginaw Bay.

Initial results of the Lake Superior benthos survey indicate very low benthic populations, averaging only 400 to 450 individuals/m^2 in the main body of the lake. Localized areas of high faunal abundance occur near some population centres, and there is a general increase in total macroinvertebrates in the eastern third of the lake culminating in abundances of 1100 to 1500/m^2 in Whitefish Bay.

West of the Apostle Island region, the benthic fauna is composed of 62% *Pontoporeia affinis*, 21% Oligochaeta, 15% Sphaeriidae and 2% Chironomidae. In the main body of the lake, Nematoda and Sphaeriidae are codominant at about 27%, with *P.affinis* 23%, Oligochaeta 19%, and Chironomidae 3%. The taxonomic composition of Whitefish Bay benthos (39% Oligochaeta, 23% *P.affinis*, 17%

Sphaeriidae and Nematoda, and 3% Chironomidae) indicates water quality nearer mesotrophic in type.

Chironomidae, overwhelmingly dominated by the oligotrophic indicator *Heterotrissocladius*, occur mainly in the more productive near-shore areas just east of the Apostle Islands, north and northeast of Isle Royale, east of the Keweenaw Peninsula, and in Whitefish Bay. *Protanypus, Micropsectra, Tanytarsus, Paracladopelma*, and *Cryptochironomus* occur rarely.

The oligotrophic indicator *Stylodrilus heringianus* (Lumbriculidae), a species of *Mesenchytraeus* (Enchytraeidae) and a new tubificid taxon (Aulodrilinae) dominate the Oligochaeta. The former appears to be restricted to glaciolacustrine sediments while the latter two species are widely distributed in both consolidated and muddy substrates in the eastern three-quarters of the lake. A number of unidentifiable Enchytraeidae and the tubificids *Peloscolex variegatus* and *Rhyacodrilus sodalis* often occur in significant abundance.

Comparative Studies on Great Lakes Biota

Identification and counting of zooplankton from the Great Lakes, especially Lakes Superior and Huron were continued. A stratified counting system has been developed which provides better estimates than previously of both more numerous small organisms (nauplii and rotifers) and the larger, less abundant adult forms. Several comparison counts were made with other labs (Canadian Oceanographic Identification Service, Ottawa and State University of New York, Albany (Dr. D.C. McNaught). The results of these intercomparisons suggest that the system has good repeatability. Examination of the forms of *Bosmina* in the Great Lakes has involved the measurement and description of a large number of types. The taxonomy of one especially puzzling form is being investigated in detail. Analysis of horizontal distributions of zooplankton populations is being undertaken using similarity coefficients and cluster analysis techniques. So far, several techniques have been evaluated in order to find the best possible method of data reduction and presentation. Most zooplankton samples collected on 9 IFYGL cruises have been identified and counted and some vertical profiles of phytoplankton abundance at stations 19 and 11, have been calculated. Preliminary correlations with Chlorophyll *a* and nutrient and temperature profiles are underway.

Identification and counting of phytoplankton samples from the Great Lakes, especially Lakes Ontario, Huron and Superior were continued. Calculations based on these counts supported earlier estimates of high abundance of flagellates, especially small nannoplankton forms. The importance of these in total primary productivity of several lake systems was demonstrated in several experiments where separations of size classes of algae were made after incubation with $^{14}CO_2$.

Several papers were prepared in the past year summarizing the current state of knowledge of Great Lakes flora and fauna, emphasizing studies conducted at CCIW. These will appear in two issues of the Journal of the Fisheries Research Board of Canada as part of the regular April issue and in a special June issue "Limnology in Canada" commemorating the 1974 Congress of the International Association of Theoretical and Applied Limnology.

Surveillance of the Lower Lakes

During 1973, analyses of past data collected from the lakes has been carried out to evaluate it for the purpose of reporting on state of the lake and trend data. Difficulties involved relate to placing and number of sampling stations and frequency of cruises to provide data of suitable accuracy. Biomass parameters must be sampled frequently enough to describe seasonal trends, and, in the past, this has not always been done.

Environmental Toxicology

The general objective of this programme is the development of criteria for aquatic life (i) for toxic materials of specific concern in the Great Lakes, (ii) in relation to accumulation of hazardous materials in aquatic food chains. A more fundamental emphasis is on the sublethal effects of toxic substances, singly and in combinations on individual organisms as well as the biomagnification of pollutants in food chains and the physiological, and perhaps ecological, significance of tissue levels of contaminants.

Toxic Substances Studies

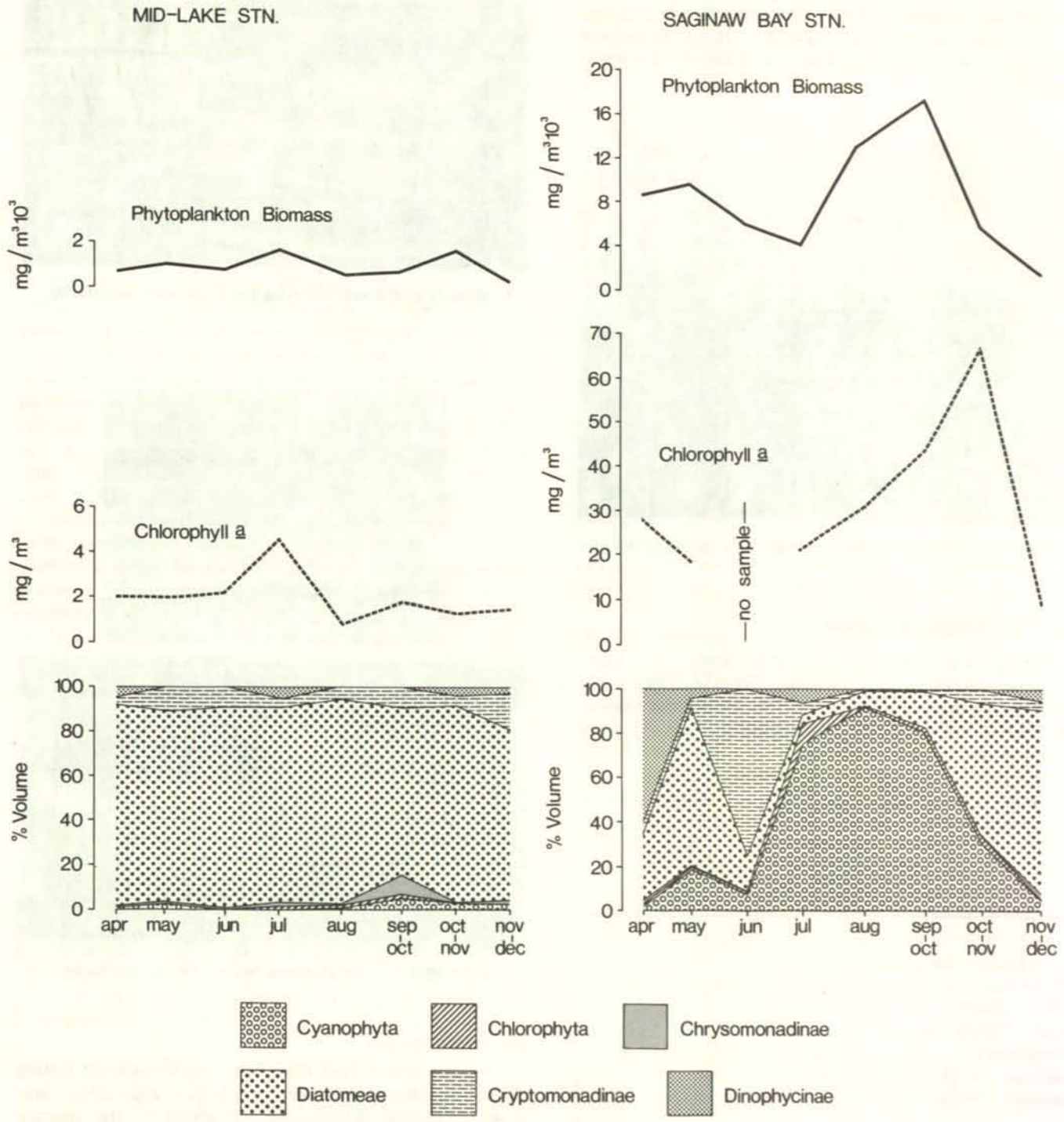
Initial work has and will involve the screening of several selected metals and organic compounds for acute toxicity on the organisms. This is to verify the techniques as well as the experimental results reported by established laboratories. Based on the results, in-depth studies on the sublethal effects will be carried out with two or three selected compounds each year.

Preliminary experiments with lead showed that organic lead (di- and tri-methyl) is more toxic to algae and bacteria than inorganic lead nitrate. Methylated leads at 1 ppm level were found to inhibit 80% of cell division of *Scenedesmus quadricanda* whereas the same level of lead nitrate had minimal effect. Moreoever, in a simulated lake system, the micro-organisms in the lake sediment were found to be capable of methylating lead nitrate as well as di- and trimethyl lead to the more toxic and volatile tetramethyl form. The final conversion was more rapid from di- and trimethyl lead than from lead nitrate.

Other activities by the members involved laboratory set-up, literature reviews, collecting and maintaining laboratory animals and visiting several well-established institutions engaged in similar studies.

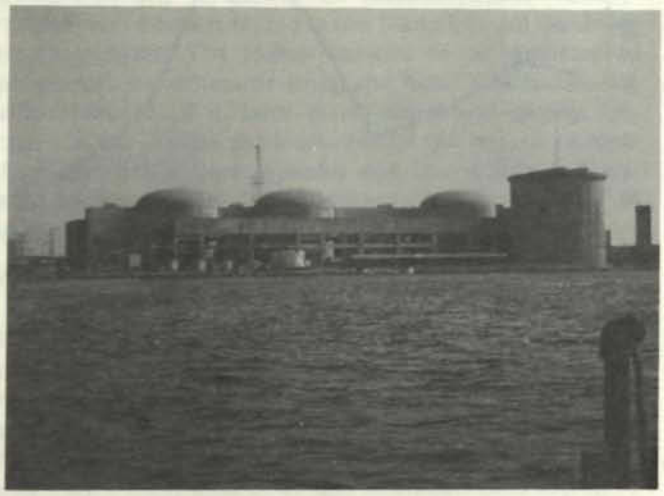
Potential for Accidental Discharge of Toxicants

A 6-month contract in support of the Canada-U.S. Agreement on Great Lakes Water Quality, on hazardous polluting substances in the Great Lakes, was awarded to James F. Maclaren, Ltd., a Toronto environmental consultant, in September 1973. The major tasks are to enumerate data available in the basin or relevant sources on (1) the quantity of materials shipped by various modes of transport; (2) the chance of accidental discharge occurring



Differences throughout the season between a typical mid-lake station, Lake Huron and a station in Saginaw Bay in total phytoplankton biomass. Chlorophyll *a* concentrations and compositions by major groups. Note the relative importance of Cyanophyta (blue greens) in Saginaw Bay and Diatomeae (Diatoms) in the main lake and the occasional high abundance of flagellates (Cryptomonadinae and Dinophycinae).

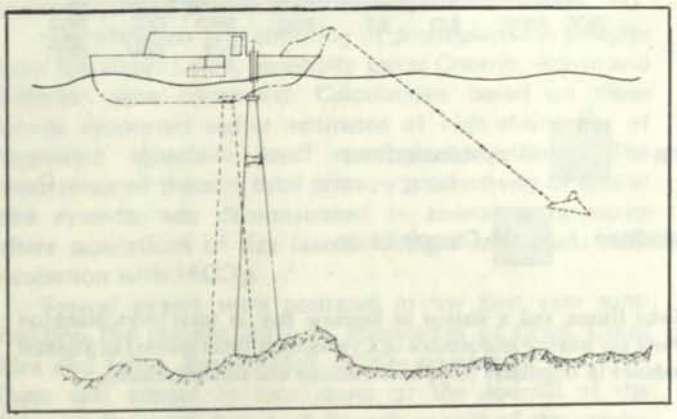
associated with each specific mode of transport; (3) the accessibility of a spill to the water environment; (4) the size and nature of a spill associated with a particular mode of transport and (5) the toxicity of chemical materials to aquatic life. When the data are compiled, the toxicants will be rated with respect to the criteria and a list of toxicants, in descending order of potential hazard to the aquatic environment, will be produced. A final report is expected in April 1974.



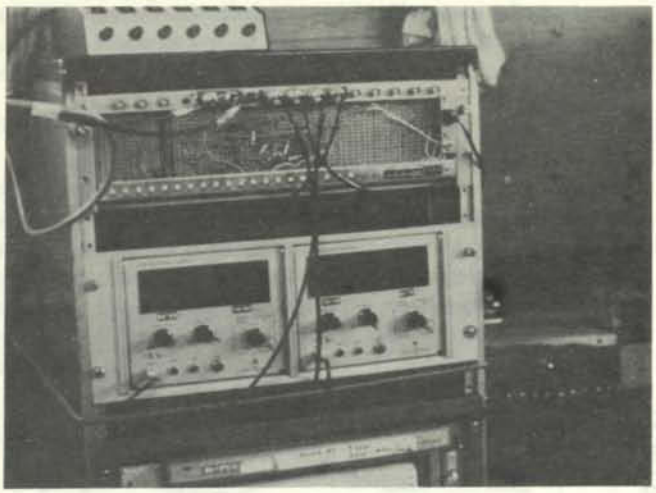
The 2160-Mwe Pickering Nuclear Generating Station, Lake Ontario.

Ecosystem Metabolism Studies

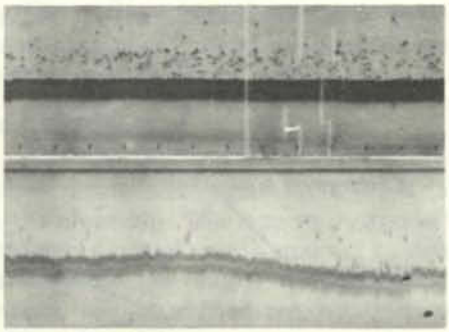
The general objective of this programme is to determine the extent of relationships among production at primary, secondary and decomposer levels and the manner and degree to which these relations are disrupted by environmental stresses, over space and through time in mixing zones, including pollution by toxic and oxygen-consuming wastes, waste heat, nutrient inputs, dredged spoils disposal.

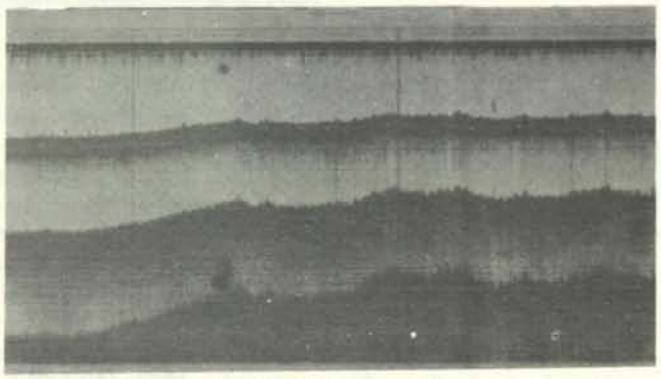


Schematic of the echo counting system and towed thermistor array.



Equipment used in echo counting and temperature monitoring.





Echograms from the Pickering Nuclear Generating Station.

Waste Heat Studies

Studies at the 2160-Mwe Pickering Nuclear Generating Station commenced in July, 1972. The major effort was directed toward determining the effect of the thermal discharge upon fish distribution, movement and behaviour. R.G. Dowd, Marine Ecology Laboratory, DOE, Bedford, provided several electronic components necessary for a system to acoustically assess pelagic fish abundance and distribution. The digital echo counting system was tested against trawls in Lakes Erie and Ontario and responded

directly to fish density and placement in the water column. Subsequently, it was used to determine density and distribution of fish in a region of Lake Ontario subjected to thermal discharge. Coincident with echo counts of fish, the thermal plume was recorded using a towed thermistor array which vertically profiled temperature. The thermal discharge appeared to advance the date of offshore migration at Pickering and delay the subsequent return of fish to the nearshore zone. Also, fish seemed to avoid the lateral aspects of plumes where isotherms tend to be compacted.

Ultrasonic tags were inserted in stomachs of a locally dominant fish, brown bullhead, and the movement and behaviour monitored at control sites and in relation to the thermal discharge. The thermal input caused fish to "mill" in the high mechanical energy areas of the plume and to move in a zig-zag fashion. Because they had to contend with high current, they swam at lower ground speeds. The association with the plume, however, was short term in nature as only 20% of fish released in the discharge were within its major influence the day following release.

To support field observations and to attain the expertise necessary for a trophodynamic study of nearshore perturbations, a number of laboratory studies have been initiated. Several manifestations of stress have been chosen, for example, ^{14}C uptake in phytoplankton and grazing rates in zooplankton. These responses will be used to examine immediate effects of thermal and also paper-mill effluents and to investigate the significance of entrainment. Since entrainment disrupts particles, electronic means of examining these changes have been assessed. Temperature exposure of Great Lakes organisms may vary between relatively stable to highly variable; these thermal regimes are being applied to a variety of local species to determine performance and success.

Paper-Mill Plume Studies

The purpose of this work, carried out at Marathon in Lake Superior mainly in July and August and in co-operation with Lakes Research Division chemists, was to determine if effluent emissions could be followed and sampled periodically to determine the dilution and degree of non-conservative behaviour of selected chemical constituents and energy. Drogues were used, with some inherent difficulties, to determine sampling points; conductivity and sodium ion were used to measure dilution rate. Some measurements of performance of the biota, were made, for example, primary production at various dilutions. The study will be refined and expanded and will be carried out in Nipigon Bay in 1974.

Project Quinte

Co-operative research on the Bay of Quinte (with Ontario Ministries of Natural Resources and Environment) was continued in order to determine the response by biota to the federal-provincial nutrient-removal programme from 1973 onward. GLBL staff worked with their Ontario colleagues on nutrient budgets of the Bay, primary production, zooplankton, benthic macroinvertebrate communities and general limnology. Plans were made to work together to produce a report which will summarize what is known about the limnological characteristics and behaviour of the Bay of Quinte.

Spoil Disposal from Dredging Operations

Studies on the effects of dredged-spoil disposal were initiated in 1973 in a co-operative study with the Ontario Ministry of Natural Resources and other groups under terms of reference of the Canada-U.S. Agreement. The work in Lake Erie offshore from Port Stanley included phytoplankton and zooplankton bioassays of serial dilutions and ambient water during spoils disposal, examination of benthic macroinvertebrate communities before and during spoil disposal, and finally, evaluation of usefulness of electrical-acoustic fish census techniques to determine response of fish to spoil disposal events. The latter technique will be of extreme value in future work on fish, and, in addition, it is possible to examine the pattern of solids sedimentation in time and space in relation to specific disposal events. The other site used in 1973 was the pilot-scale artificial island in Lake St. Clair where samples of the benthic macroinvertebrate community were taken and similar bioassays of spoils were conducted. This work will be intensified in 1974, not only in field studies, but also in the laboratory employing lake-column simulators which will be loaded at various rates with a variety of dredged materials.

Joint Programmes with Universities

During 1973 GLBL staff co-operated on several projects with university colleagues through supervision of FRD Grants, development of contracts, and in some cases, by lending assistance in the supervision of graduate studies. Those involved included Dr. J.M. Bristow, Biology Dept., Queen's University – a study of aquatic macrophytes in the Bay of Quinte; Dr. R.W. McCauley, Biology Dept., Wilfred Laurier University – the relationship between varied thermal history and thermal preference in fish; Mr. E.E. Pickett, Institute of Environmental Studies, University of Toronto – development of surveillance strategies for the Great Lakes; Dr. J.C. Roff, Zoology Dept., University of Guelph – IFYGL Lake Ontario zooplankton studies; Dr. J.B. Sprague, Zoology Dept., University of Guelph – Bay of Quinte studies; and Dr. G.M. Sprules, Biology Dept., Erindale College, University of Toronto – zooplankton community structure in Ontario Lakes; Dr. C. Mayfield, Biology Dept., University of Waterloo – effect of detritus on toxicity of pesticides.

Marine Sciences Directorate (Central Region)

T.D.W. McCULLOCH, Director

HIGHLIGHTS

Several organizational changes occurred during the year. A Research and Development Division was officially established under the leadership of Mr. N. Freeman. This was previously known as the Geotechnology Division.

Mr. A. J. Kerr was appointed Regional Hydrographer early in the year. Mr. H. Blandford who had been acting in this capacity was transferred to Headquarters as the Chief of Planning and Development. The Hydrographic Division took over the responsibility for surveys in Hudson Bay and James Bay, at the same time withdrawing its western boundary to the Saskatchewan-Manitoba border. The responsibility for Tides and Water Levels was transferred back to the Hydrographic Division from Research and Development. Plans were made for the transfer of the Tidal Instrument Group from Headquarters.

Field participation in the I.F.Y.G.L. (International Field Year for the Great Lakes) program was terminated early in the summer after completing the bathymetric survey of Lake Ontario and closing down the Decca positioning system.

Probably the major project of the year resulted from the abnormally high lake levels during the spring. Under an agreement between the Canadian Government and the Government of Ontario, a joint program to study Shore Property Damage and Shore Erosion was set up. This program costing a total of $700,000, shared equally by both governments, involved both the Department of the Environment and the Department of Public Works. Several sectors of D.O.E. were involved.

Hydrographic Surveys in the Arctic were emphasized. The Ministry of Transport light icebreaker 'NARWHAL' was again used in James Bay, completing the navigable corridor into Fort George. C.C.G.S. 'N.B. MCLEAN' was also used for a short reconnaissance survey in Chesterfield Inlet. Further north, the Polar Shelf Project team surveyed Norwegian Bay and hydrographers from Central Region participated in two icebreaker probes aboard 'JOHN A. MACDONALD' to Victoria Strait and 'LOUIS ST. LAURENT' to the Ringnes Islands.

A pilot project for a major tidal current study in the Lower St. Lawrence was carried out by the Research and Development Division using C.C.G.S. 'PORTE DAUPHINE'. Summer and winter physical oceanographic measurements were undertaken in James Bay in support of an Oceanic impact assessment of the James Bay Power Development. Two scientific contracts were let: 1) to develop operational techniques for storm surge forecasting on the Great Lakes and 2) to analyze and interpret the physical oceanographic measurements on James Bay.

A major hydrographic survey of Lake Winnipeg, which is planned to extend over five years, was initiated. This survey used a Mini-fix positioning system and Bertram launches.

Another contract was let for a hydrographic survey of Georgian Bay to the value of $100,000 with COMDEV Marine again winning the contract. The results of the survey have been appraised and considered to be very satisfactory.

The hydrographers' exchange program with U.S. Lakes Survey was again carried out with the Canadian hydrographers not only visiting Great Lakes Survey parties but also National Ocean Survey groups in the southern states.

The automation of hydrographic surveys may be considered to have come of age. A very successful survey utilizing the HAAPS (Hydrographic Acquisition and Processing System) was used in James Bay and earlier in Lake Ontario and Lake St. Clair.

Two minor research vessels were acquired. 'ADVENT', a fast cutter, 77 feet in length and 'HILDUR', 106 feet in length. 'HILDUR' which had originally been built as a research vessel in Norway was purchased from the estate of the late T. E. Eaton.

In summary, this was another successful year for Central Region with a number of new programs being undertaken and a vigorous approach to increasing the scope of the work.

CANADIAN HYDROGRAPHIC SERVICE

A. J. KERR, Regional Hydrographer

INTRODUCTION

Central Region had another very successful year during 1973. Forty-six Field Hydrographers were actively involved in supporting Central Region Programs which covered many areas of our geographic responsibility.

These programs were carried out under the direction of Mr. A.J. Kerr, who was appointed to the position of

Regional Hydrographer early in the year.

Eight major surveys were undertaken in 1973 in addition to a number of smaller surveys.

In the Northern Arctic, two programs were carried out. A through-the-ice bathymetric survey of Norwegian Bay and a Decca Signal Velocity study in Amundsen Gulf.

Further south, a major survey was continued in James Bay where a navigation corridor was completed between La Grande Rivière and Hudson Bay. In Chesterfield Inlet, on the Northwest side of Hudson Bay, a reconnaissance survey was undertaken to prepare for a major effort in 1974.

In the western area of the Region, parties operated on Lake of the Woods and on Lake Winnipeg. At Lake of the Woods, the survey concluded a seven-year effort to chart the waterways. The Lake Winnipeg survey was the first year of a planned five-year program to survey the northern half of the Lake and complete detailed surveys of all the Lake's harbours.

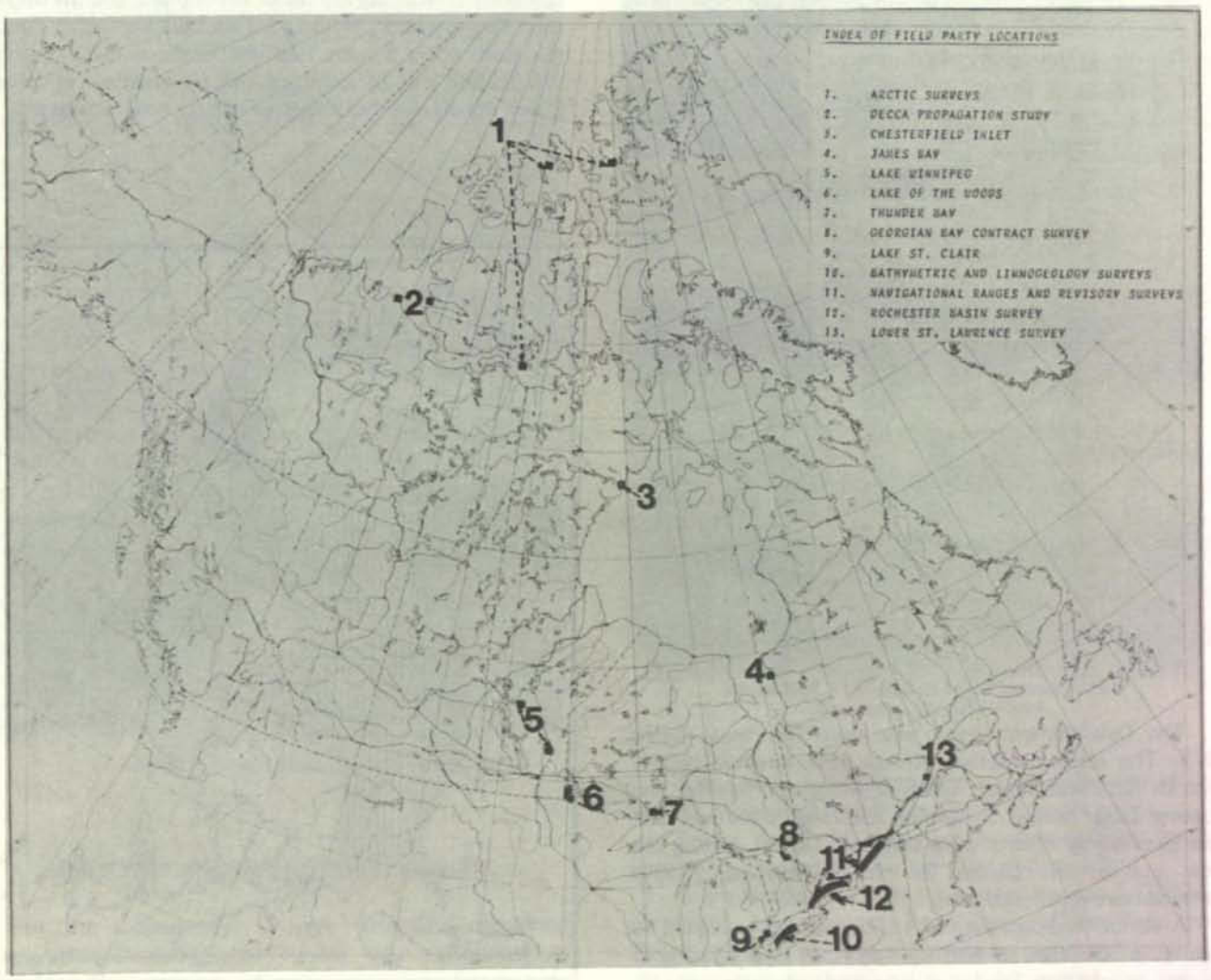
Closer to home, a good number of activities were underway in the Great Lakes. On Lake Erie, hydrographers again supported the I.W.D. Limnogeology program in addition to collecting standard hydrographic data. A complete re-survey of Lake St. Clair was undertaken. The charting of this area will be a cooperative program with the U.S. Lake Survey Center. The Bathymetric program on Lake Ontario, which was part of the International Field Year for the Great Lakes, was completed early this year.

On Lake Superior, a horizontal control operation was completed at Thunder Bay to prepare for a full Hydrographic survey in 1974.

In 1973, the Region contracted its second complete hydrographic survey and provided continuous monitoring to the project. The results of these surveys in Georgian Bay are a clear indication that private industry, if monitored and guided, can provide hydrographic survey data to C.H.S. specification.

The most easterly survey was on the Lower St. Lawrence River. It was the fifth season on this project with another two years anticipated to reach Québec City.

The systematic Revisory Survey, required to maintain charts up-to-date, was continued. The Navigational Ranges Survey was also continued and all Ranges between Niagara



Surveys – 1973.

and Kingston were accurately determined.

Generally, the surveys had an obvious basic hydrographic orientation; however, many of our hydrographers had some involvement with other disciplines. The James Bay Survey staff were very much involved in an oceanographic program, while on Lake Erie hydrographers worked on a Limnogeological program. Locally, staff were assigned to the R & D Section primarily to work with the Hydrodynamics and Shore Properties Groups.

During the latter part of the year, a Tides and Water Levels Section was established within the Division with the aim of becoming more actively involved in water levels and horizontal movements which affect navigation.

1973 was the second year of a technical exchange program with our counterparts south of the border. This exchange was again very successful and will be continued in 1974.

This year, side scan sonar operations were introduced into all of the major surveys. The sonar unit, with a competent operator, was rotated between the field parties. This system was successful not only in detecting possible navigation hazards, but with exposure to many hydrographers, its future potential and operational capabilities were clearly demonstrated and received with enthusiasm. In addition to its use on standard surveys, the sonar unit was used to study sand wave formation on the St. Lawrence River. Very interesting results were obtained.

R.P.S. scanner fitted to Bell 205A helicopter.

The Development Group was again very busy during 1973. The instrumentation efforts were directed mainly towards Side Scan Sonar, Loran-C, Integrated Sat-Nav and Doppler Sonar navigation systems and HAAPS hardware. In data processing, efforts were concentrated on getting the most out of the Gerber 22 plotting system. Results achieved were most gratifying.

A senior hydrographer of the Region was assigned to Algonquin College to instruct on the Hydrography I Course. In addition, Pacific Region was assisted greatly by the assignment of three experienced hydrographers to

WILLIAM J. STEWART and CSS PARIZEAU.

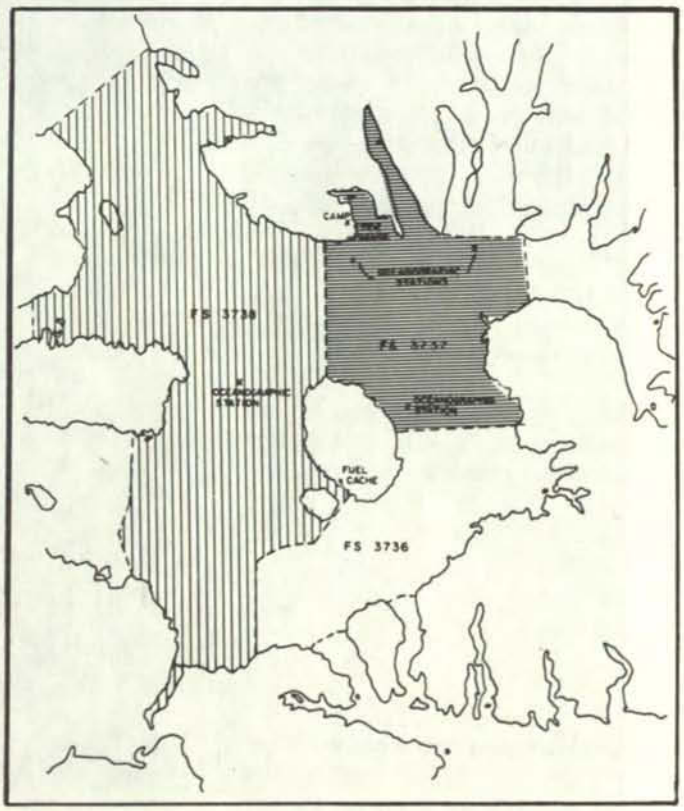
During 1973, two hydrographers took advantage of the University Training Plan. In addition, many others took courses on a part-time basis in order to advance their technical capacity.

The Cartographic Section of the Region, although very small, made a very important contribution to our Division and the Directorate, as did the Marine Information and Hydrographic Data Centres.

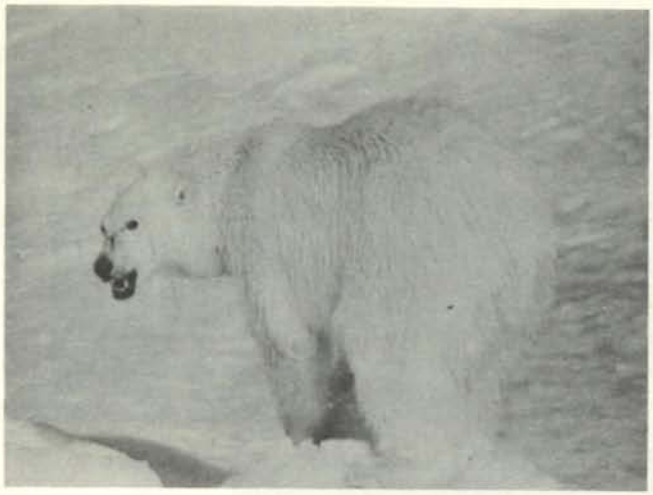
Without the support of other Divisions of the Region, Hydrography could not function. We appreciate the excellent support received in 1973 and look forward to continued cooperation in 1974.

ARCTIC SURVEYS

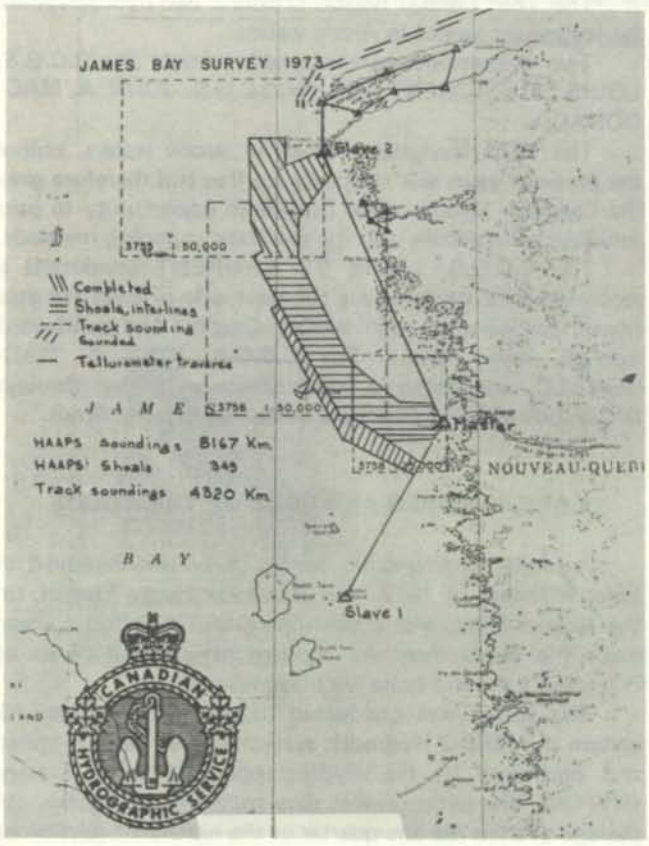
Hydrographers worked for yet another year with the Polar Continental Shelf Project. Partially in response to the needs of the oil companies for improved bathymetry, and partially to ensure the safety of icebreakers en route to Eureka, a bathymetric survey of Norwegian Bay was completed. This survey used helicopters and through-ice sounding methods. Hydrographers also worked in Amundsen Gulf where a joint Regional/Headquarters experiment was carried out to compare the propagation velocity of Decca signals over both ice free and ice covered waters.



Norwegian Bay field sheet layout.



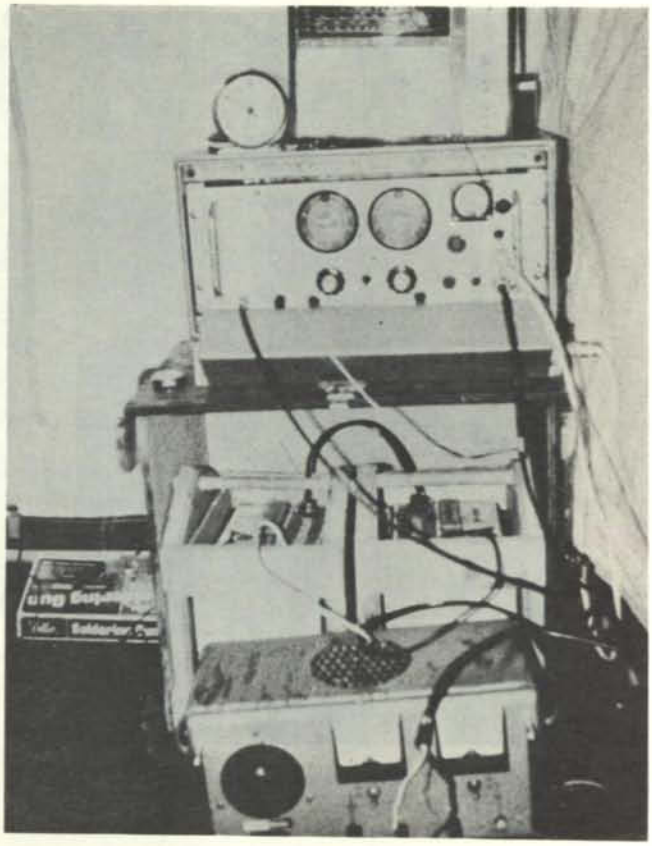
Typical Surprise Fiord visitor.



James Bay field sheet layout.

JAMES BAY AND CHESTERFIELD INLET

For the second year, a very successful combined Hydrographic/Oceanographic survey was conducted in James Bay. The results of this survey provides a 5-mile wide safe shipping route from Cape Jones to Fort George.



Equipment layout for velocity propagation study.

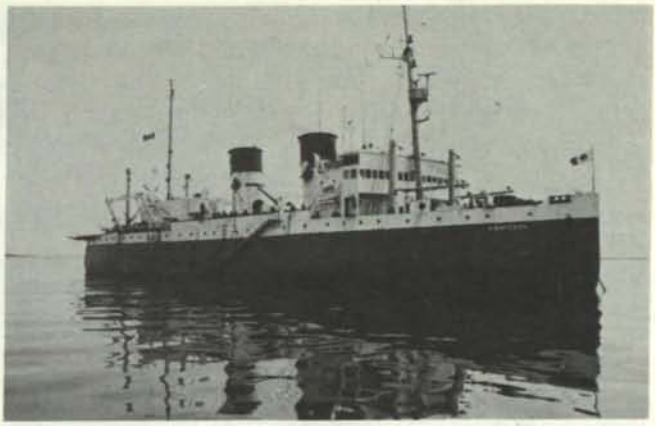
Base camp, Surprise Fiord.

This was a fully automated survey using the Hydrographic Acquisition and Processing System (HAAPS).

During the field season, two oceanographic cruises were conducted in the northern part of James Bay.

In preparation for a major survey planned for 1974, a reconnaissance survey was conducted in Chesterfield Inlet. The purpose of this operation was to gain familiarity with the area and establish sufficient horizontal control for sounding operations in 1974.

Oceanographic observations being taken in James Bay.



C.C.G.S. N.B. MCLEAN in Chesterfield Inlet.

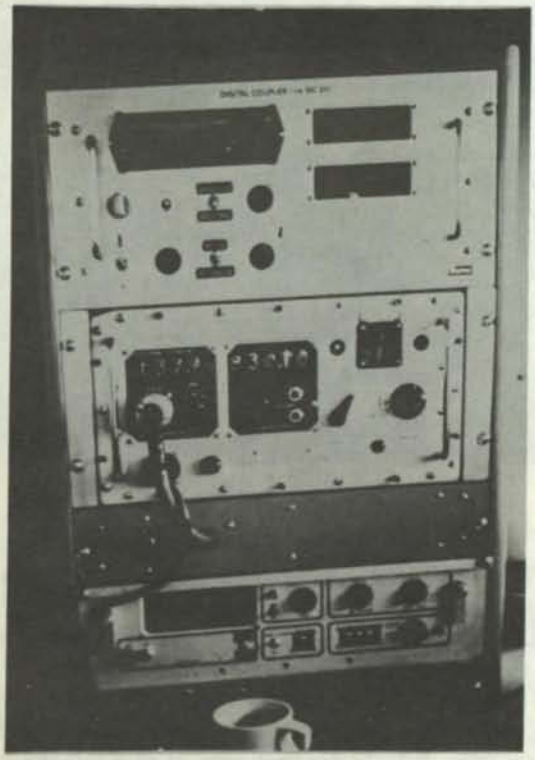
NORTHERN ICEBREAKERS

This year, Central Region provided two hydrographers for Icebreaker service in Arctic waters.

Two icebreakers were manned, namely the C.C.G.S. LOUIS ST. LAURENT and the C.C.G.S. JOHN A. MACDONALD.

The 1973 Navigation season in Arctic waters, unlike the previous year, was relatively ice free and therefore gave the Canadian Hydrographic Service an opportunity to gain valuable bathymetric data by the track sounding methods.

The C.C.G.S. LOUIS ST. LAURENT conducted a reconnaissance survey along the west side of Ellef Ringnes Island, eastward through Belcher Channel and southward through Penny Strait. The C.C.G.S. JOHN A. MACDONALD conducted a reconnaissance probe through M'Clintock and Peel Channels, as well as Victoria Strait.



HAAPS equipment as installed on launches in James Bay.

LAKE WINNIPEG AND LAKE OF THE WOODS

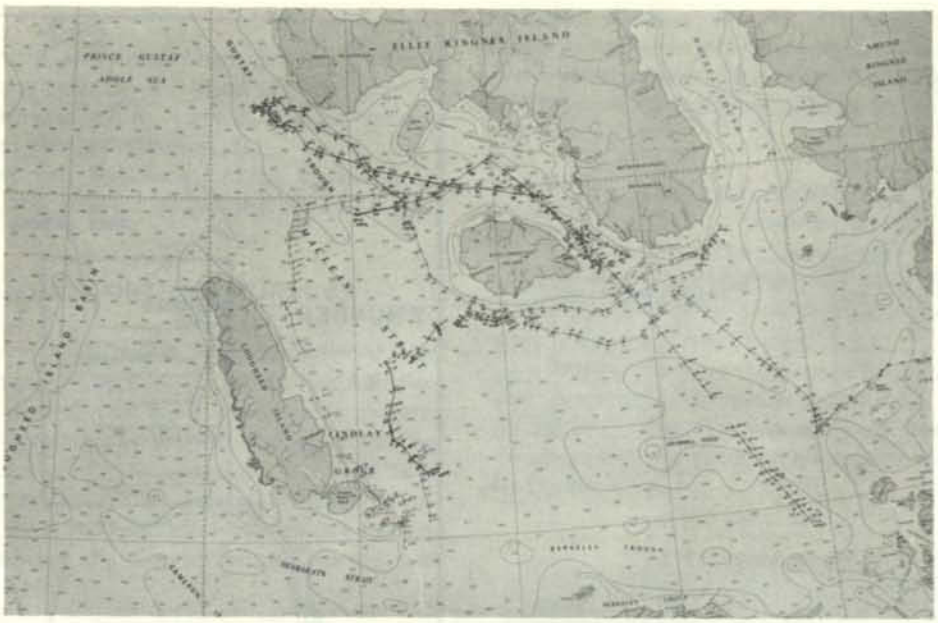
A major hydrographic survey party was deployed in Lake Winnipeg in 1973. The Manitoba Hydro Project, on the Nelson River, and a developing tourist industry, have made the requirement for modern navigational charts of Playgreen Lake and Lake Winnipeg essential.

The survey was conducted using a 50 watt Mini-fix system and MRB-2 Hydrodist system with all data compiled and portrayed by the Hydrographic Processing System (HYPOS). The hydrographic data collected will enable safe passage of ships for one-quarter of the northwest portion of the lake in the area of Grand Rapids.

A mobile survey party was stationed in Gimli, Manitoba, and established a horizontal control network which will enable the production of photogrammetric plots for use in 1974 surveys.

It may be interesting to note that present plans indicate that a new revamped HAAPS system will be utilized in Lake Winnipeg during the 1974 survey.

The 1973 hydrographic survey of Lake of the Woods was a continuation of the project started in 1967. Shoal



Track soundings from C.C.G.S. LOUIS ST. LAURENT.

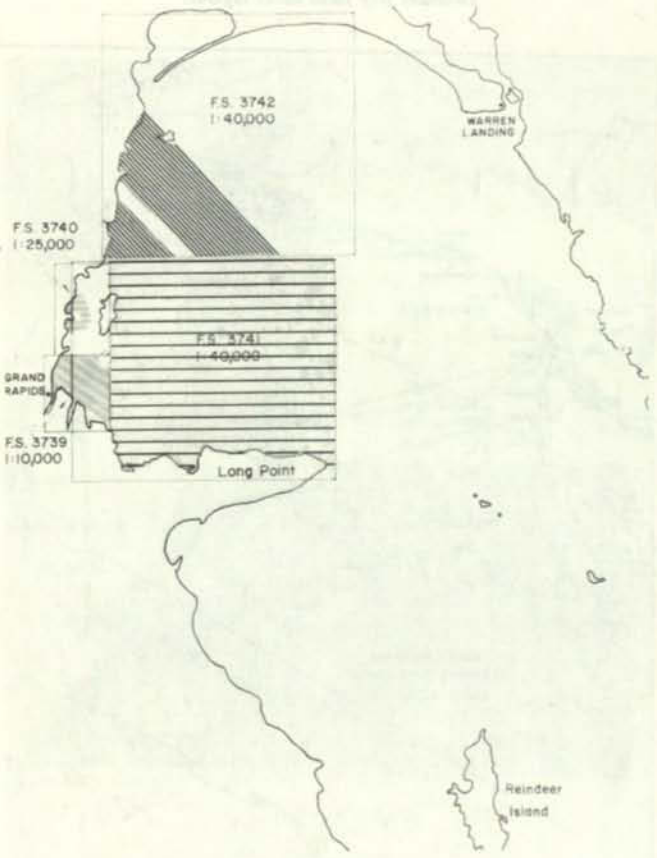
examinations were completed on all remaining field sheets and revision made on some of the earlier field sheets.

GREAT LAKES SURVEYS

Lake Erie – North Shore

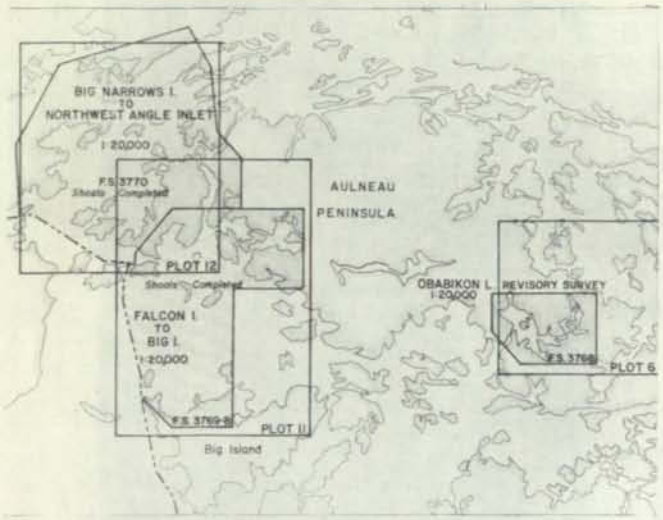
This year, as before, limnogeology support in Lake Erie continued. Our involvement consisted of supplying a navigational survey system and the expertise in checking positioning and depth record quality. At the same time, this operation provided sounding coverage with wide-line spacing.

In order to bring the sounding coverage up to C.H.S. standards, a small hydrographic survey party was operational to add additional bathymetric detail.



Lake Winnipeg Survey, 1973.

Typical Mini-fix/Hydrodist equipped launch.



Lake of the Woods Survey, 1973.

Lake St. Clair and Thames River

In 1973, priority was given to a survey in Lake St. Clair in a cooperative venture with the U.S. Lakes Survey, for the purpose of issuing a new edition of the U.S. Chart.

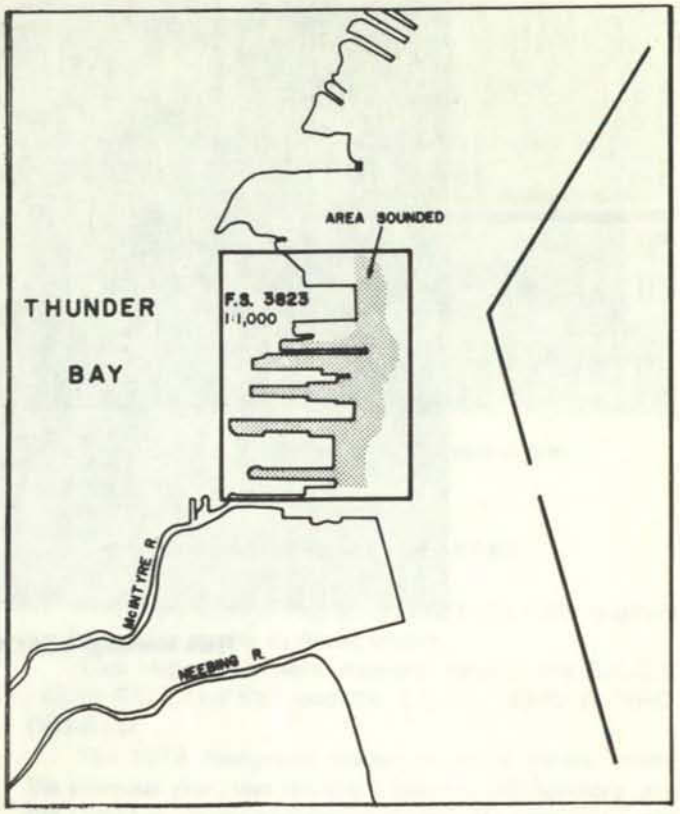
A Motorola Range Positioning System was used for positional data and all parameters were logged by the Hydrographic Acquisition And Processing System (HAAPS).

The Thames River, which is used extensively by large cruisers and small pleasure craft, was surveyed at a natural scale of 1:10,000. This was a reconnaissance survey using air-photo interpretation for positioning. The side scan sonar was used to locate obstacles and shoal areas.

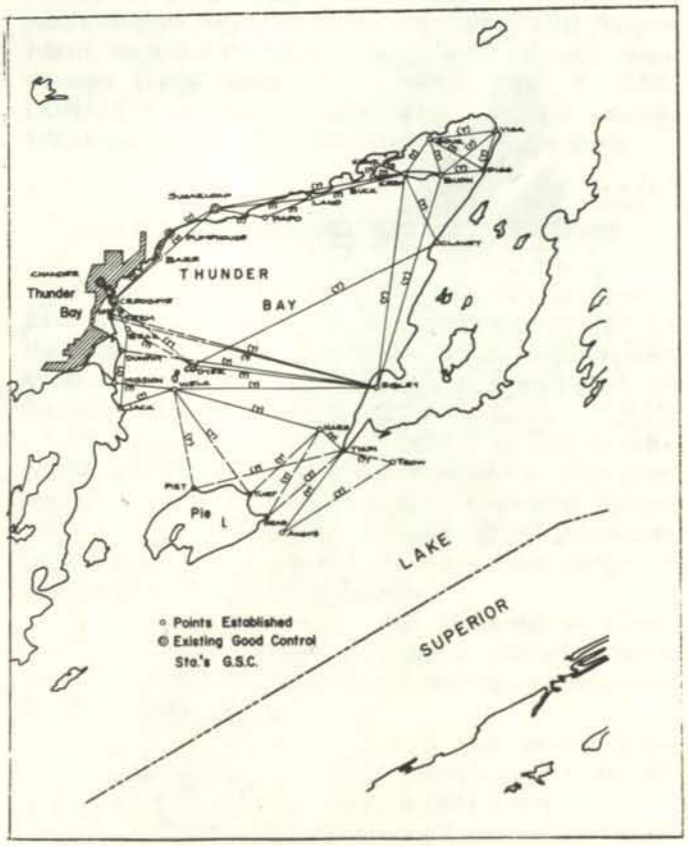
Lake Ontario – Rochester Basin

This was an extension of the HAAPS bathymetric survey of Lake Ontario, started in 1972. This survey was implemented to more fully develop the intricate bathymetry of Rochester Basin.

Thunder Bay Harbour.



Thunder Bay field sheet layout.



Thunder Bay Control Layout.

Thunder Bay

Horizontal control was established around Thunder Bay to facilitate the location of electronic positioning systems for future surveys and to establish accurate control for the production of photogrammetric plots.

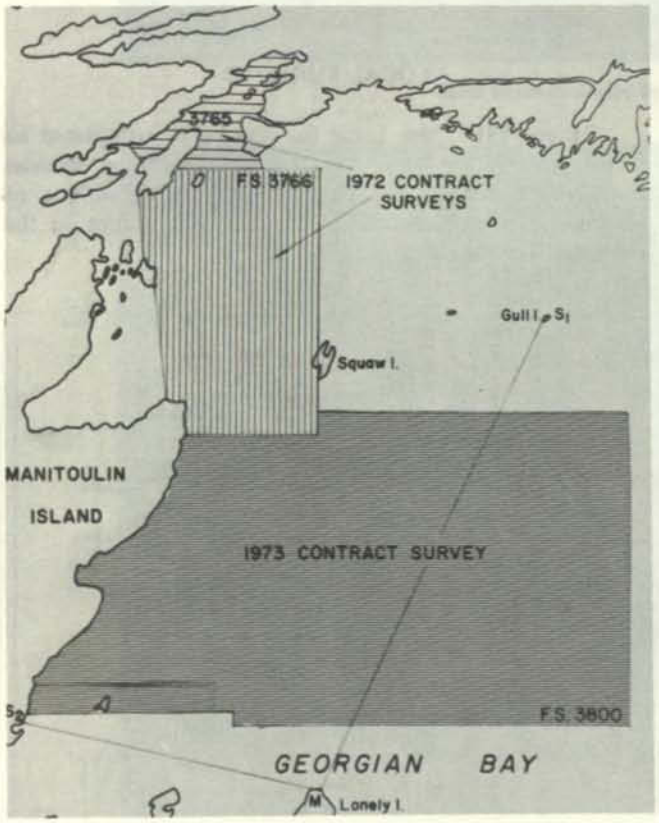
One field sheet was completed which consisted of approximately half the wharves in Thunder Bay Harbour.

GEORGIAN BAY CONTRACT SURVEY

The Science Council of Canada has recommended that where possible, government and university laboratories contract work to develop technical expertise in private industry. With this in mind, a survey was conducted for the second consecutive year, under contract by COMDEV Marine and closely monitored by Central Region hydrographers. The field sheet has been submitted to this Region and from all indications, the second contract survey was very successful.

HAMILTON SCOURGE PROJECT

This project was conducted in conjunction with the Royal Ontario Museum. The objective of this detailed survey was to locate and position two U.S. schooners sunk in 1812. Utilizing the PORTE DAUPHINE and HAAPS, both bathymetric and megnetic data were logged during the survey, a computer-aided analysis made to locate anomalies. Unfortunately, the search did not locate the sunken vessels.



Georgian Bay contract survey field sheet layout.

LOWER ST. LAWRENCE SURVEY

This early summer survey was a continuation of a project started in 1969, with the objective of recharting the Lower St. Lawrence River from Pointe-au-Père to Quebec City, a distance of 133 miles.

The party's second objective of establishing control for the preparation of photogrammetric plots from Crane Island to Quebec City was achieved. This will now provide photogrammetric plots for all remaining hydrography as far as Quebec City.

PORTE DAUPHINE lifts survey launch on the St. Lawrence River Survey.

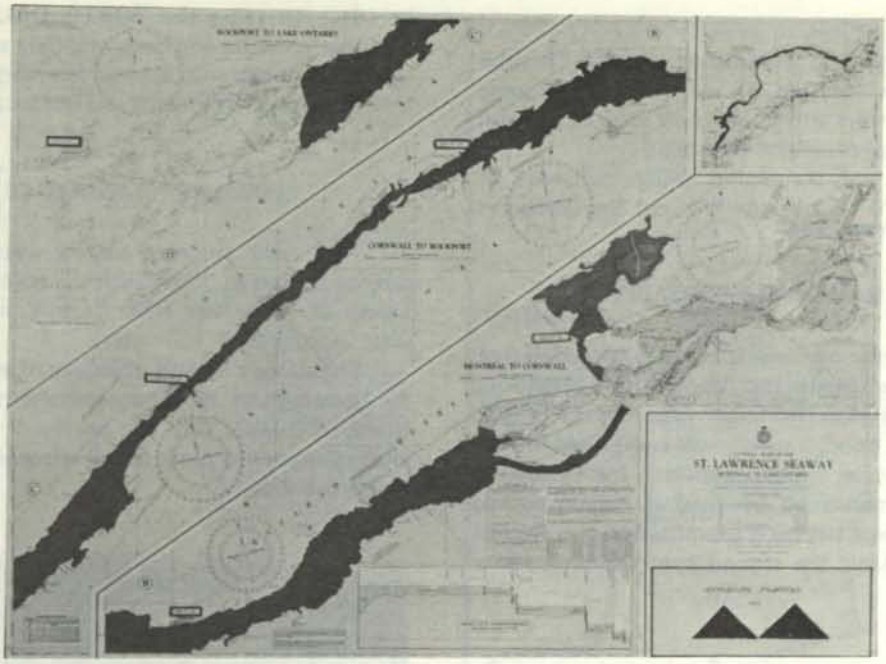
REVISORY SURVEY

This year's Revisory Survey followed the Canadian Hydrographic Service policy of systematically updating all existing charts.

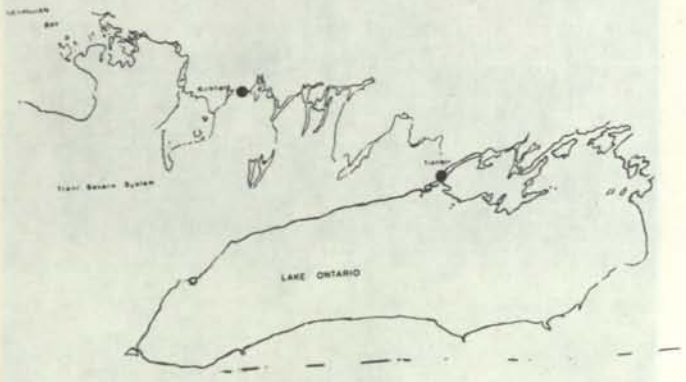
All charts of the Rideau Canal, Lower Ottawa River, The St. Lawrence Seaway from Montreal to Kingston, and the Trent River from Trenton to Balsam Lake, were completed.

NAVIGATIONAL RANGES SURVEY

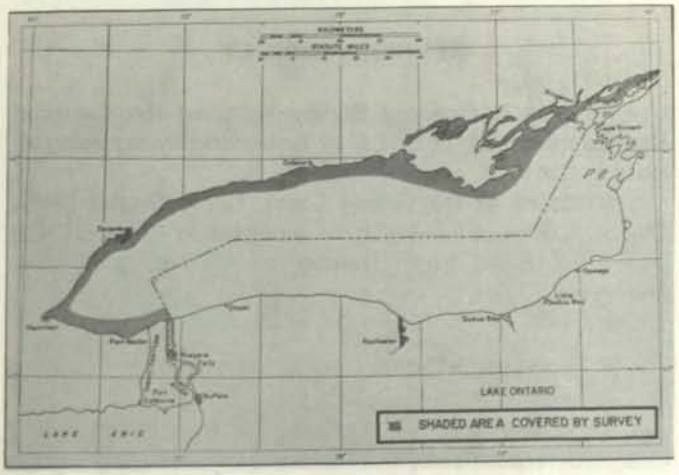
In May, 1968, the Canadian Hydrographic Service accepted responsibility for determining and checking the positions and true bearings of all navigational ranges



St. Lawrence Seaway.



Revisory Survey 1973, Trenton to Kirkfield.



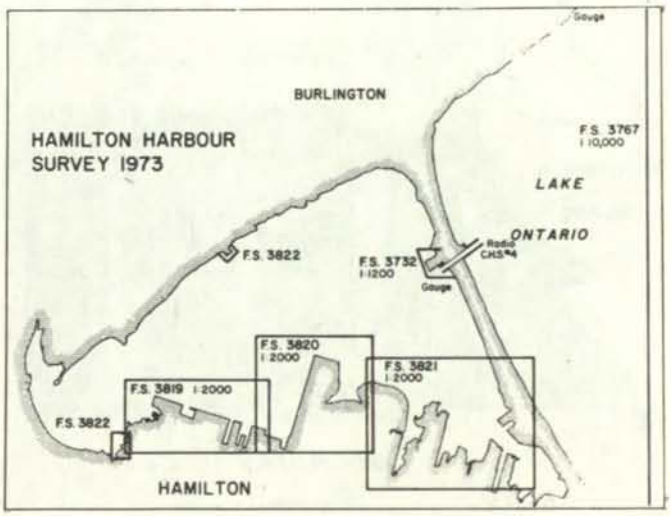
Navigational Range Survey.

established and maintained by Federal Government agencies and shown on Canadian navigational charts.

Each region assumed responsibility for the ranges in their respective areas and Central Region, during 1973, sounded and surveyed all ranges from Kingston to Niagara and a set of ranges at Nanticoke on Lake Erie.

LOCAL SURVEYS

During 1973, the Local Surveys party completed its major project, the survey of Hamilton Harbour. Besides Hamilton Harbour, the party completed a variety of commitments to assist C.C.I.W. scientific parties in the Hamilton-Toronto area.



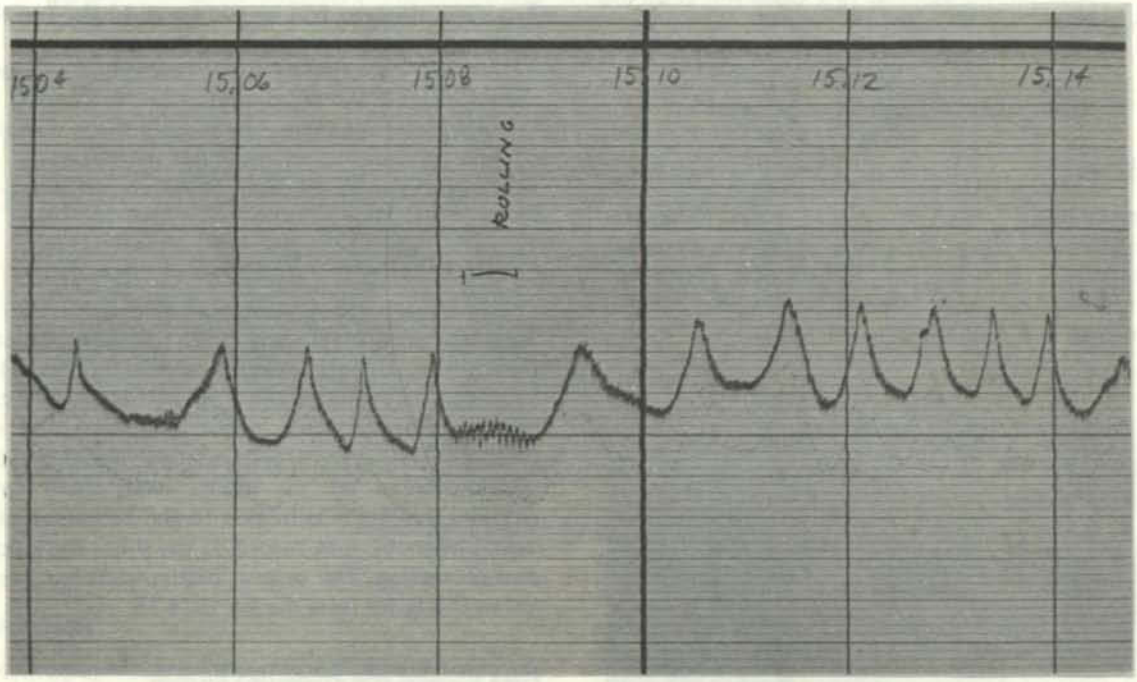
Field sheet layout for Local Surveys.

SAILING DIRECTIONS

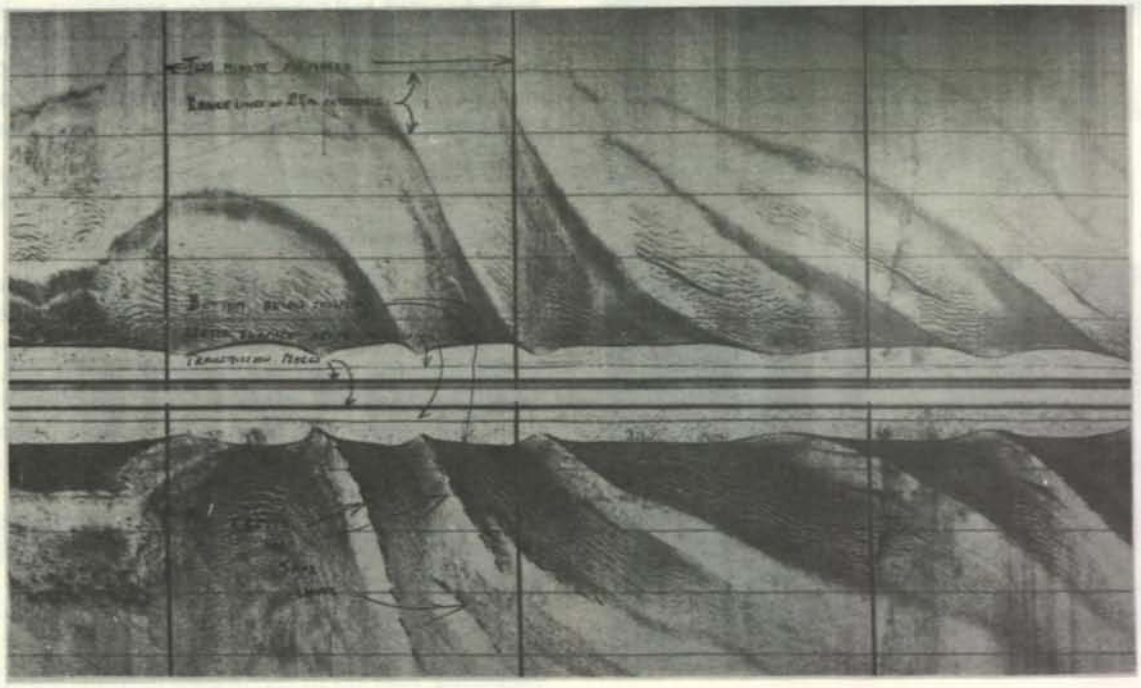
In 1972, it was decided Central Region would produce a volume of sailing directions for small craft operators. During 1973, a Small Craft Volume for the Trent-Severn Waterway was completed and published. In the fall of 1973, field data was collected for additional publications which will cover the Richelieu River, The Lower Ottawa River and the Rideau Canal.

LOWER ST. LAWRENCE SAND WAVE STUDY

This was a short project directed toward the study of sand waves near and in the ship channel between C. Brule and C. Gribane and also near Île d'Orleans.



Sand waves indicated by conventional sounder trace.



Sand waves indicated by side scan sonar trace.

U.S. TECHNICAL EXCHANGE

This was the second year for the four-month technical exchange program between the United States National Ocean Survey and the Marine Sciences Directorate, Central Region, Canadian Hydrographic Service.

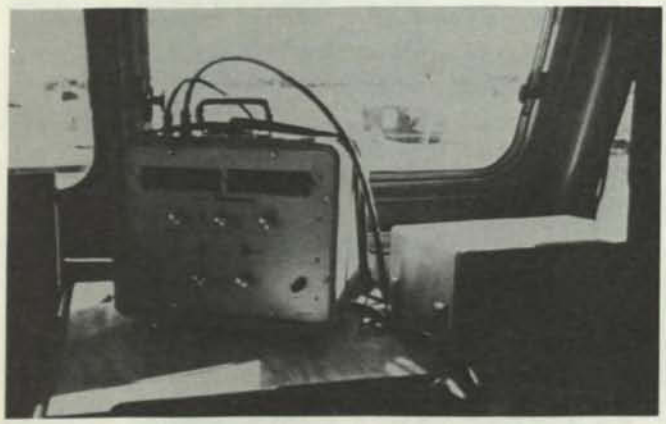
This arrangement was proposed in 1971 by the Director, Lake Survey Center, and the Chief, Central Region and agreed to by Admiral Jones of the National Ocean Survey and Dr. A. Collin of the Department of the Environment.

HYDROGRAPHIC DEVELOPMENT

Side Scan Sonar

During 1973, an analysis of the sonar field data acquired in 1972 was completed and a report was presented at the Canadian Hydrographic Conference. From the promising results obtained, a side scan sonar was purchased and implemented in a field program for 1973.

Lake survey launch LAIDLY.



Trisponder range positioning system display.

Loran-C

The data collected in 1972 with the Internav 101 and the Austron 5,000 system was analysed and the suitability of Loran-C for positioning research vessels operating on the Great Lakes was determined. A presentation was made to the Canadian Institute of Surveying Conference outlining the results of the analysis.

A two-week cruise on Lake Superior was used to test the Internav 101 receiver in an operational environment. The data obtained will be compared to the navigation data obtained by radar fixing.

A demonstration of a low power Loran-C slave station manufactured by Megapulse was conducted. The test showed promising range capability but the overall stability of the system could not be demonstrated with the synchronization in the test.

Integrated Navigation System

The plans for a navigation system for CSS LIMNOS were developed for use with the International Joint Commission Upper Lakes Reference Studies. The system has a central computer with inputs from a gyro-compass, a doppler sonar velocity sensor and a satellite navigation receiver. The system continuously computes the ship's position based on the inputs from these sensors and provides steering information to the helmsman as well as a digital magnetic tape record of the ship's track position for post-processing. The system requirement has been submitted to D.S.S. for lease during 1974-75.

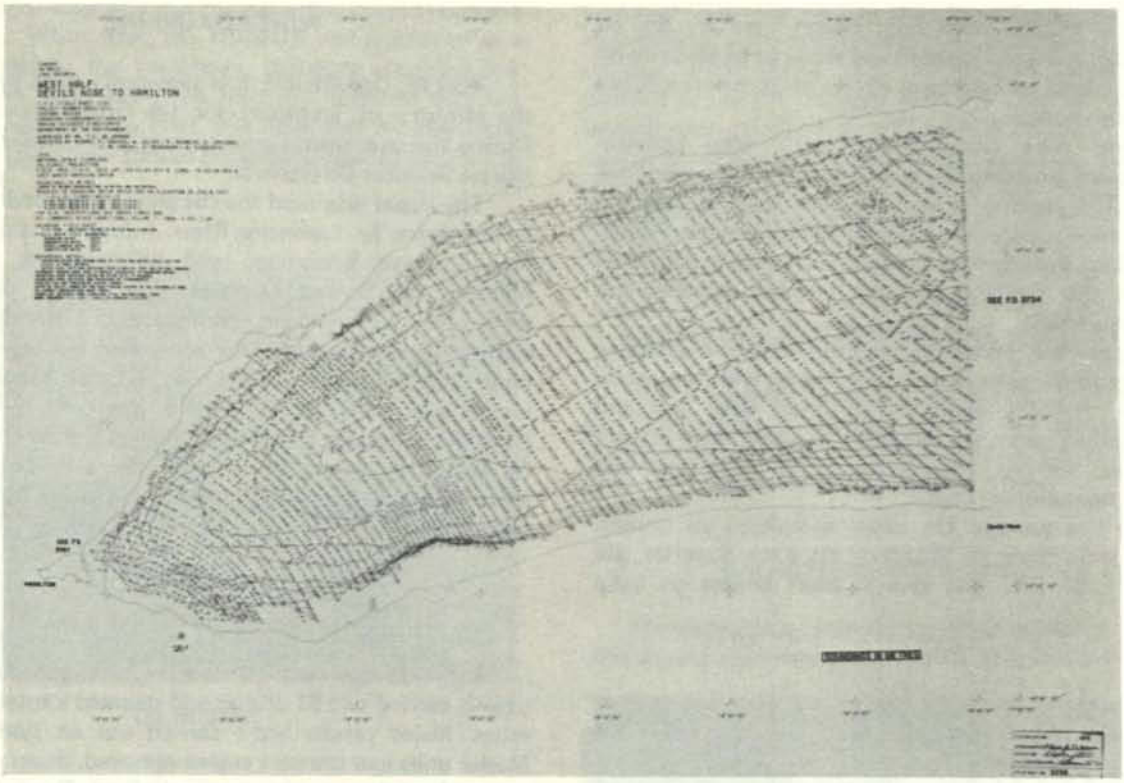
Data Logging and Processing System

A second-generation logging system requirement has been prepared and submitted for acquisition early in 1974. Three computer-based logging systems utilizing digital cartridge recorders will be acquired for use on hydrographic launches. A computer processing system with a plotter will be used to produce field sheets as with the present HAAPS system.

Marine Information Centre

During 1973, the Marine Information Centre was relocated and reorganized. The Chart and Map Sales Outlet was relocated and integrated with the Public Relations Unit of C.C.I.W. The centre was renamed the C.C.I.W. Information Centre and will combine Chart and Map Distribution with the general distribution of C.C.I.W. material. The arrangement of tours within the Centre will also be handled through this outlet.

The unit in which Technical Data are retained has been renamed the Hydrographic Data Centre. All field manuscripts, field note books, control information, and associated data are filed with this unit. Books and Publications related to hydrography are retained while other publications are sent to the C.C.I.W. Library after circulation.



Central Region's first fully automated field sheet.

HAAPS Processing

The Hydrographic Acquisition And Processing System, or HAAPS equipment, appears to have come of age and was used with great success on the James Bay Survey, Lake St. Clair Survey, Lake Ontario, Hamilton-Scourge Project and the Lower St. Lawrence Sand Wave Study during the 1973 season.

HYPOS Processing

The Hydrographic Processing System was used with reasonable success on the Lake Winnipeg Survey during 1973. Slowdowns due to mail service seem to be the major drawback of HYPOS. No further attempts will be made in using this system for support of major surveys.

Gerber 22 Processing

The Gerber 22 plotting system produced numerous lattice sheets for both Central Region and the Atlantic Region; has been used extensively for preparing HYPOS sounding plots and for producing final field sheets for James Bay, Lake St. Clair, Lake Winnipeg and Norwegian Bay.

SHIP DIVISION

A. QUIRK, Regional Marine Superintendent

INTRODUCTION

The Ship Division had another busy year with a heavy demand for ship and launch support for scientific and hydrographic programs. The flexibility and strength of the fleet was improved by the addition of ADVENT, a 77' high speed crew boat and HILDUR, a 106' research vessel. In addition several launches were added to the fleet and others were modified. LIMNOS and MARTIN KARLSEN, which remained on charter, continued to provide strong support for the major scientific programs. In the Arctic the Region was fortunate to have the use of NARWHAL once again and N.B. MCLEAN from the Ministry of Transport.

ADVENT

ADVENT was officially accepted on January 4. This

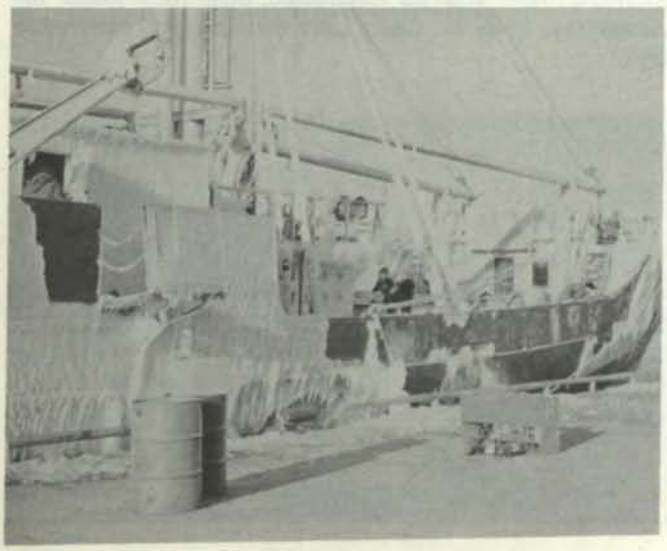
77' vessel is of the crew boat design used by the oil companies for transporting men and material to offshore oil rigs. It is capable of speeds in excess of 20 knots but has limited accommodation.

Problems were encountered shortly after commissioning because no adequate provisions had been made for wintering. The heating system designed only to heat the accommodation, operated erratically and proved unreliable. Until mid May, outside contractors and Divisional personnel worked on this problem and also installed winches and scientific equipment.

The vessel was evaluated for both scientific sampling and hydrographic surveying. It was found, with respect to the former that the equipping of heavy deck gear and overside towing, seriously reduced the speed. With respect to the latter, the fuel capacity was found to be small and limited the operational range.

During the summer the vessel completed six cruises. Six weeks were spent at Marathon on Lake Superior, six weeks on Lake Erie and several short cruises on Lake Ontario.

The ADVENT.



The MARTIN KARLSEN after a winter cruise.

PORTE DAUPHINE

PORTE DAUPHINE had previously been operated by the Ministry of Transport for the Great Lakes Institute. During the year operational control was transferred to the Marine Sciences Directorate.

The vessel was used for the greater part of the summer in the Lower St. Lawrence River. Initially it was fitted for hydrographic operations and arrangements made for hoisting two Botved launches. Due to the poor winch arrangements this proved unsatisfactory. Later the ship was outfitted again for a tidal current survey but once more the poor deck gear proved something less than efficient. Later in the year PORTE DAUPHINE was used by personnel from the Royal Ontario Museum for an archeological search for two schooners sunk off the Niagara River in 1813. A spin-off from that operation was a precise hydrographic survey.

LIMNOS

LIMNOS operated without a winter break. During the year it carried out 31 cruises and steamed a total of 24,299 miles. Major repairs were carried out on both Harbour Master units and the port engine removed, disassembled and replaced, while the ship remained afloat. Drydocking, with all its accompanying frustrations and delays was carried out in July. However, the five year hull and machinery inspection was completed and the vessel sailed on schedule. The only lost time by this vessel during the year was caused by the unavailability of parts for the 5-ton Auston Weston crane that is used for mooring operations.

Experience this year has shown that the vessel is unsuited for winter operations in the Great Lakes. Not only do large amounts of ice form on both superstructure and decks but various underwater parts, particularly the nautilog and gears in the Harbour Master units get damaged by the ice.

MARTIN KARLSEN

This large chartered vessel completed 21 cruises throughout the Upper and Lower Lakes. This vessel and LIMNOS provide the major support for scientific programs in the Great Lakes.

A 20 KW Motor Generator was installed aboard to overcome the acute shortage of AC power experienced the previous year. The installation experienced serious vibration and bearing failures. Vibrometer and clock gauge readings were taken and analysed by Divisional staff. The recommendations made to the suppliers were successful in curing the problems.

HILDUR

The newly purchased yacht HILDUR was delivered to the Centre on December 5, 1973. The vessel, a 106' ship,

will be used for scientific and hydrographic purposes on the Great Lakes. When new, the HILDUR was employed as a research vessel in the Caribbean, therefore requiring few modifications. After being renamed and outfitted with the equipment necessary to start Scientific and Hydrographic operations, this vessel should prove beneficial to the Centre during 1974.

The HILDUR.

LAC ERIE

LAC ERIE, a chartered, converted tug was again used for limnological work in the Lower Lakes making a total of 14 cruises. As an economic measure this vessel was taken off charter in the fall.

NARWHAL

For the second year Central Region was fortunate in having the use of the Ministry of Transport's light ice-breaker NARWHAL for work in James Bay. This project was under way early in July when the C.C.G.S. NARWHAL was equipped at Burlington with two major launches, STURDY and SURGE, and two DEL QUAY dories. Two new engines were installed on the SURGE, and the STURDY was equipped with two reconditioned engines. All launches were outfitted at Burlington with electronic survey equipment and were tested in Hamilton Harbour to insure that the launches and all equipment were in first-rate condition before being transported to James Bay. Excellent weather in James Bay enabled the survey to be completed on October 2. The NARWHAL returned to Halifax where all launches and equipment were returned to Burlington for winter overhaul and modification.

N.B. MCLEAN

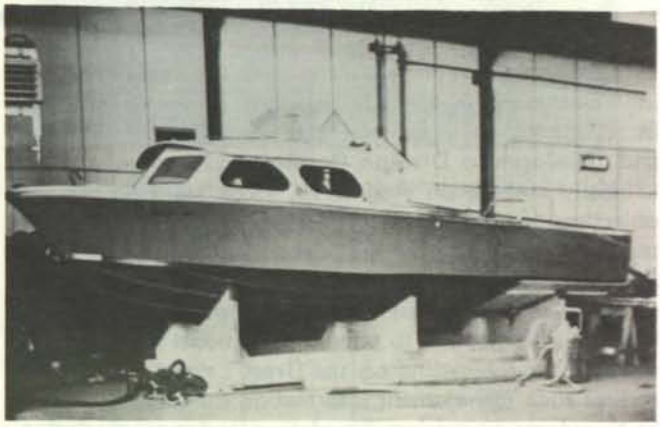
The alteration of Regional boundaries to include Hudson Bay, presented Central Region with one more challenge. With the start of the Chesterfield Inlet Survey in Hudson Bay, another icebreaker, the C.C.G.S. N.B. MCLEAN on loan from M.O.T. was outfitted at Halifax. It was planned to use the launches from the Thunder Bay Survey, loading them aboard N.B. MCLEAN at Churchill. However, due to a railway strike this was not possible. Instead, two landing barges normally carried by N.B. MCLEAN were temporarily outfitted and used as sounding vehicles for this survey.

VESSELS – ENVIRONMENTAL PROTECTION

An oil recovery barge was used at the Centre for testing Oil Contingency equipment for the full season and was finally removed from the program when ice conditions no longer permitted operation here at the base.

LAUNCHES – HYDROGRAPHY

Reconditioning and repair of launches got an early start during the latter part of 1972. This was made possible



Stretched Bertram launch.

Enclosed DEL QUAY dory.

by the early closing of many field surveys and therefore, enabling all launches to be repaired and tested before freeze up. When all launches were tested and found to be in order they were winterized and placed in outside storage. However, on de-winterizing and testing prior to the field season, it was found that most of the work had to be duplicated, particularly the work to the electrical systems. Severe corrosion caused by dampness during winter storage, pointed out a need at the Centre for a dry covered storage area.

VEDETTE and VERITY, the larger class of survey launches, were used for Revisory Surveys on the Trent-Severn Waterway, the St. Lawrence River and the Ottawa River. Some difficulties developed with the V-drive on VERITY during the season. Two launches, the SURGE and STURDY, were used in James Bay, also launches were transported to Lake Winnipeg and the Lower St. Lawrence to continue the Hydrographic Surveys in these areas. Launch support was provided to survey parties on Lake Superior, Lake Huron, Georgian Bay, Lake St. Clair, as well as Lakes Erie and Ontario.

Some interesting changes were made to some of the Bertram class launches. BRUCE was stretched in length by adding an additional 6 feet, making the boat 31 feet overall. A Cummins TM 370 diesel engine was installed.

Two modified Bertram Launches were received from Dartmouth, HYDRO I and HYDRO II, each powered by GM 6V 53 diesel engines.

Work was started on completely overhauling these boats and installation of single gasoline engines.

SHIP VISITS

In September the Centre was honoured by a visit from the H.M.C.S. MARGAREE and the BRIGANTINE PATHFINDER. Open House for these vessels was arranged by the Centre followed later by a successful Open House for the ships here at Burlington.

RESEARCH AND DEVELOPMENT DIVISION

N. Freeman, A/Head

In order to respond effectively to the Region's increasing involvement in scientific programs on the Great Lakes, St. Lawrence River Estuary, and James Bay, the Research and Development Division (formerly Geotechnology) was officially created on August 15, 1973. Its main program objectives in 1973 were: 1) to provide a descriptive and predictive capability for the tides and currents in the Upper St. Lawrence River Estuary; 2) to provide a marine and estuarine environmental impact assessment of the James Bay Power Project; 3) to provide operational techniques for storm surge forecasting on the Great Lakes; 4) to provide coastal zone management information for the Great Lakes; 5) to provide an erosion, inundation, and property damage assessment resulting from the high water levels on the Great Lakes; 6) to provide survey electronics support to the Hydrographic and Limnological field programs; and 7) to provide tide, current and water level support to Hydrographic charting operations. These programs were formulated into fourteen project areas and were carried out by the four sections: Hydrodynamics, Shore Property Studies, Survey Electronics and Oceanographic Research.

In addition to the above ongoing programs, new program areas in 1974 will include: 1) the provision of information on current predictability and spatiality in the St. Clair-Detroit Rivers for "Operation Preparedness", 2) the development of photogrammetry techniques for erosion studies, 3) increased instrument development capability in Survey Electronics.

HYDRODYNAMICS SECTION

The section evolved out of the Hydrographic, Tides and Water Levels Unit to become the main group for the planning, collection, analysis, and interpretation of current and water level data, principally on marine waters, for the description and prediction of hydrodynamic processes.

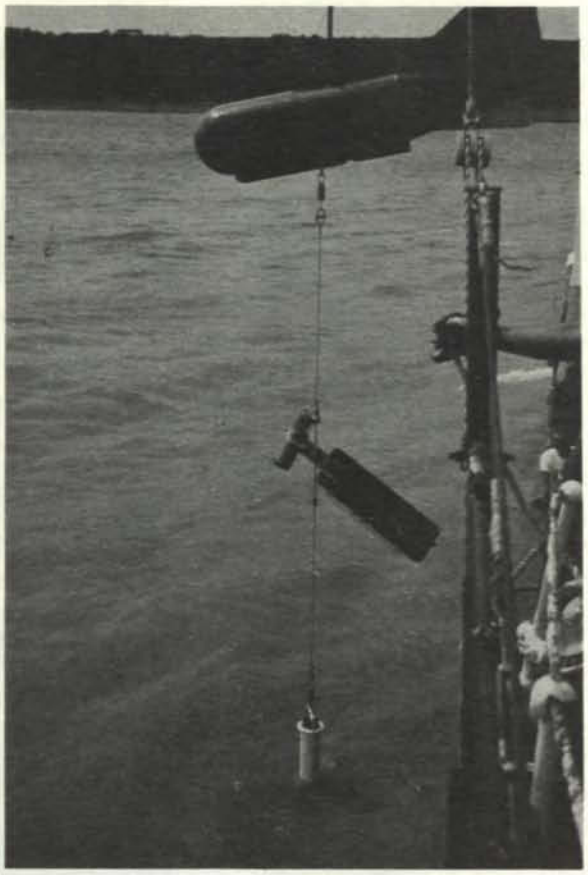
All Hydrographic surveys received support on an on-going basis for: sounding datums, field sheet checking, bench mark information, tide gauging, daily water level retrievals, automated sounding reductions, and co-tidal charts. Some 30 monthly water level records were digitized for submission for publication and for scientific spectral analysis by physical limnologists. A weekly water level bulletin, indicating present levels, as well as trends from past and future levels, was produced for Public Relations and a few external organizations. The sounding datum for Playgreen Lake was reviewed in light of new data and was retained. A sounding datum for Lake Winnipeg was also calculated. The Killarney sounding datum was revised based upon a one month water level transfer from Little Current. The Bass Engineering *in situ* tide gauge was successfully deployed and recovered off Cape Henrietta Maria by the James Bay Hydrographic Survey party. Positioning techniques using Motorola R.P.S. were developed for tracking 3 meter drogues. Our staff took part in the development of a water levels display for the Toronto Boat Show and were on hand to answer questions regarding the high lake levels. In December, the Hydrographic support function was transferred back to the Tides and Water Levels unit, Hydrography.

The main objectives of the St. Lawrence River Hydrodynamics Pilot Study were: 1) to gain experience in laying and retrieving current meter strings in complex tidal waters; 2) to evaluate the reliability of the 1939 Tidal Current Atlas and thus the need for a long-term study. Operationally, the program consisted of two phases: (a) a single

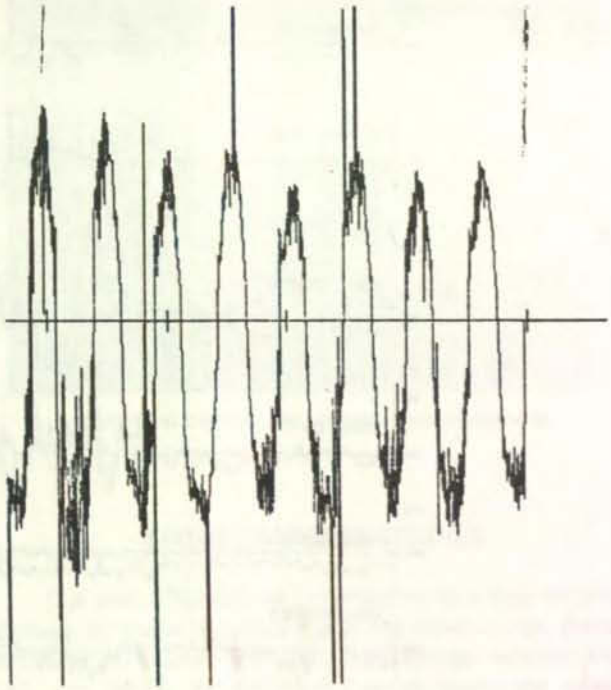
fixed current station and portable current observations off Grande Isle in Kamouraska Basin, carried out jointly by H.G. Acres, Technical Operations, and Marine Sciences in May; (b) a number of fixed current stations, portable current observations and drogue tracks off Isle d'Orleans, carried out by this section in August. The first location provided current data in a two-layered region, and the second provided data in a well-mixed region at the boundary of N.R.C.'s two-dimensional numerical model. In the field operation, some difficulties were experienced with the instrumentation, the newly developed surface referenced mooring, the stability of the tower, and the maneuverability of the deployment vessel. Preliminary analysis of the Grande Isle data indicates that the tidal flow in the freshwater layer, between 15 to 30 meters thick, leads the lower saltwater layer by approximately 3 hours and a significant cross-channel flow exists. While the Isle d'Orleans data is still in the analysis stage, some immediate observations can be made: 1) the tidal current, specifically the turning of the tide, is significantly affected by wind action, thus making precise prediction difficult in these shallow areas; 2) some discrepancies with the Atlas do exist requiring further investigation.

Early in the year, various instruments were evaluated by contacting users and reviewing the appropriate National Oceanographic Instrument Centre, Fact Sheets, resulting in the purchase of 6 Aanderaa RCM-4 current meters, 3 Lewis tide gauges, 3 Interocean acoustic command releases. Three commercially available current meters were tested in a controlled magnetic field to ascertain their usefulness close to the magnetic north pole in Canada's central Arctic. A surface referenced mooring system, which maintains the current meter at a fixed distance from the surface at all stages of the tide, was developed and tested on the St. Lawrence River Survey. It was found that insufficient weight caused the anchors to move together and a jammed pulley caused the steel wire to chafe, resulting in the whole system coming adrift (the instrumentation was recovered). During the year, discussions involving Atlantic, Central and Pacific Regions, M.S.D. and I.W.D., Burlington, were held to ascertain the feasibility of establishing a national current calibration facility using the Hydraulics and Engineering capabilities at C.C.I.W. A physical model depicting waves breaking on a beach and marine structures was built by the staff in order to dramatize, at the Toronto Boat Show, the erosive and inundative effects of the recent high lake levels. Three excellent symposiums on instrumentation were attended by our staff: 1) I.S.A. Marine Science Symposium at Cocoa Beach, Florida; 2) Third Annual Buoy Technology Workshop at Wood's Hole; 3) Tides and Water Levels Workshop at Vistoria, B.C.

Numerous computer programs for the data translation constituent and spectral analyses, coordinate plotting, calculation of oceanographic parameters, solution of simultaneous equations, etc., were written, modified and/or converted to the CDC-3100. A method for fitting a sum of cosine terms was developed, whose frequencies are known, to a curve, by method of least squares. The Plessey translator program was significantly modified to handle the



Current meter mooring system showing subsurface float, current meter and acoustic release.



Current observation over a 4-day period.

Aanderaa tapes. Presently we are in the process of developing a mathematical technique to decipher tidal information from the Bass tide gauge.

A two-dimensional numerical hydrodynamical model of Lake Huron, developed by the section, demonstrated that sub-synoptic scale meteorological processes can generate a large portion of the storm surge set-up. A two-dimensional numerical tidal propagation model is presently being developed. A numerical technique to model the response of the surface-referenced mooring system to various static and dynamic loading conditions has been developed by a cooperative student at University of Waterloo in consultation with staff in this section. A statistical model for sloping sounding datum calculations was also developed.

The increased potential in recent years for inundation of low lying shoreline by short-term water level fluctuations, necessitated the joint (A.E.S., M.S.D., Ontario Hydro, I.W.D.) implementation of a storm surge warning system for Lakes Erie and St. Clair. The predictive model for Lake Erie was taken from Ontario Hydro, while our staff prepared a preliminary statistical method for Lake St. Clair. Late in August, a one year contract (shared with I.W.D.) was let to a research scientist to develop operational techniques for storm surge forecasting on all the Great Lakes.

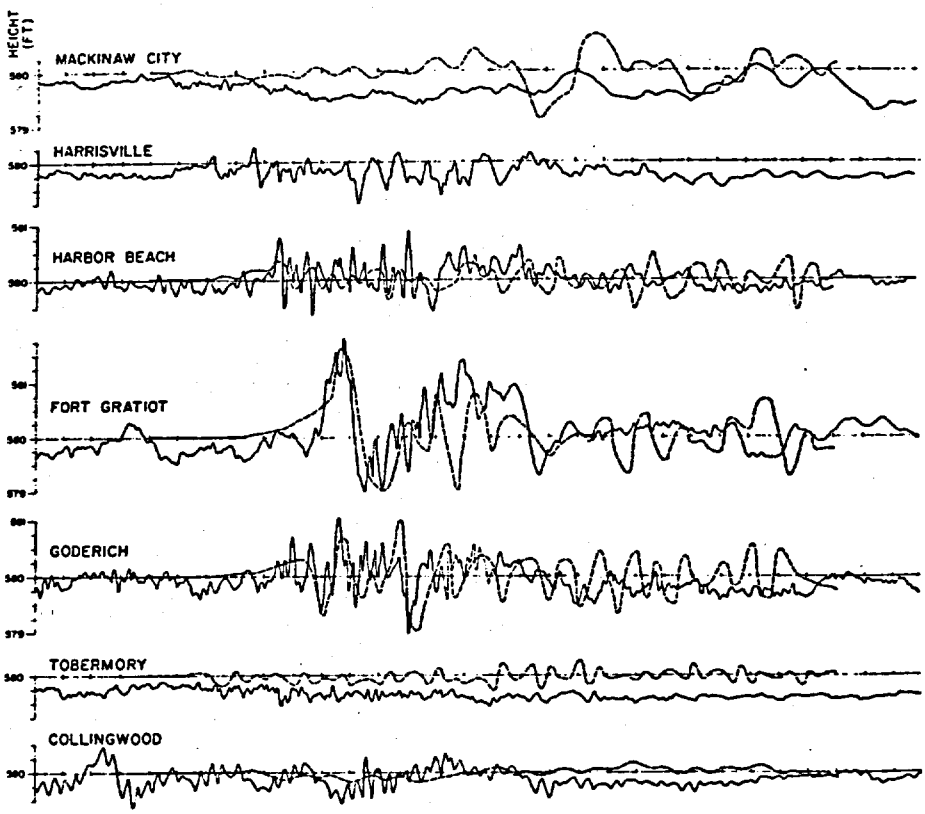
Future projects in 1974 will include the development of a two-dimensional model of the St. Clair-Detroit River system, the measurement of currents in this system, the analysis and interpretation of the St. Lawrence River current data, and the continuation of on-going projects. Also the surface-reference mooring system with appropriate modifications will undergo extensive testing in 1974, in the Niagara River, and will be instrumented to evaluate the response of the mooring system and current meter to such external forcings as line strumming and surface wave action.

SURVEY ELECTRONICS

As usual the Survey Electronics group was very busy again this year. The loss of key personnel to other regions and other departments resulted in the appearance of several new faces in the shop.

Technicians were in the field with survey parties on James Bay, on Lake Winnipeg, on Lake St. Clair, on the Polar Shelf project, aboard the BAFFIN in the Caribbean and with the St. Lawrence Hydrodynamics Pilot Study. In addition we supported the launches and projects based at and from the Canada Centre for Inland Waters.

Again this year, the James Bay Survey was one of the most demanding as far as the Electronics Shop was



Computed and observed water levels (squall scale forcing), Lake Huron.

concerned. In addition to outfitting the launches with HAAPS equipment, all systems including the Minifix were set up and field tested at Burlington prior to proceeding north. The survey utilized Ross Sounders, three HAAPS systems and a shipboard computer processing system. The long range Minifix system was again employed successfully.

The Lake Winnipeg Survey also utilized a high power Minifix system. In fact as a consequence of the high power and resulting interference with the Provincial Forestry Service the frequency of the Minifix Chain will be changed for the 1974 operation.

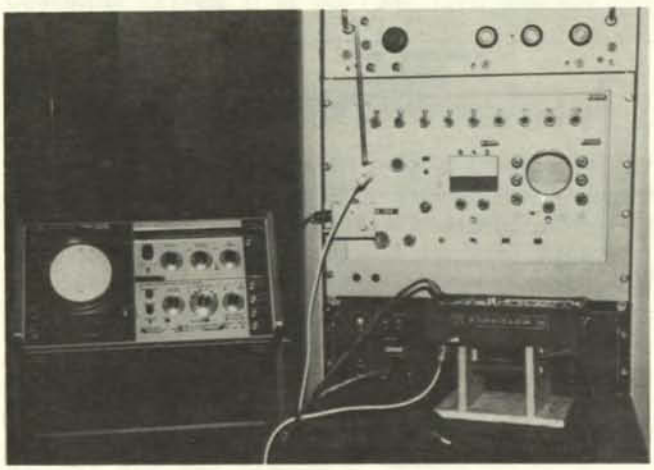
We were again involved in the Polar Continental Shelf Program with a technician participating in the full survey. In addition, considerable time was spent outfitting the helicopters before they went north. The survey utilized two RPS systems and Edo Sounders. As a result of the extreme cold, several novel equipment problems were encountered.

Support was also given to an automatic HAAPS system survey on Lake St. Clair in conjunction with the Motorola RPS system.

The choicest field assignment this past year was Mr. Smith's three-month assignment to the BAFFIN on her Caribbean cruise. Mr. Smith and a technician from the east coast were responsible for maintaining the electronic equipment used on the training program.

Again this year, but for the final time, a technician was seconded to the Hydrographic Development Section. Hydrographic Development is now defining their own Electronic Technologist position. The seconding of technicians from the Electronics Shop has been a very valuable undertaking in that it has brought one technician a year up-to-date with what Hydrographic Development is doing and thus knowledgeable on the new systems to be introduced to field operations. It is hoped to continue close involvement with Hydrographic Development in the form of short-term assignment of technicians to development work.

Due to the ever increasing complexity of the equipment being utilized, the Electronics Section has spent a considerable amount of time on staff training again this year. This included courses on Motorola RPS, Tellurometers, HAAPS system, Minifix and computers.



VHF test equipment.

During the year the facilities were upgraded for servicing our VHF radio telephones, of which we now have more than one hundred.

We also became responsible for service and maintenance of the HAAPS system and for three Digital Equipment Corporation computers. This has also necessitated the purchase of new test equipment and need for additional training. Additionally, we acquired an extremely stable standard frequency signal generator for calibration purposes in the shop.

During the summer a Career Oriented Summer Student was employed and as a result of his excellent performance he will be hired in the spring.

Other areas of present involvement, in addition to the yearly overhaul, include preparation for trials and evaluations to extend the range of the Minifix system, modification to the Digital Coupling units for the HAAPS system and modifications to the RPS system in order to reduce the interference from marine radar.

Computer, teletype and associated test equipment.

SHORE PROPERTY STUDIES

The year 1973 will be remembered as a year of severe damage to shoreline property on the Great Lakes. Record erosion, inundation and structural damage resulted from fall and spring storms superimposed upon the already existing high water levels. This condition created an

Lake Ontario – aftermath of spring storms, 1973.

unusually heavy work load for the section. In order to record the extent of the damage an immediate inventory of changes was necessary. To accomplish this in the shortest time possible following the storms, a low altitude airborne survey was conducted. The results of this survey led to the agreement between Canada and Ontario Governments to undertake a more detailed evaluation of the damages along the erodible shoreline of the Great Lakes.

Shore Property Studies Section was charged with the direction and implementation of this task, which was comprised of the following projects:

1. Stage Damage

The important aspect of this survey was to collect sufficient information as to the extent of the damage caused to individual properties along the 800 miles of the erodible shoreline of Lakes Ontario, Erie, St. Clair and the southern portion of Huron and Georgian Bay and their connecting rivers.

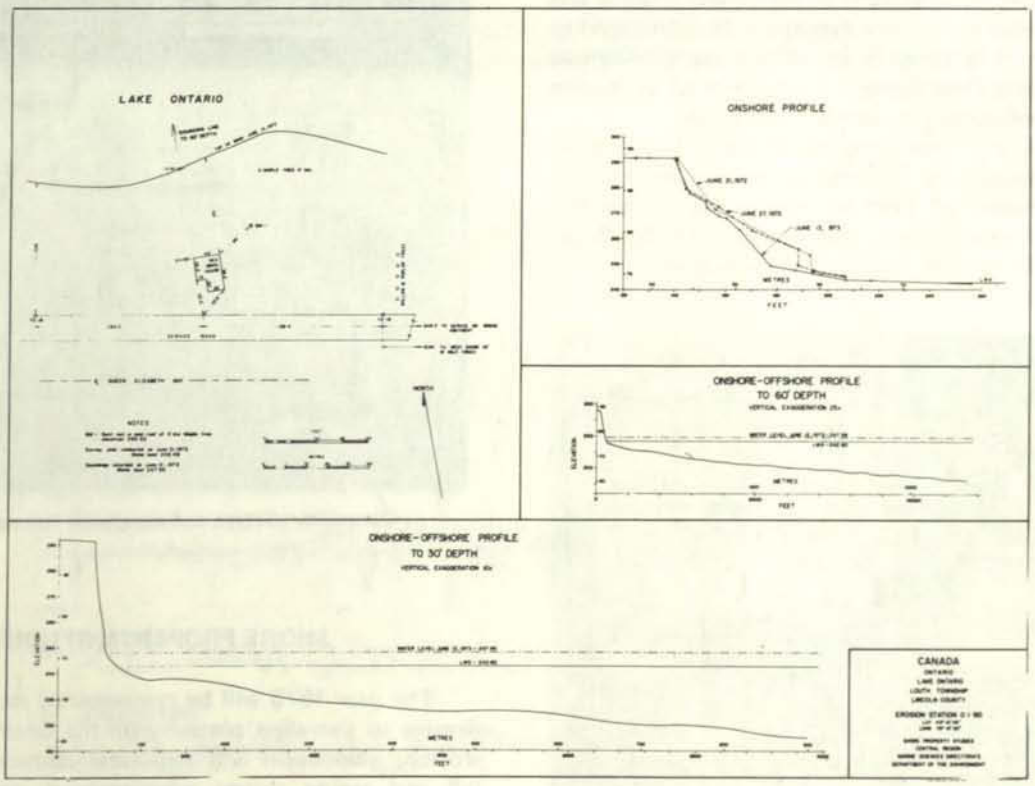
2. Erosion

The ongoing program of reprofiling the subaerial and subaqueous shore zone of 50 previously established erosion stations throughout the Great Lakes System was extended to include the addition of 100 or so new stations to cover the total erodible shoreline.

This data will enable in-depth analysis of the amount of sediment contributed to the lake bottom by offshore erosion, maximum depth at which erosion occurs, the movement of sediment in an offshore direction and also rates of erosion to be related to varying lake level conditions. The recorded periodic changes are shown on master profile sheets, indicating location plan and profile with onshore and offshore features.

3. Aerial Photography

To delineate peak high water mark, ground controlled aerial photography of the erodible shoreline was completed in early June. The photography, taken at a true altitude of



Master profile sheet.

10,000 feet above mean sea level, shows land detail to a one-mile width along the entire shoreline from the head of the St. Lawrence River through to Georgian Bay.

This photography will be used in the production of a Coastal Zone Atlas consisting of master strip maps on a scale of 1:10,000, showing 3-meter contour lines, shoreline physical characteristics, land use, ownership, present structures, areas of erosion, inundation and potential damage, etc. Also, the comparative analysis of aerial photography – old, recent and new, in terms of shoreline changes due to geomorphic processes (recession and accretion) is being conducted jointly with L.R.D., results of which will be incorporated into a final map of erosion rates.

4. Property Values

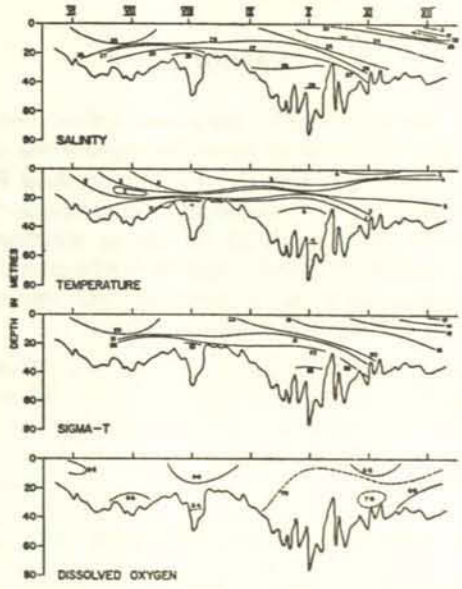
In cooperation with the Social Sciences Research Section, a shoreline property inventory of ownership, value and use of land and its improvement, is being compiled from assessment rolls of Ontario Regional Assessment offices from Ontario/Quebec border on the east to the Ontario/Minnesota border at the head of Lake Superior on the west.

This inventory will provide the background information necessary in the evaluation of the extent of shoreline damage. For purposes of facilitating data retrieval a computer data base and coding design has been developed. The capability for updating has also been incorporated in the program design so that information stored there will always be of a current nature.

5. Technical Report

The end of the 73/74 fiscal year will see the emergence of a preliminary report containing information on past and present shoreline conditions, which will lead to recommendations on waterfront planning.

In August a research contract for photogrammetric bluff surveying and mapping for Great Lakes shoreline was awarded to Laval University, to develop aerial photogrammetry procedures to reduce the compilation time and costs, when compared with classical ground surveying and mapping. In 1974, additional projects are envisaged as a result of the section's representation on the Technical Committee of Task D of the I.J.C. Land Drainage Reference Group.



Above: Contours produced from data obtained from Knudsen Water Sampling Bottle.
Below: Knudsen Sampling Bottle being removed.

OCEANOGRAPHIC RESEARCH SECTION

In order to provide basic research backup for the Division's programs, this section was created during reorganization, and staffing of a research scientist position to head the section, is still in progress. However, throughout the past year, staff from the Hydrodynamics section and from Hydrography undertook oceanographic field surveys.

The 1973 program consisted basically of reoccupying, at the beginning of August and end of September, the sixteen stations of the 1972 survey. These stations were located on two latitudinal sections in the northern half of the Bay and two longitudinal sections off La Grande Rivière. A total of 32 continuous salinity, temperature and depth profiles, 143 discrete salinity, and dissolved oxygen samples, 41 bottom samples, 41 mechanical BT casts and 32 vertical plankton tows were taken. The data is presently being analysed to determine heat and water mass budgets.

A program of through-the-ice physical oceanographic measurements off La Grande Rivière is being carried out this winter and will permit evaluation of the extent of the fresh water plume under ice cover and its effect on ice growth and thermohaline circulation. At the mouth of the La Grande Rivière, current, salinity, and temperature measurements were taken over a 13-hour tidal cycle, with four additional stations occupied up river, at three different stages of the tidal cycle. These data will be

used for planning future programs to study the estuarine dynamics.

ADMINISTRATION

A.W. Appleby, Regional Administrative Officer

During 1973, the Administrative Support Division provided services to three major operating Divisions as follows:

(1) Hydrographic Survey Division with 13 Field Party Accounts.
(2) Research & Development Division with 2 Field Party Accounts including a number of subparties surveying shore property damage on the Great Lakes.
(3) Ships Division providing Ship and Launch support to all Hydrographic Surveys, Hydrodynamics Programs and Scientific Support to CCIW programs with 12 field accounts.

PERSONNEL

The Central Region personnel office retained its staffing, pay and benefits duties throughout the year with some assistance provided by the Ontario Area Personnel Office located at CCIW, Burlington. No personnel files have been transferred from MSD Ottawa as anticipated, and therefore all personnel actions continue to be coordinated by Administrative Services. A total of 162 man-years accounted for 184 staffing actions as follows:

FTC	15 employees
Term	53 employees
Ships Crew Seasonal	73 employees
Career & Co-op Students	36 employees
Contract	7 employees

Peak staff level reached 225 during the summer of 1973.

Classification was active with approximately 88 positions submitted for review or reclassification.

While the local Ontario Area Personnel office at Burlington is understaffed, Central Region will continue to provide much of the interface workload for some time into 1974.

ACCOUNTS

Three accounts staff members catered to a budget of 4M, accounting for 27 field party account activities throughout central Canada and the Arctic. During the 1974 calendar year, 2,600 supplier invoice accounts were processed to RSO for payment.

Key members of the accounts staff won promotion transfers during the period for a 1000 batting average.

Roughly 20,000 photocopies of invoices, purchase orders and other audit documents were passed to MSD Headquarters; a record that is hoped can be diminished in the future.

SUPPLY SERVICES

A central procurement and supply service consisting of 6 staff members maintain field support to all areas of the region.

Inventories hold at about 6,000 accountable line items with stock values reaching $14M.

The scope of 1974 procurement, valued at 1.6M, is as follows:

750 Purchase Requisitions	—	$1,381,493
300 Standing Offer Purchases	—	155,000
508 Memo Orders	—	53,397
		1,589,890

MOBILE EQUIPMENT

The regional mobile fleet consists of approximately 30 vehicles ranging from station wagons and travelalls, to two ton trucks; 40 boat haul trailers and 15 workshop, living and office trailers. Additionally, 5 vehicles were leased to meet operational needs.

All equipment was mobile in the Manitoba, Ontario and Quebec provinces throughout the operational season. All maintenance is conducted through contract.

During 1973, Central Region vehicles travelled 221,487 miles. Five accidents were recorded costing $1,708 to repair. Main cause factors were:

(1) speed too fast for conditions
(2) inattention

Although a degree of negligence was exhibited in four of the five accidents, it was judged to be of a minor nature and none of the drivers were assessed damages.

During the month of April, 25 user drivers attended a Defensive Driving Course conducted at the CCIW by an Ontario Safety League instructor.

SAFETY

Management and Staff have responded favourably to the increasing emphasis on Safety procedures and programmes outlined in recent departmental minutes and memoranda.

CARTOGRAPHY

The Cartographic Unit of the Marine Sciences Directorate, Central Region, comprising of Mr. J. Elliott, Head, and Mr. S. Holm, technical assistant, was involved in increasingly diversified assignments during 1973.

Shore property plan and profile drawings for the Lake Erie erosion stations were completed during the summer and work is now progressing on the Lake Ontario stations. Cartographic support was given in the preparation of a number of technical data reports. This consisted of the drawing of graphs, illustrations and the silk screening of the report covers. During 1973, in-house production of 35 mm slides and photo-enlarging was commenced, resulting in substantial savings. Assistance was given to the Electronics Unit in the production of electronic circuit boards. Utilizing the photo-typesetter, the unit is preparing formats of the literature to be used for the Canadian Hydrographic Conference in March, 1974. The Cartographic Unit continues to coordinate the reprographic and photographic needs of the Central Region, purchase drafting materials and instruments as required by the hydrographers and maintaining a slide library.

Office of the Senior Scientist

Office of the Senior Scientist

The Office of the Senior Scientist, CCIW, established in 1973, carries responsibilities for ensuring coordination of limnological and related research programming between Services, for assessing research developments and results in specific areas, for consultation with scientists on projects, and for undertaking research of a synthesizing nature. Also, the Senior Scientist provides advice on, and assists the Director of CCIW in national and international scientific programme developments.

To this end, the Senior Scientist acts as Chairman of the Scientific Council for Coordination. The office comprises the Secretariat to the Council and to programme review boards and keeps liaison with national and international committees.

The membership of the Scientific Council is composed of Chiefs of Research Divisions and research units of all Services, plus working scientists named by the CCIW scientific community. The Council is responsible for identifying for managers, needs and opportunities for closer coordination of projects and programmes, for developing long-term research objectives and strategies, for advising CCIW managers of *scientific* merits and priorities of proposed projects and programmes and for periodically reviewing progress of scientific programmes, advising on changes or possible termination.

During 1973, the basic concepts of the Council have been developed and activities have been initiated in several areas, including project forecast and progress review. With the increasing number of research programmes and projects, which presently number some 250 individual projects per year, it has become necessary to revise the categories of programmes and to define their interrelationships. More concise programming and long-term planning has been initiated in a few areas through establishing several task groups with continuing responsibility to the Council.

TOXIC SUBSTANCES GROUP

This group comprises some 25 scientists drawn from Lakes Research Division, Social Science Research, Water Quality Division, the Great Lakes Biolimnology Laboratory, the Environmental Protection Service and the Environmental Quality Coordination Unit. It played an active role in preparing background information, reports and recommendations on presently or potentially hazardous substances in the aquatic environment, their effects, toxicity and distribution.

The Toxic Substances Group has met fairly regularly and has to date, prepared specific reports on polychlorinated biphenyls (PCB's) and phthalic acid esters with recommendations for specific studies regarding these contaminants. Other subjects which have been dealt with are toxic substances, with respect to water quality criteria and objectives as specified in the Canada-US Agreement on the Great Lakes, and chlorinated hydrocarbons in the lakes environment.

PHOSPHORUS LIMNOLOGY GROUP

Membership of this group is mainly drawn from Lakes Research Division, the Great Lakes Biolimnology Laboratory, Hydraulics Division, the Environmental Protection Service and Scientific Support Division. A preliminary report outlining areas in which further research is needed was presented to the Scientific Council. Continuing attention is given to nature and amounts of phosphorus inputs into the Great Lakes and movement of phosphorus within the lakes.

NEARSHORE PROCESSES TASK GROUP

Membership of this group is drawn from Physical Limnology, Geolimnology, Hydraulics, Chemical Limnology, Biolimnology and Remote Sensing. The objective of this group was to elucidate, on an interdisciplinary basis, research needs for assessing the complex interactions between shoreline and lake bottom, waves, biota and man-induced stresses in the nearshore zone. A preliminary report to the Scientific Council has been submitted outlining areas for interdisciplinary studies. From this,grew the formulation of several joint projects by scientists in different disciplines. A nearshore experimental site has been established by physicists, geologists and hydraulicists at Hamilton Beach to investigate waves and sediment dynamics close to shore.

Further discussions are continuing on definition of inshore versus offshore processes and regions in order to find a better conceptual basis on which future programming can be built.

INSTRUMENTATION DEVELOPMENT TASK GROUP

The scope of this task group is to anticipate major instrumentation needs for environmental application rather than to react to requests for instrument manufacturing for specific purposes. The need to develop new technology and

apply advanced techniques is particularly felt in regard to monitoring and surveillance to minimize costs of such programmes. The task force has begun studying feasibility of producing automated water quality monitoring packages, sensors already available or in the stage of anticipated applicability, automated devices for sampling, application of optical principles, etc. Expertise is drawn from Scientific Support Division, Scientific Operations Division and all research units involved in field programming.

ANALYTICAL METHODS TASK GROUP

This group provides a forum for coordinating of development of analytical techniques in water chemistry, sediment geochemistry, biology, etc. at CCIW and recommends priorities. Input originates with all components requiring analytical methods, and from task groups such as Toxic Substances Group. The Analytical Methods Task Group operates on an *ad hoc* basis rather than on one of continuing conceptual review. During the year, a number of requests for methods development channeled through this group have been forwarded to the Analytical Methods Research Section for project initiation, in particular, automated methods for ATP, chlorophyll *a* and phthalic acid esters.

In addition to these activities, the Senior Scientist was involved in several national and international Committees and Boards providing input to the IJC, Great Lakes Water Quality Board (member), the IJC Research Advisory Board (Chairman of the Standing Committee on Eutrophication), the NRC Committee on Water. For the latter, a report on the present state of eutrophication research regarding the relationship between phosphorus input and trophic state has been prepared by his office.

In international activities, the Senior Scientist has participated in preparation of an OECD report on thermal discharges. He has chaired the Technical Bureau of the OECD Programme on Eutrophication Monitoring and Measurements and, in collaboration with federal, provincial and EPA staff, has initiated the coordination of the North American Project. Further, he has been actively involved in arranging the International Congress of Limnology to be held in Winnipeg, August, 1974.

Environmental Quality Coordination Unit

Environmental Quality Coordination Unit

The Environmental Quality Coordination Unit (EQCU) is responsible for the integration and/or coordination of research results from components of CCIW with research results produced by other groups in a form suitable for use by federal, provincial and municipal water managers and to assist in ministerial and departmental policy decisions. EQCU provides technical secretariat support to all IJC Great Lakes Boards and Reference Groups related to Great Lakes water quality and provides the Chairman of the Water Quality Board's Implementation Committee. Coordination is provided for CCIW research and surveillance activities called for under the Canada-U.S. Agreement and for the International Joint Commission's two new water quality References. Assistance is provided to the Director in discharging responsibilities as Technical Committee Chairman under the Canada-Ontario Agreement. The coordination of CCIW research contracts of a multi-disciplinary nature is a continuing function.

CANADA-UNITED STATES AGREEMENT

EQCU was actively involved in the Canadian implementation activities associated with the Canada-United States Agreement on Great Lakes Water Quality signed in April 1972: through support to the Director, CCIW, who was named to the Interdepartmental Committee on Water's Subcommittee concerned with implementation; and through participation in the development of submissions to Treasury Board for resources to carry out the various studies and other activities required by the Agreement and the associated "Make or Buy" analysis.

EQCU staff were involved in the semi-annual "stock-taking" meetings held by the two countries to assess developments with respect to the terms of the Agreement.

EQCU has for a number of years been extensively involved in IJC activities. With the signing of the Great Lakes Water Quality Agreement, additional activities were generated with a number of personnel from CCIW and Inland Waters Directorate, Ottawa, being named to various Boards and Reference Groups which were established. EQCU is providing the technical secretariat for the Canadian Chairmen of the Great Lakes Water Quality Board, the Research Advisory Board, the Land Drainage Reference Group and the Upper Lakes Reference Group.

EQCU participated in the preparation of annual and semi-annual reports for the various Boards and Groups to the International Joint Commission, and in the planning and drafting of study plans for the Upper Lakes and Land Drainage Reference Groups, as well as assisting in the development of submissions to Treasury Board for resources to carry out the various studies called for in these plans.

A major activity was assisting in the preparation of the Great Lakes Water Quality Board's first annual report on Great Lakes water quality, a 300-page document prepared for the International Joint Commission and submitted in April 1973.

Assistance was provided in the preparation of a report to the International Joint Commission on the extent of phosphorus loadings and recommended gross reductions in phosphorus loadings to the Upper Great Lakes. This report was subsequently adopted by the two countries.

CANADA-ONTARIO AGREEMENT

EQCU continued its coordinating role in support of the Canada-Ontario Agreement on Great Lakes Water Quality. This federal/provincial agreement provides a basis for Canada's participation in the Canada-U.S. Agreement. The Unit participated in the activities of the Technical Committee's Subcommittees on Technology Transfer and the Land Disposal of Sludge. Other principle activities concerned the administration and review of external contracts awarded under the provision of this Agreement, the preparation of detailed financial statements and the development of publication policies for Canada-Ontario Agreement reports. Staff also participated in the planning of two Phosphorus Removal Design Seminars which were attended by personnel from industry, universities and local, regional and national governments. These activities help ensure that the information produced both by the in-house (Canada and Ontario) and external research activities is effectively put into practice both by government agencies and by the private sector, particularly in the design of wastewater treatment facilities required as a result of the Agreement.

ENVIRONMENTAL CONTAMINANTS

EQCU participated in several projects related to the control of environmental contaminants. Staff assisted in defining objectives and developing protocols related to research in this area. The pesticide and organochlorine surveys of the lower Great Lakes, initiated in the previous year and coordinated by the EQCU, were completed. A report documenting the levels of these contaminants in water, plankton and fish was prepared. A report on

polychlorinated biphenyls (PCB's — in the Great Lakes environment, prepared for the IJC Water Quality Board the previous year, was up-dated. Staff members drafted Canada's reply to a questionnaire from the Organization for Economic Cooperation and Development (OECD) on the distribution of phenols in the Canadian aquatic environment, the extent of the problem, methods of treatment and economics of control.

The detection of asbestos-like particles in Lake Superior and in the Duluth water supply resulted in the initiation of considerable action. Background information was assembled to evaluate the significance of this contaminant, particularly as it pertains to Canadian waters. Evidence gathered to date indicates that Canadian population centres on Lake Superior (notably Thunder Bay) have no higher levels of asbestos in the water supply than most Canadian cities such as Toronto or Ottawa. Also, the asbestos found in the Thunder Bay water supply is a different kind from that found in Duluth, Minnesota. Meetings were called involving government and university scientists to review the implications of the available data. A sampling programme was initiated and close coordination and liaison was maintained by EQCU with U.S. Environmental Protection Agency officials.

The Unit prepared a preliminary assessment of the effects on water quality of the 1970 detergent reformulation legislation. A significant reduction in phosphorus loads to waste treatment plants was demonstrated. Thus the loading to the environment has been reduced. It has not yet been possible to demonstrate an effect on the Great Lakes themselves due to their vast size and large year-to-year variability.

The Unit continued its support of the national NTA monitoring programme through liaison with industry and by scientific assessment of the results of the monitor. The almost total absence of NTA in water supplies and the continued low level in surface and ground waters in the face of large increases in NTA usage in detergent formulations clearly indicates that NTA biodegrades rapidly and completely in the natural environment.

EQCU continued to represent CCIW on a number of interdepartmental committees, carried out a number of international functions pertinent to the work at CCIW, and carried out extensive information programmes through the giving of talks and papers at a number of conferences and symposia throughout the year.

Public Relations Unit

Public Relations Unit

In 1973, there were several new initiatives in the Centre's public relations activities. A film on the work and purpose of CCIW was completed. A new and considerably improved public visits programme was begun, and two new publications were produced.

The 20-minute colour film takes the viewer into the laboratories, aboard the research ships, and into remote field locations across Canada, showing scientists, technicians, engineers and surveyors of the CCIW at work.

This motion picture was important to the success of a new programme of public visits designed to bring the Centre and its work to larger audiences in our 300-seat auditorium. Each of the monthly events had as its highlight, a talk given by one of the Centre's many specialists and illustrated with supporting visual aids. In addition to the film on CCIW, other motion pictures augmented each presentation. Visitors also toured a laboratory specially equipped to demonstrate various pieces of current research and survey work. Considerable satisfaction was expressed by many of the more than 1,600 who had attended by year's end.

Exceptionally high lake levels with attendant storms, heavy shore erosion and considerable property damage in the early part of the year stimulated the production of two new publications designed to help the public better understand the problems and limitations of lake levels

Film crew from Visual Education Centre aboard M.V. MARTIN KARLSEN shoot CCIW staff at work on Lake Ontario.

Press conference on Great Lakes levels and shore erosion held at the Centre in March 1973.

control. "All You Wanted to Know About Great Lakes Levels" and "Shore Erosion–Cause and Cure" proved immediately popular, and with the volunteered assistance of the Ontario Ministry of Natural Resources, over 75,000 copies were distributed. By December, work was in hand to produce a short film on the subject for distribution the following spring.

Apart from the press conference called in March to launch the above publications and provide answers to the many questions being asked about floods and shoreline damage, over 30 media interviews were arranged for CCIW staff during the year.

Requests for information numbered 1,478.

Apart from several hundred people who took advantage of an "Open Ship" invitation aboard C.S.S. "Limnos" during Environment Week in the autumn, public visitors to the Centre in 1974 totalled almost 5,000.

Through the Speakers' Bureau Service, 32 outside speaking engagements were undertaken before audiences totalling over 2,200.

Statistics are one thing. Public relations effectiveness is another. The question as to what effect these efforts and those of several preceding years were having in creating awareness of the Centre and the Department's work and attitudinal changes required for better water management in Canada, was the subject of a special study by outside consultants begun at year's end. Managed by the Social Science Research Unit, this study was expected to yield a report in March 1974, which will influence the direction of future public relations programmes.

Symposium on Water Quality Parameters

Symposium on Water Quality Parameters

CCIW and the Chemical Institute of Canada sponsored a Symposium on Water Quality Parameters—Selection, Measurement and Monitoring. The 3-day Symposium, held November 19-21, 1973, at the Canada Centre for Inland Waters, was attended by more than 600 scientists from all over Canada and the United States. Other delegates came from Europe, South America and Japan.

Dr. S. Barabas, Head, Analytical Methods Research Subdivision, was General Chairman of the Symposium. He was assisted by Programme Chairmen W. J. Traversy (General and Inorganic Chemistry), A. S. Y. Chau (Organic Chemistry) and B. J. Dutka (Biological Aspects). Dr. B. K. Afghan acted as Secretary-Treasurer while Dr. Mary E. Thompson and Mr. W. Wakeham were responsible for publicity and local arrangements, respectively. Other Programme Chairmen were Mr. O. P. Bhargava of the Steel Company of Canada (Session on Parameter Selection), Mr. W. T. Sayers of the United States Environmental Protection Agency (Session on Continuous Monitoring and Remote Sensing) and Dr. T. G. Brydges of the Ontario Ministry of the Environment (Session on Quality Control).

Mr. J. P. Bruce, Director of the Canada Centre for Inland Waters, gave the opening keynote address entitled "The Role of Research in Lake Management." The second-day keynote address, given by Dr. R. A. Vollenweider, Senior Scientist at CCIW, was entitled "Sources, Pathways, Exposure and Risks of Environmental Pollutants."

In all, 127 papers were presented in six subject sessions at the Symposium. Of the 49 papers presented by DOE scientists from across Canada, 25 were by CCIW staff; there were 26 contributions by United States' scientists and one from Japan.

The Proceedings of the Conference will be published by the American Society for Testing and Materials (ASTM).

Mr. J.P. Bruce, CCIW Director, introduces the Symposium Dinner Speaker, Mr. Richard Rohmer, author of the current best seller, "Ultimatum."

Mr. Victor Copps, Mayer of the City of Hamilton, presents Dr. S. Barabas with a plaque recording the Mayor's proclamation of "Water Quality Week" for the duration of the Symposium.

Dr. R.A. Vollenweider delivers the keynote address on "Sources, Pathways, Exposure and Risks of Environmental Pollutants" to some 400 scientists.

Appendix A • CCIW Staff List

CCIW Staff List

CCIW

Director, CCIW & Director, Ontario Region, Inland Waters Directorate – J.P. Bruce
Secretary – Mrs. C.J. McMunn
Senior Scientist – Dr. R.A. Vollenweider
Assistant to Senior Scientist – P.J. Dillon
Secretary – Mrs. S.M. Horne

PUBLIC RELATIONS UNIT

Head – A.R. Kirby
Secretary – Mrs. I. Powell
Information Officer – D.M. Canning
Assistant – Mrs. E.B. Callaghan
Visual Aids Officer – I.F. McGregor

ENVIRONMENTAL QUALITY COORDINATION UNIT

Head – Dr. A.R. LeFeuvre
Secretary – Mrs. H. Hetherington
Assistants – J.W. Schmidt
Dr. J.D. Wiebe
G.A. Jones
Scientific Assistant – G. Osellame
Training Position – Dr. R.R. Weiler

HYDRAULICS DIVISION

Chief – Dr. T.M. Dick
Secretary – Mrs. E. Gervais
Administrative Officer – Mrs. E. Eidsforth
Dr. Y.L. Lau – fluid dynamics
J. Marsalek – waves, combined sewers
Dr. C.K. Jonys – sediment
Dr. M.G. Skafel – simulation
Dr. G. Tsang – ice and cold
Dr. B.G. Krishnappan – fluid dynamics

Hydrometry Unit

Head – P. Engel
Technical Staff – C. Bill, B. Leaney

Technical Services Unit

Head – C. DeZeeuw
Technical Staff – D. Fekyt, Mrs. J. Huehn, K. Pratt, J. Ross, W.K. Stage, G. Voros, D.J. Wagner, W. Welmers

SOCIAL SCIENCES RESEARCH

Head – J.P.H. Batteké – economic studies and information systems.
Secretary – Mrs. R. Riggs
G.E. Bangay – water use and environmental quality in the Great Lakes Basin
P.B. Burns – public law and administration
D.E. Coleman – dynamic modelling and geographic studies
R.G. Davy – legislative and institutional studies
T.D. Leah – toxic substances.
J.L. Pando – economics of water resources and water management
R.M. Shimizu – legislative and institutional studies
M.R. Sinclair – attitude and perception studies.
A.S. Williams – economics of water resource planning

Support Staff: Mrs. S. Begin
Ms. Marian Kaye
Mrs. J. Thomblison

SCIENTIFIC OPERATIONS DIVISION (INLAND WATERS DIRECTORATE)

Chief – Dr. R.K. Lane
Secretary – Mrs. R.E. Morrison

Microbiology Laboratories

Head – B.J. Dutka – Methods development, water quality assessment
Secretary – Mrs. M. Jurkovic
Dr. A. El-Shaarawi – biometrician (T)
Dr. W.E. Lowe – numerical taxonomy, assessment of trophicity
Dr. M.S. Mahdy – virology consultant
Dr. A.A. Qureshi – P.D.F. – ecology of fungi in Great Lakes
Dr. S.S. Rao – Great Lakes water quality assessment, assimilation studies
Technical Staff – J. Bell, D. Bolton (T), D. Doerffer, J. Henderson, W. Jack (T), A. Jurkovic, S. Kuchma, A. Kwann, R. McGinnis (T), D. Nutley

Physical Sciences Laboratories Section

Head – Dr. R.W. Durham
Secretary – Mrs. L. Roy
T. Pang – electron microscopy
F.A. Prantl – radiochemistry

Radiochemistry Technologists — R.J. Goble, Mrs. E. Csillag (T)
Electron Microscopy Technologist — D. Manolescu (T)

Technical Operations Section

Head — H.B. Macdonald
Secretary — Mrs. L.C. Bouverat
Senior Operations Officer — D.J. Cooper
Senior Diving Officer — J.T. Roe
Operations Officer, M.V. MARTIN KARLSEN — D.J. Brooks
Operations Officer, C.S.S. LIMNOS — D.H. Hanington
Standards and Development Officer — D.J. Williams
P.R. Youakim — IFYGL Centre, Special Projects
L.E. Benner — Meteorological Buoy Project
T.J. Carew — LIMNOS and MARTIN KARLSEN
H.K. Cho — Wave Climatology Beach Stability Study
J. Compton-Smith — transferred from Hydraulics, February, 1973
B.E. Clemmens — LIMNOS and MARTIN KARLSEN
F.J. deVree — Marathon
F.H. Don — LIMNOS and MARTIN KARLSEN; Diving
H. Greencorn — Rigger
P.M. Healey — Operations Officer — C.S.S. ADVENT
J.R. Irwin — LIMNOS and MARTIN KARLSEN, resigned July 1973
G.J. Koteles — LIMNOS and MARTIN KARLSEN
J. Lomas — Foreman Rigger
M.R. Mawhinney — LIMNOS and MARTIN KARLSEN
B.H. Moore — Bay of Quinte
H.K. Nicholson — Shore Sensor Programme
G.M. Perigo — Rigger
J.E. Ross — LIMNOS and MARTIN KARLSEN; Diving; transferred to Hydraulics
S.B. Smith — LIMNOS and MARTIN KARLSEN
W.B. Taylor — Electronics Technician; Meteorological Buoy Programme
M.R. Thompson — Special Projects
S.P. Withers — Operations Officer LAC ERIE; MARTIN KARLSEN
H.W. Zimmermann — LIMNOS and MARTIN KARLSEN
Term Employees — J. Bouwman, J. Hill, W. Jack, B. Killins, J. Lloyd, R. McCrea, D. Moore, K. Salisbury, D. Spry, C. Timmins, E. Walker

Remote Sensing Section

Head — Dr. K.P.B. Thomson (Acting) — remote sensing and lake optical studies
Dr. R.P. Bukata — satellite studies
Dr. H.E. Howard-Lock — consultant — remote sensing of oil spills
Dr. R. McNeil — P.D.F. — remote sensing optic studies
Technical Support — E. Bruton, J. Jerome, H. MacPhail, W. McColl

Data Management Section

Head — Dr. H.S. Weiler (Acting)
Computer Applications
Support Staff — B. Hanson, G.S. Beal, J. Dowell, H.E. Comba, B. Pyde, K. Beal, R. Morrow (T), S. Mlynek (T), R. Duffield (T)
Data Archiving — W. Nagel
Support Staff — J. Byron, K. Schopf, M.G. Smith, K. Miles, J. McAvella (T), J. Sims (T), E. Thomson (T)
Special Projects — R. Gottinger
Support Staff — A. Zingaro, D.E. Jordan

SCIENTIFIC SUPPORT DIVISION (INLAND WATERS DIRECTORATE)

Chief — A.S. Atkinson
Secretary — Mrs. L.L. Sutherland

Scientific Services

Instrumentation R & D Engineer — K.N. Birch

Computer Services

Head and Software Specialist — H.C. Pulley
Operations Supervisor — M. Kinder
Computer Console Operators — P. Moody, M. Thomson, P. Varga
Peripheral and Keypunch Operator — P. Kirkwood

Library Services

Head Librarian — Mrs. E.A.C. Fosdick
Technical Services Librarian — L.M. Brownlee
Technical Services Clerk — B.J. Davis
Cataloguing Clerk — L.J. Watson
Reference and Circulation Clerk — A.E. Thompson

Engineering Services

Head — G.A. Jones
Secretary — S. McVey

Electronic Engineering

Head — A.S. Watson
Instrument Maintenance and Calibration — A. Eatock
Digital Systems/Logic Design — E. Harrison
Electro-Optical Design — R. Desrosiers
Digital Systems/Logic Design — J. Valdmanis
Electro-Acoustic Design — B. White
Technologists — K. Mollon, J. Diaz, M. Moschos, A. Tyler, M. Larocque, M. Pedrosa, A. Fletcher, E. Smith, T. Nudds

Mechanical Engineering

Head — A.E. Pashley
Mechanical Engineers — P. Ward-Whate, B. Brady, W. Gibson

Technologists – R. Boucher, J. Heidt, H. Saville
Tradesmen – D.H. Whyte, R.V. Chumley, K.K.P. Kalter, J. Bidinost

Drafting and Illustrating

Supervisor – W.D. Finn
Draftsmen – A. Gris, M. Donnely, J. Bodnaruk

Technical Services
Head – D.F. Stewart
Building Maintenance – J. Slaz, G. Clim
Warehouse Supervisor – A.W. Mayes
Warehouse Support Staff – R.J. Haswell, D. Murphy
Stationary Plant Supervisor – K. Pearce (DPW)
Stationary Plant Support Staff – J. Cerniuk, K. Platt, A. Hyslop, J. Thomas, R. Williams, M. Connors, K. Fees, E. Kennedy, J. Smith, A. Morley (DPW)
Security – S/Sgt. R. Legg and twelve members of the Canadian Corps of Commissionaires on rotation.

Staff Services

Financial Services
Supervisor – A. Mitchell
C.C.I.W. Accounts Staff – D. Jefferson, E. Mulvaney, F. Boyd, R. Money, J. Doerr, C. Furlong

Central Registry and Duplicating

Supervisor – E. Rae
Support Staff – B. Titley, J. Hall, H. Green

Stores

Supervisor – C. Hicks
Support Staff – F. Kushner, T.A. Williams

LAKES RESEARCH DIVISION (INLAND WATERS DIRECTORATE)

Chief – Dr. P.G. Sly – distribution and variance of lake bottom sediments
Secretary – Mrs. J.E. Cunningham

Administration

Head – Mr. J.E. Aris (left Dec. 7, 1973)
Secretary – Miss N. Taylor
Support Staff – D. Jefferson, F. Boyd (transferred to CCIW, May 21, 1973)

LAKES RESOURCES SUBDIVISION

Head – Dr. G.K. Rodgers – physical and descriptive limnology
Secretary – Mrs. S. Fauman

Descriptive Limnology Section

Head – F.C. Elder – energy budgets of lakes
Dr. E.B. Bennett – circulation
Dr. N.M. Burns – nutrient cycles, especially organic sedimentation
C.H. Chan – chemical properties of the Great Lakes
H.H. Dobson – nutrients and water quality
M.E. Fox – organic compounds in lakes
A.S. Fraser – analysis of Monitor Cruise data: lower lakes
Dr. W.A. Glooschenko – toxic chemicals; chemical-biological relationships in lakes
Dr. R. McNeil (PDF) – remote sensing and optical properties of lakes
Miss S. Patrick – precipitation chemistry
D.G. Robertson – nearshore thermal regimes
M.T. Shiomi – atmospheric precipitation chemistry, nutrient cycles in large lakes (transferred to Water Quality Branch, April 1, 1973)
Dr. P. Stadelmann – photosynthetic production
N.D. Warry – analysis of Monitor Cruise data: upper lakes
Support Staff – R. Chapil, F. Chiocchio, M. Kerman, K. Kuntz (transferred to Water Quality Branch, Sept. 30, 1973), Mrs. H. Lam, F. Rosa

Regional Laboratories (Freshwater Institute, Winnipeg)

A/Head – Dr. T. Jackson – geochemical limnology
B.C. Kenney – physical limnology (educational leave – University of Waterloo)
W. Warwick – paleoecological interpretation of chironomid fauna
Support Staff – W.R. McGregor, J. Mollison

Regional Laboratories (CCIW Detachment, Vancouver)
Head – Dr. B.E. St. John – trace element geochemistry
Dr. C. Pharo – sedimentary geology of lakes and rivers
Support Staff – G. Bengert

CHEMICAL LIMNOLOGY SUBDIVISION

Head – Vacant
Secretary – Mrs. B. Blain

Water Chemistry Section

Head – Dr. M.E. Thompson – specific ion electrodes, low temperature aqueous geochemistry
Dr. R.M. Baxter – biodegradation of resin acids, nitrogen and phosphorus cycles in lakes
Dr. Y.K. Chau – trace elements and natural complexation in lakes
Dr. R. Gächter (PDF) – modification of metal toxicities by chelates
K. Lum-Shue-Chan – metal-organic interactions in natural waters
Dr. R.F. Platford – electrochemistry of mixed salt solutions
H. Saitoh – trace elements, especially lead compounds in lakes
Dr. W.M.J. Strachan – organic chemistry applied to lakes
Dr. R.R. Weiler – (seconded to EQCU for one year, Nov. 5, 1973) – CO_2:air/lake interactions

Geochemistry Section

Head – Dr. A.L.W. Kemp – distribution and diagenesis of organic compounds in recent sediments, sedimentation rates, geochemical budgets
Dr. V. Cheam – metal fulvate complexes; geochemistry of dredging
C.B.J. Gray – diagenesis of recent organic compounds, especially chlorophyll
Dr. J.O. Nriagu – stable isotopes; stabilities of authigenic minerals
Dr. J.D.H. Williams – sediment/water interface exchanges; geochemical processes in sediments
Support Staff – R.D. Coker, Mrs. N. Harper, Mrs. T. Mayer, Mrs. A. Mudrochova

Impacts and Pathways Section

Head – Dr. D.R.S. Lean – phosphorus, carbon and nitrogen dynamics in lake ecosystems
Dr. B. Brownlee – detergents and organic substances in freshwater systems
Dr. K. Burnison – microbiological ecology
Dr. K. Kaiser – toxic substances (PCB's pesticides, NTA) in the environment
Dr. C. Laio (PDF) – nitrogen metabolism in lakes
Dr. E. Nagy – oil/water studies
Support Staff – M. Charlton, J. Hart, Miss K. McEachern, T. Murphy

GEOPHYSICAL LIMNOLOGY SUBDIVISION

Head – Dr. R.L. Thomas – distribution, occurrence and authigenesis of minerals, major elements and heavy metals
Secretary – Miss N. Taylor

Geolimnology Section

Head – Dr. R.L. Thomas, acting
Dr. T.W. Anderson (GSC) – palynology of recent sediments
J.P. Coakley – distribution, occurrence and relation to erosion, transportation and deposition of active sediments
Dr. V. Damiani (PDF) – sedimentology and applied geochemistry of lakes
Dr. C.I. Dell – stratigraphic correlation and mineralogy, including clay mineralogy, of recent sedimentary sequences
J.B. Henry – geophysical instrumention (left May 24, 1973)
Dr. J.M. Jaquet (PDF) – mathematical geology
Dr. N.A. Rukavina – interpretation of sediment distributions in the nearshore area
A. Zeman – geotechnical and mineralogical studies of recent sediments
Support Staff – W. Booth, R. Dolling, G. Duncan, J. Horseman (GSC), Mr. G. LaHaie, Mrs. L. Mansey, T. Morton, R. Sandilands, D.A. St. Jacques

Physical Limnology Section

Head – F.M. Boyce – internal waves and heat content
Dr. J.O. Blanton – thermal structure and demonstration basin studies
Dr. M.A. Donelan – air/lake interaction
Dr. P.F. Hamblin – circulation and seiches
Dr. D. Lam (PDF) – numerical modelling
Dr. C.R. Murthy – diffusion and circulation
H. Ng – Okanagan – Basin studies and retention times
Dr. T.J. Simons – hydrodynamical modelling
Support Staff – D. Beesley, J. Bull, K. Miners, W. Moody

PALEOENVIRONMENTAL RESEARCH GROUP, WATER RESOURCES DETACHMENT

Coordinator – Dr. L.D. Delorme – ostracode taxonomy and ecology, use of shelled invertebrates in defining trophic state indices
Dr. L.L. Kalas – freshwater and terrestrial mollusc taxonomy and ecology
V.W. Hanson – programmer – systems analyst; paleoenvironmental research
Support Staff – Miss N. Peters

WATER QUALITY BRANCH RESEARCH (INLAND WATERS DIRECTORATE)

ANALYTICAL METHODS RESEARCH SUBDIVISION

Head – Dr. S. Barabas
Secretary – Mrs. R. Andrew
Research Scientists – Dr. B.K. Afghan, Dr. P.D. Goulden, Dr. F.I. Onuska, Dr. I. Sekerka, Dr. A.W. Wolkoff
Research Technologists – P. Brooksbank, M. Comba, R. Larose, J. Lechner and J. Ryan

WATER AND WASTEWATER TREATMENT RESEARCH SUBDIVISION

Head – Dr. C.P. Fisher
Secretary – Miss Nancy Dale
Dr. A. Netzer – Head, Research Contract Liaison and Coordination Section – ozone
P. Wilkinson – oxone technologist
Dr. H.K. Johnston – Membrane Separation – reverse osmosis
H. Huneault – Membrane Separation/reverse osmosis technologist
Dr. B.G. Oliver – toxic materials, heavy metals
E. Cosgrove – toxic materials/heavy metals technologist
Dr. J. Lawrence – water chemistry
Mrs. H. Tosine – water chemistry technologist

GREAT LAKES BIOLIMNOLOGY LABORATORY (FISHERIES RESEARCH AND DEVELOPMENT DIRECTORATE)

Director — Dr. M.G. Johnson
Secretary — Mrs. D. Moore
Typist — Mrs. N. German

DESCRIPTIVE BIOLIMNOLOGY

Dr. N.H.F. Watson — community analysis; zooplankton
Dr. M. Munawar — phytoplankton
Dr. D.G. Cook — benthos
J.B. Wilson — zooplankton
G.F. Carpenter — mysis
Technical Staff — H.F. Nicholson, L.R. Culp, E.L. Mansey, L. Devey, E. Kay, D. Gorney, G. Dupuis, C.C. Loveridge, I.F. Munawar, T. Hall and P.A. Fencott

ENVIRONMENTAL TOXICOLOGY

Dr. P.T.S. Wong — algae, bacteria
Dr. W.A. Glooschenko — algae
Dr. D.G. Wright — invertebrates
Technical Staff — L. Luxon, O Kramer, G. Burnison, B. Blunt, D. Simpson, V. Glooschenko

ECOSYSTEM METABOLISM STUDIES

Dr. J.R.M. Kelso — fish ecology and production
Dr. J.M. Cooley — zooplankton ecology and production
J.E. Moore — primary production
J.K. Leslie — electronic techniques
Technical Staff — R.H. Collins, W.H. Hyatt, M.M. Psutka, B. Moyles, M. Brooksbank, G. Dunlop, C. Charlton, J. Rockwood

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MARINE SCIENCES DIRECTORATE CENTRAL REGION

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Secretary — Miss L. Ram.

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Secretary — Mrs. R. Mikoda

Assistant Regional Hydrographer — E. Brown
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Hydrographers-In-Charge — Field Surveys
R. Courtnage — Navigational Ranges
F.L. DeGrasse — Great Lakes Surveys
R. Lewis — Playgreen Lake
R. Marshall — James Bay
J. McCarthy — Thunder Bay Survey
J. Statham — Revisory Survey
E. Thompson — Lower St. Lawrence
R. Treciokas — Lake of the Woods
G. Wade — Amundsen Gulf Decca Phase Lag Study
J. Wilson — Arctic Surveys
B. Wright — Chesterfield Inlet
Hydrographers — R. Beri, M. Casey, R. Chapeskie, I. Charron, V. Crowley, M. Crutchlow, K. Daechsel, P. Davies, B. Eidsforth, G. Goldsteen, C. Gorski, K. Hipkin, D. Kimmett, R. Langford, R. Lasnier, C. Leadman, G. Macdonald, J.R. MacDougall, R. Mahaffy, H.J. Marshall, J. Medendorp, R.L. Moulton, E.I. Norman, W.H. Pulkkinen, R. Rehbein, R. Robitaille, W. Silvey, R. Solvason, J.H. Weller, A.P. Welmers

Hydrographic Development

A/Head — R. Bryant
Technical Staff — R. Tripe, C. Doekes, N. Robinson, P. Richards

Marine Information Centre and Local Surveys

Head — A.R. Rogers
Technical Staff — R. McMicking, P. Pagé, J. Kean, M. Grant

U.S. Exchange Program

E. Thompson — U.S. Lake Survey
P. Heltunen — U.S. Exchange

Cartography — Drafting

Head — J.C. Elliott
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Secretary — Mrs. J. Fiddes

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R. Boulden
D. Paganucci
V. Rawlins
J. Shaw
G. Willson
B — Co-op Students

Hydrodynamics Section

Head — N.G. Freeman
L. Barfoot
J. Gervais
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T. Pullen
S. Venkatesh
1 – Co-op Student

Survey Electronics Section

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Shop Foreman – W.W. Smith
H. Boyce
G. Kavanagh
P. Millette
W. Montgomery
M. Moore
A. Prudhomme
D. Pyatt
B. Waldock

SHIP DIVISION

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Secretary – Mrs. F. Haaka
Engineering Superindent – A.T. Hughes
Shore Boatswain – W.S. Corkum
Shop Foreman – K.D. Robertson
Shop Staff – M. Ames, J. Boyle, D. Cook, J. Fasullo, V. Rahelic, J.A. Vanderslikke

C.S.S. "Limnos"

Master – Capt. N.L. Keeping
Officers – M.C. Birchall, R. Dean, T.C. Kenney, G. Sproule, J. Stansfield (11 Ships Crew)

C.S.S. "Advent"

Master – Capt. I. Williams
Officer – R.R. Charles (2 Ships Crew)

Launches

Scientific Support – 18 Seasonal Ships Crew
Hydrographic Surveys – 70 Seasonal Ships Crew

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Secretary – Miss J. Major
Assistant Administrative Officer – B.J.T. O'Hagan
Office Manager – J.R. Dobson
Accounts – A.B. Mitchell
Procurement & Sotres – E.R. Gibbons
Support Staff – Mrs. J. Crescuolo, B. Day, C.J. Fulton, Mrs. L. Gibson, Miss M. Girouard, Mrs. F.M. Hannay, J. Mellon, J.G. Rothwell, Mrs. P. Taylor, T.H. Taylor

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Head – N.W. Schmidtke
Physical Processes Unit – Dr. B.P. Le Clair
Biological Processes Unit – Dr. B.E. Jank
Chemical Processes Unit – Dr. E.E. Shannon
Soil Processes Unit – Dr. V.K. Chawla

Demonstration Section
Head – R.E. Mills

Laboratory Services Section
Head – K. Conn

Facilities Services Section

A/Head – A.D. Stephenson
Stores – D.M. Niles

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Administration

Administrative Officer – J. Dobson
EPS Accounts – Mrs. J. Crescuolo
Support Staff
Stenographic and Clerical – Mrs. R.L. Veerdonk, Mrs. S. Perrone, Mrs. S. Lawson, Mrs. M. Wilson
Technical and Operational – G.A. Anthony, W.K. Bedford, D.N. Bryant, P.J. Crescuolo, P.J. Fowlie, J.L. Fraser, R.G. Gillespie, D.H. Ide, Mrs. K. Kwasniewska, E.J. Ladouceur, G.J. Lawrence, S.C. Lee, N.C., Longhurst, E.G. Luxon, S. Metikosh, B.A. Monaghan, J. Salvo, A.R. Stickney, D.T. Vachon, P.A. Van Hardeveld

ENVIRONMENTAL EMERGENCY BRANCH CENTRE OF SPILL TECHNOLOGY

Head – Dr. S.L. Ross
Dr. W.J. Lem – Oil Spill Treating Agents
Mr. W.J. Logan – Mechanical Equipment

INLAND WATERS DIRECTORATE
ONTARIO REGION OPERATIONS

WATER QUALITY BRANCH

WATER QUALITY LABORATORY AND NETWORK

Head – W.J. Traversy
Secretary – Mrs. V. Walker
Administrative Officer – W.M. Wakeham

Analytical Services Section

Head – F.J. Philbert
Inorganic Analysis – D.P. Sturtevant
Ship Support Laboratory – O. Elkei
Organic Analysis – R.C.J. Sampson
Support Staff – H. Alkema, N.C. Arafat, K.D. Austen, D.T. Bennie, W.D. Blythe, P.D. Bothwell, A.D. Bobrowski, J. Carron, Mrs. C. Dean, J. Gamble, S. Hicks, J.R. Leacock, K. Li, R. Luft, D. Marsh, P.W. McDermott, G.M. Paquette, D.B. Sergeant, Y.M. Sheikh, K.A. Terry, H.H. Tse, J. Verlinden, R.W. Wales, R.J. Wilkinson

Special Services Section

Head – A.S.Y. Chau
Quality Control – D. McGirr
Method Development – K. Aspila
Chemists – H. Agemian, J. Coburn

Monitoring and Surveys Section

Head – M.T. Shiomi
Support Staff – K.W. Kuntz

WATER PLANNING AND MANAGEMENT BRANCH

Toronto Office

Head – D.M. Foulds
Secretary – Miss W. Grant

Burlington Office

Engineer-in-Charge – N.P. Persoage
Secretary – Miss D.M. Smith
Engineers – J.D. Keefe, D.W. Brown, W.M. Jones, P.P. Yee
Technical and Support Staff – C.L. Hanes, J.P. Charron, R.J. Lloyd

Cornwall Office

Engineer-in-Charge – D.F. Witherspoon
Secretary – Mrs. S.A. Lowe
Assistant Engineer – J.R. Robinson
Technical and Support Staff – R.J. Young, E.G. Allen, Mrs. A.L. David

WATER SURVEY OF CANADA

DISTRICT ENGINEER	E. A. MacDonald
SECRETARY	Miss M. R. Milson
ASSISTANT DISTRICT ENGINEER	M. H. Quast (Acting)

Field Operation Section

Southern Ontario – Area Engineer – M. H. Quast
Support Staff –

M. J. W. Abrahamse	B. D. Magee
D. J. Copeland	G. R. Melendy
E. J. Firman	J. Ritchie
F. Kovats	P. J. W. Ryan
D. J. Lawlor	B. D. Smith
R. S. LeBlanc	R. P. Stephens
R. A. Mace	E. G. Waugh

Northern Ontario – Area Engineer – F. M. Sullivan
Support Staff –

R. T. Bishop	F. J. Rading
D. B. Curtis	D. G. Rowe
J. J. Doucet	J. H. Swann
R. E. Hayward	J. W. Ward
O. D. E. Larsen	G. P. Wiggins

Data Control Section

Head – R. J. Myslik
Data Review – Engineer – B. W. Kitchen
H. A. McGarvey Mrs. F. C. Howitt
Hydrometric Data – Mrs. V. L. Cunningham
Mrs. D. M. Lucchetta

Administrative Officer – W. A. Taylor
Support Staff – Mrs. M. J. Kelly, Mrs. G. M. Rolston

Network Planning and Forecasting – J. E. Slater

Special Studies and Services – B. D. Poyser
Support Staff – R. A. Rees

Niagara River Board of Control – W. M. Archer

Appendix B • Publications and Presentations

Publications and Presentations

PUBLISHED PAPERS

Anderson, T.W. Historical evidence of land use in a pollen profile from Osoyoos Lake, British Columbia, Geological Survey of Canada, Report of Activities, Paper 73-1, Part A, 1973, p. 178-180.

Barabas, S. Analytical research at the Canada Centre for Inland Waters. Can. Res. Devel. 6(2): 21-25. 1973.

*Baxter, R.M., R.B. Wood and M.V. Prosser. The probable occurrence of hydroxylamine in the water of an Ethiopian lake. Limnol. Oceanog. 18: 470-472. 1973.

*Talling, J.F., R.B. Wood, M.V. Prosser and *R.M. Baxter.* The upper limit of photosynthetic productivity by phytoplankton: evidence from Ethiopian soda lakes. Freshwat. Biol. 3: 53-76. 1973.

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Bruce, J.P. The role of research in lake management. Proc. Symp. on Lakes of Western Canada, Univ. of Alberta Water Resources Centre Publ. No. 2, 1973, p. 8-24.

Bruce, J.P. Opening remarks, "Water resources management in Canada." Proc. Symp. on Remote Sensing and Water Resources Management. Amer. Water Resources Assoc. Proc. Series 17, 1973, p. 1-2.

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Bukata, R.P. and *W.D. McColl.* The utilization of sun-glint in a study of lake dynamics. Proc. Symp. on Remote Sensing and Water Resources Management. Amer. Water Resources Assoc. Proc. Series 17, 1973, p. 351-367.

Bukata, R.P., U.R. Rao, K.G. McCracken, and E.P. Keath. Observation of solar particle fluxes over extended solar longitudes. Solar Physics 33: 229-240. 1972.

Falconer, A., S.H. Collins, W.T. Dickison, R. Protz, *R.P. Bukata, K.P.B. Thomson,* G.P. Harris, and P.J. Howarth. Studies in the Lake Ontario Basin using ERTS-1 and high altitude data. Proc. Symp. on Significant Results Obtained from ERTS-1. Goddard Space Flight Centre, Maryland, Paper W. 14, 1973, p. 819-828.

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*Based on work done before joining CCIW.
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Dutka, B.J. Coliforms are an inadequate index of water quality. J. Envir. Health. 36: 39-46. 1973.

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Appendix C • Contracts and Grants

Contracts and Grants

To construct and test a bank of six or eight simulator columns; half to be used for studies simulating sediment/water exchange processes under lacustrine conditions, and half to study biotic processes under controlled lighting and thermal structure regimes. Phase II (Techwest, Vancouver – $150,000). (Contract liaison by LRD and FRB-CCIW).

Repair, overhaul, modification and reduction to spares of Recording Current Meters and associated equipment, including Special Investigations and Technical Studies, both in and out of the plant. (Canadian General Electric Co. – $95,000).

To design, supply and erect at site Cold Rooms A, B and C. (Crescent Air Conditioning Ltd. – $92,098).

Design of Wind/Wave Flume. (Dilworth, Secord, Meagher & Associates Ltd. – $92,000).

Design, supply, install and test wave generation equipment. (MTS Systems – $88,597).

To assess the effect of selected dredging and dumping activities on a BEFORE, DURING AND AFTER basis. Studies have been designed to look at the physical and hydrographic aspects of the sites, the geochemistry and engineering properties of the sediments, and the related benthic communities. (In addition, special studies have been made to look at the possibilities of exchange which may take place in sediment plumes related to both dredging and dumping activities. A preliminary assessment of repopulation of benthic forms is also included.) (Chemex-Envirocon Ltd. – $55,000, extended by $21,000 to $76,000).

To design and supply a fan and drive system for the wind/wave flume. (Sheldons Engineering Ltd. – $73,184).

To apply a physical-mathematical model to estimate the potential benefits and costs if offshore diffusers were employed for waste heat rejection to the Great Lakes. (H.G. Acres Consulting Services Ltd. – $53,500).

To design and supply a reversible, variable speed pump for the wind/wave flume. (Peacock Brothers Ltd. – $34,237).

Development of a submersible sensing head. (Dilworth, Secord, Meagher & Associates Ltd. – $21,000).

To determine the water loss from the Great Lakes Basin due to waste heat discharge to be expected by the year 2000. (H.G. Acres Consulting Services Ltd. – $19,800).

Development of electrochemical devices for use as environmental sensors to detect and measure dissolved oxygen, water vapour and velocity of water currents. (Trent University – $19,107).

To provide a team of eight technicians to perform laboratory services for the Department of the Environment with water samples. (Technical Services Laboratories – $19,000).

To compile radiation measurements from over Lake Ontario during the International Field Year and develop a radiation balance model for Lake Ontario (Department of Geography, McMaster University – $17,624). Prof. John Davies.

Reduction and analysis of radiation data collected during the International Field Year on the Great Lakes. (McMaster University – $17,624).

To provide X.R.F. and analyses of Great Lakes bottom sediment samples, to show the regional distribution of major and trace elements and nutrients, and to provide data for factor analysis and correlation of variables. (Poseidon Consultants, B. Cook – $15,000).

To calibrate an X-ray Fluorescence Spectrometer for 36 major and trace elements for the analysis of dredged sediments at CCIW. (Poseidon Consultants Inc. – $15,000).

Analysis of a pump test from a well penetrating several aquifers to determine the characteristics of individual aquifers. (James F. MacLaren Limited – $13,000).

Examine effectiveness of CCIW public relations programme. (Resources Management Consultants Limited – $13,000).

Pilot plant studies on biological nitrification/denitrification. (McMaster University – $12,500).

Supply engineering services for sediment handling equipment. (Reid, Drowther, & Partners Ltd. – $12,000).

Examination of Ottawa River water and recreational waters for human pathogenic viruses. (University of Ottawa – $11,945).

The establishment and development of sensitive techniques for the concentration and detection of small amounts of virus in large volumes of water. (University of Western Ontario – $10,250).

Studies on detection of animal viruses in farm effluent. (University of Guelph – $10,250).

Applicability of Vollenweider's model to small lakes. (University of Toronto – $9,998).

To design and evaluate a bank of eight simulator columns, approximately 1 m diam. x 4·5 m high; and to conduct materials testing to ensure a contaminant-free system. Phase I (Techwest, Vancouver – $9,900). (Contract liaison by LRD and FRB-CCIW).

Advise on water quality criteria in the Great Lakes with respect to potentially polluting substances. (D.H. Matheson – $8,000).

To study the atmospheric contribution to loading of nutrients, heavy metals, and toxic materials to the waters of the upper Great Lakes. (D.H. Matheson – $8,000).

To investigate the effect of winter ice action on shoreline erosion on Point Pelee, Ontario. (Industrial Research Institute, University of Windsor, Dr. G.J. Dickie – $7,382).

Provide consulting services in the design of a magnesium carbonate pilot plant. (Cambrian Engineering Group Ltd. – $5,500).

To provide electronic and data processing support. (J. & F. Associates – $5,400).

Analysis of organic carbon isotope ratios of Lakes Ontario and Erie plankton, bottom sediment, and bluff materials. (University of Waterloo – $5,000).

Analysis of organic carbon isotope ratios in 80 samples of Lakes Erie and Ontario plankton. (University of Waterloo – $5,000).

Provide analytical services to a research program on the Bay on Quinte. (University of Guelph – $5,000).

To carry out chemical analysis, to determine the carbon 12/carbon 13 isotope ratios of photoplankton – sediment organic matters – bluff materials – and suspended load from selected samples around Lakes Ontario and Erie. (University of Waterloo, Earth Sciences. Dr. P. Fritz – $5,000).

To analyse water level and current meter data collected in the Oshawa region of Lake Ontario and during the IFYGL for edge waves and compare the results with the predicted behaviour. (Mr. James R. Salmon – $4,900).

To conduct a high resolution seismic profiling survey in the nearshore zone of the Scarborough Bluffs. (Ter-mar-ex Limited – $4,500).

The effect of run-off from cattle feedlots on the water quality of receiving streams. (York University – $4,305).

To assess by means of controlled greenhouse experiments, the ability of polluted sediment materials taken from selected dredged sites in the lower Great Lakes in 1973, to develop desirable textural conditions and to support plant growth, and to study the relative uptake (plant) and residue (in soil) of various toxic/trace metal components. (Miss June Judge – $4,000).

Research study on the biological conditions of the Lower Great Lakes. (University of Waterloo – $3,500).

Heat content surveys on Lake Ontario. (University of Toronto – $3,474).

Analytical services as part of a study of the Bay of Quinte. (University of Guelph – $3,300).

Examination of methods of treating contaminated bottom sediments, and preparation of a program of work designed to identify and develop processes with high potential. (Acres Consulting Services Ltd. – $3,000).

To examine methods of treating contaminated bottom sediments and to prepare an outline design to study and identify and develop processes related to mechanical inversion, pelletizing or chemical stabilization, and bottom sealing. (H.G. Acres Consulting Services Ltd. – $3,000).

Calibration of X.R.F. facility, at CCIW, for online analyses of an extended selection of trace metals. (Poseidon Consultants, B. Cook – $2,000).

To complete ongoing studies on metal fulvate complexes in relation to natural and artificial chelation activity. (Dr. V. Cheam – $1,500).

To determine whether palynological techniques can be used to date nearshore sediments of sand size in the same manner that they have been applied to finer basin sediments. (Miss G. MacInnis – $1,300).

The following contracts were let by CCIW and funded under the Canada-Ontario and Canada-United States Agreements on Great Lakes Water Quality.

Land Application of sewage sludges. (University of Guelph – $119,660).

Dredging impact study. (Chemex-Envirocon Ltd. – $55,000).

Waste heat mathematical model development and benefit analysis of offshore diffusers. (Acres Consulting Services – $53,500).

Urban Runoff study. (James F. MacLaren Ltd. – $50,000).

Settling behaviour of physical-chemical slurries. (University of Toronto – $28,000).

Assessment of polymers as aids to removal of phosphorus from waste-water. (McMaster University – $25,543).

A study to identify hazardous polluting substances and specify realistic concentration limits. (James F. MacLaren Ltd. – $20,000).

Economic impact of possible price increases resulting from management of waste heat discharge. (Canadian Resourcecon Ltd. – $20,000).

Comprehensive compendium of critical sediment motion data for mobile boundary channels. (Northwest Hydraulic Ltd. – $20,000).

Study of the recovery of metals from sludge incinerator ash. (Cambrian Processes Ltd. – $20,000).

Land application of sewage sludge under adverse conditions. (Regional Municipality of Niagara – $19,000).

Effects of waste heat inputs. (Acres Consulting Services – $19,800).

Feasibility of chemical regeneration of activated carbon for use in municipal wastewater treatment. (Canadian Industries Ltd. – $18,800).

Studies to control and treat combined sewer overflows. (Acres Consulting Services – $17,000).

Development of a computer-aided technique for the design of regional sludge disposal systems. (B&P Silveston Ltd. – $16,800).

Studies to control and treat combined sewer overflows. (Pollutech Pollution Advisory Services Ltd. – $15,900).

Study to refine the computer model to predict equilibrium conditions within the sewage lagoon. (Pollutech Pollution Advisory Services – $15,000).

Effluent polishing by filtration through activated alumina. (Pollutech Pollution Advisory Services – $15,000).

Methods of reclaiming phosphates and metals from activated sludges. (University of Waterloo – $14,471).

Removal of nutrients from water samples by partial ozonation. (University of Sherbrooke – $14,271).

Establish viable methods of maintaining waste treatment facility efficiencies. (James F. MacLaren Ltd. – $13,700).

Novel vessel waste treatment systems. (James F.

MacLaren Ltd. – $12,050).

Study of the economic consideration of the solidification of phosphate sludges using industrial sulphate waste and fly ash. (Acres Consulting Services – $12,000).

Examination of sewage and sewage sludge for enteroviruses. (Ontario Ministry of Health – $11,000).

To provide specific information concerning nature and location of specialized land use categories in the Great Lakes Basin. (Crysler and Lathem, Consulting Engineers and Resource Planners, Willowdale, Ontario. – $10,400).

Aerobic digestion of organic sludges containing inorganic phosphorus precipitates. (University of Toronto – $10,000).

Determine behaviour of heavy metals applied in chemical sewage sludges to agricultural land. (University of Toronto – $10,000).

To prepare and conduct a Technology Transfer Design Seminar concerned with phosphorus removal. (James F. MacLaren Ltd. – $10,000).

Lake Column Simulator – Phase I feasibility study. (Techwest Enterprises Ltd. – $9,930).

Evaluation of Barber-Colman Wetox process for sewage sludge disposal. (Ontario Research Foundation – $9,000).

Technology Transfer Design Seminar on phosphorus removal. (James F. MacLaren Ltd. – $5,000).

To undertake a legal analysis of potential public participation in water resources management in Canada. (G. Morley, University of Manitoba – $5,000).

Construct a prototype bed level plotter. (Mr. Roy Gitzel – $4,000).

Design and inspection of motor drive for instrument carriage of the 2M flume. (Dilworth, Secord, Meagher & Associates Ltd. – $4,000).

Handling of quicklime for phosphorus removal. (Control & Metering Ltd. – $3,000).

Study of four basic ship sewage treatment systems as part of the programme on novel vessel waste treatment. (Pollutech Pollution Advisory Services Ltd. – $2,900).

To analyse survey data on the Attitude of Municipal Officials toward innovative treatment techniques. (R. Echlin, Toronto – $1,500).

To research the economic of information. (Professor J. I. Vorst, University of Manitoba). IWD, Ottawa.

Physiological and ecological studies of the bacterial flora of the Saint John River in relation to industrial pollution ($24,580). Drs. Mervin and Maxine Franklin and Dr. W. Coulter, University of New Brunswick.

Traitements biologiques des eaux usées. ($15,000). Prof. R. E. Simard, Laval University.

Bacterial ecology in relation to water quality in the Ottawa River. ($13,500). Dr. D. J. Kushner and Dr. J. B. Armstrong, University of Ottawa.

Studies on the efficiency of available techniques for the concentration and recovery of viruses and the examination of Ottawa River water and recreational waters for the presence of human pathogenic viruses. ($11,945). Dr. J. C. N. Westwood, University of Ottawa.

The establishment and development of sensitive techniques for the concentration and detection of small amounts of virus in large volumes of water. ($10,250). Dr. E. L. Medzon, University of Western Ontario.

Studies on the detection of animal viruses in farm effluents. ($10,250). Dr. J. B. Derbyshire, University of Guelph.

The examination of recreational water for the incidence of pseudomonas aeruginosa and coagulase positive staphylococcus aureus and their potential as indicators of water quality. ($9,920). Pat Seyfried, Dept. of Hygiene, University of Toronto.

Decomposition of water pollutants by aquatic fungi from polluted waters in New Brunswick. ($3,700). Dr. N. J. Whitney, University of New Brunswick.

Confirmatory Tests for the identification of pesticide residues as effected through reduction with sodium naphthalenide. ($4,994). Waterloo Research Institute, University of Waterloo.

ERTS Contracts

Optical studies for assisting in the evaluation and interpretation of ERTS satellite imagery relating to water quality ($23,600) *Phase I:* Design, assembly and testing of transmitter-receiver system. Conduct propagation and scattering studies at CCIW to determine feasibility of the system as a workable water Lidar. *Phase II:* Operational field test on board CCIW research ship. Prof. A. Carswell, York University.

Application of satellite imagery to the study of Big Quill Lake. ($23,560). J. Whiting, Saskatchewan Research Council.

Application of satellite imagery to the study of the St. Lawrence Valley area in particular Lake St. Louis and Lake St. Pierre. ($12,568). Dr. A. Soucy, Centre de Recherches sur l'eau, Laval University, Quebec City.

Application of satellite data to freeze-up, break-up and changing configuration of lakes in Northern Quebec and Labrador. ($9,210). Dr. J. T. Parry, McGill University.

Application of ERTS imagery to the study of the ice regime on Lake Erie and the reservoir areas above the Churchill Falls power development in Labrador. ($3,500). Mr. P. J. Denison, H. G. Acres Consulting Services Limited, Niagara Falls.

Application of satellite imagery to the inventory of the surface and ground water patterns in the Cooking Lake and Gull Lake basins in Alberta, Canada. ($3,209.40). Prof. A. H. Laycock, U. of Alberta, Edmonton, Alberta.

Application of satellite imagery to water mass delineation of western Lake Ontario. ($2,714). Dr. J. C. Munday, Jr., Erindale College, U. of Toronto.