Environment Canada | Environnement Canada

Planning and Finance Service
Report No. 4

ENVIRONMENTAL MONITORING

A Compendium of Data Gathering Activities of Environment Canada

D. Robert MacKay and D. Glenn MacDonell

ENVIRONMENTAL MONITORING
A Compendium of Data Gathering Activities of Environment Canada

---

D. Robert MacKay and D. Glenn MacDonell

Résumé en français

Environment Canada
Planning and Finance Service
Report No. 4
Ottawa, 1975

Issued under the authority of the
Honourable Jeanne Sauvé
Minister, Environment Canada

Information Canada
Catalogue No. En36-509/4
Ottawa, 1975

PREFACE

There have recently been a number of national and international initiatives related to environmental monitoring and surveillance received by the Department and it has had to respond to requests for information from both the United Nations Environment Program and the Interdepartmental Committee on Environmental Statistics. These and other concerns have dictated the need for a departmental policy paper on our on-going data-gathering activities.

As a first step, two members of the Science Policy Branch, D. Robert MacKay and D. Glenn MacDonell, were asked to prepare a comprehensive inventory of the existing on-going data-gathering activities undertaken by Environment Canada. While an attempt was made to emphasize only those programs which were on-going in nature, it would be naive to presume that the programs are rigidly unalterable. Consequently there are certain to have been small changes made since this description was prepared. Also, because of the delay in publishing this paper, budgetary and manpower figures should only be used for comparative purposes. Finally, while numerous references to the number of various reporting or sampling procedures are made, it should be remembered that these too, may have changed.

Its publication at this time hopefully will provide a starting point for discussion and debate as to the types of monitoring programs that will be needed in the future. This is an essential precursor to the preparation of the policy paper.

M.C.B. Hotz,
Director,
Science Policy Branch.

SUMMARY

This compendium of environmental monitoring activities in the Department lists and describes those programs which perform regular data-gathering activities, in terms of the physical parameters measured and the use to which they are put. The prime requisite for inclusion in this compendium is whether or not the program is open-ended and the data is being collected continuously. In essence, this means that research projects have not been included. While the primary purpose of this publication is to serve as an inventory of the existing programs undertaken by the department, a restriction was imposed at the outset to include only environmental data, and leave the description of demographic and economic data collection activities to another study.

RÉSUMÉ

Dans ce résumé des activités de contrôle environmental du ministère de l'Environnement, on énumère et décrit les programmes de collecte régulière de données en termes de paramètres physiques mesurés et de leur utilisation. Il faut avant tout savoir si le programme est ouvert ou non et si les données sont recueillies continuellement pour qu'ils soient inclus dans ce résumé. Autrement dit, les projets de recherche en ont été exclus. Le but premier de cette publication étant d'inventorier les programmes actuels entrepris par le Ministère, on a imposé une restriction au début pour qu'elle ne comprenne que les données environmentales; la description de la collecte de données démographiques et économiques doit faire l'objet d'une autre étude.

CONTENTS

Elements of the Department of Environment carry out a large number of "routine" data gathering activities in order to fulfill their various mandates. In the recent past, concern about whether we are doing the right things (or enough or too many) to meet previous commitments and the attempt to deal with the environment as a whole have led us to examine these activities. In a department composed of various groups, each with its own history and traditions and each continuing its programs from the past, we need to consider the different approaches to monitoring to see whether a Departmental policy can be created and described.

In 1972, senior management requested a study of the programs. The emphasis in the initial report, prepared by Dr. Peter Meyboom, then Director of the Science Policy Branch, lay in clarifying the concepts underlying environmental measurements, especially monitoring, and listing what were seen to be the main federal-provincial and organizational issues in Environment Canada with respect to environmental measurements. This report was accepted for information but no action was taken.

Recently, interviews have been conducted with staff of all the Services to gather data for a compendium listing long-term data gathering activities of the Department. In addition, the views of those involved in these activities were obtained on the more general problem of *monitoring*. Many definitions have been advanced for this word and almost every person we spoke with used the word in a different sense.

As several senior scientific staff of the Department have pointed out to us, it is difficult to distinguish between *monitoring* data collection, and *research* data collection - in fact, data collected in monitoring programs are frequently used for research projects. As a result, the aspect of monitoring that seems key to our present concern is that monitoring programs are "open-ended". In other words, they are programs of data collection that are initiated with a view to their indefinite continuation. We have used this as the most important criterion in our definition of monitoring.

The concept of monitoring is clearer when the measurements are made on a well-understood system. In simple systems that we deal with every day, observations are repeatedly made which lead to actions to modify the system if necessary. In very simple cases, such as the heating of a room, the process can even be automated. Temperature measurements are made continuously; if the temperature drops below a certain value, more heat is added to the room. However, in the large, interdependent systems that we deal with in

the environment, we often have a poorly developed understanding. We are not sure of the key parameters that control the system, or in fact indicate what is happening within the system. Hence it is logical that research must be carried on so that monitoring programs can be properly designed and adequately implemented. The same data collection programs often provide information for research projects to increase our understanding as well as information used for managing the system as best we can with our present knowledge. Hopefully the ultimate utilisation of some of the data for research purposes will lead to modifications to improve the data system from a management information point of view.

It has been fashionable to attempt to distinguish between surveys, surveillance, and monitoring. We think that this can be useful, although it is important to point out that, since there are no commonly accepted definitions, we must somewhat arbitrarily create our own. Our definitions are based on those put forward by M.W. Holdgate, the Director of the Central Unit on Environmental Pollution of the British Department of Environment. His definitions dealt primarily with pollutants and we have broadened them to encompass both the Environmental Quality and Resource Management concerns of our Department. A *survey* is an operation designed to assess the present pattern of certain variables in *space*. *Surveillance* deals with *temporal trends* and the relation of such trends to various causes. In *monitoring*, the values of the parameters and trends in them are examined to judge the effectiveness of measures undertaken by Government agencies or others as part of a *management* program. This definition can apply to programs as diverse as fish population studies and effluent outfall measurements. As Holdgate says, "Surveys, surveillance and monitoring are tools of administration and an essential part of resource management". By *managing* a resource, we would include both controlling it as in the case of plant, animal or fish populations, and making management decisions on the basis of the information (such as responding to weather forecasts for agricultural decisions, flood precautions, etc.).

Often we can discern a progression from a research activity which studies a particular area at one time, or perfects a new technique or checks for the presence of some substance, to a monitoring program in which data is routinely collected to be available for management decisions. An example of this is the NTA program instituted at the Canada Centre for Inland Waters (CCIW) and now part of the Water Quality Branch's monitoring program. Initially a research project attempting to detect the presence of this substance in samples collected at a number of locations, it has become a regular

monitoring program to follow the concentration of NTA and ensure that it is not found to occur in potentially harmful amounts.

As a general rule, baseline studies, such as the description of the present state of an area where planned industrial activity may have an environmental impact, have been considered as research projects. However, in those cases where there is a high probability of continuing repeated measurements of the type made in baseline studies, the project is listed in this compendium. These represent examples of research projects which could become monitoring projects.

Certain charting and assessment activities, such as hydrographic mapping and the Canada Land Inventory, have not been included in the main body of this compendium because it was felt that they did not meet the criterion of continuing, repeated measurements of a number of parameters.

This compendium is restricted to Environmental Data, in particular, physical, chemical, and biological data. Demographic and economic statistics (for example, numbers of ships in fishing fleets, and numbers of people employed on them) are not included.

In the course of conducting the interviews, a number of general observations were made. Our more detailed investigations confirm Peter Meyboom's observation, "The widespread use of the term 'environmental monitoring' may have created the impression that all parts of the Department are essentially doing the same thing, for the same reasons and without much coordination ... however, there are many types of environmental measurements and ... these measurements can be taken in various ways.... Thus, the issue of duplication in data networks and environmental monitoring is essentially one of semantics. In fact, there seems to be very little overlap of activities...." Data are being collected to meet particular program needs, and even in cases where it seems that similar data are being collected by different groups there often are essential differences in the accuracy required, the frequency of observations, etc. For example, both the Ocean and Aquatic Affairs and the Fisheries Management collect sea-surface temperatures on the West Coast. However, the Ocean and Aquatic Affairs requires quite accurate data, but not available immediately, whereas the Fisheries Management requires much less accurate data, in real-time, and often from different areas, for broadcasts to fishermen.

Several people commented on the good inter-service co-operation developing at the operating level in the regions. They pointed out that data which had been collected was usually willingly

exchanged. However, the structure of the existing programs (each designed to serve its service) made it difficult to acquire *new* data which would be of interest to people not in the service operating the program.

2.1 Central and Field Services Directorates

One of the major objectives of Atmospheric Environment Service (AES) is to contribute effectively to the improvement of the national economy, the enhancement of the environment and raising of the quality of life through the full application of atmospheric and ice information. Extensive data-gathering networks have been established over the years to provide the necessary information in order to pursue this end. The data-collection networks, encompassing both atmospheric and ice information, serve two purposes - those of a real-time nature for immediate analysis, forecasts and information use, and those requiring archived historical data in depth for statistical analysis and subsequent use by planners, engineers, designers, etc. These networks have incorporated high levels of sophistication over their hundred years of operation. It is because of this marked sophistication and extended coverage that 46.4% of the operating and capital expenditures for 1972-73, representing $26.2 million, was used for the collection of atmospheric and ice data. A further $18.4 million or 32.4% of AES's budget, was used in support of processing and analysing this scientific information and providing forecasts and other related information.

2.1.1 Synoptic Observations

The principal network which represents the core of AES's commitment towards data collection consists of 295 synoptic observing stations of which 11 are fully automated. These stations take detailed observations every six hours on various aspects of the atmosphere. In addition to the detailed data collection every six hours, 172 of these same stations also gather hourly observations of more general atmospheric parameters such as temperature, wind, pressure, humidity, precipitation and cloud cover.

All field operations within AES are administered by six regional offices. The management and administration of the observing networks are handled by the regional offices, although over-all planning and coordination is provided by AES Headquarters. There is a Weather Central in each region and 11 major weather offices (sometimes co-located with the Weather Centrals) where weather analysis and forecasting duties are carried out. In addition there are 43 secondary weather offices where information and advice on local weather conditions are provided, based on forecasts received from the Weather Centrals and major offices. Weather observations are taken at these offices as well. The remainder of the synoptic observing stations are classified as weather stations and their function is limited to observing and transmitting the local weather conditions.

Every hour the observed data are collected by a central computer complex and supplied to all Regional Weather Centres and most weather offices for analysis and forecast purposes. The data also go to a Canadian Meteorological Centre in Montreal where actual and prognostic maps are prepared and transmitted to the Regional Weather Centres and weather offices across the country by facsimile. Weather forecasts are transmitted from the Weather Centres to the press and to smaller weather offices for distribution to concerned user groups and the public. In addition, data from a large number of Canadian stations are routinely transmitted to the United States and other nations for their analysis and forecasting and procedures. While the hourly and six-hourly synoptic observations are taken primarily for immediate weather analysis and forecast requirements, all of the information is eventually processed, quality controlled, and archived as climatological data. All original observing sheets from all types of stations are sent to AES Headquarters in Toronto, usually through regional processing centres. Final responsibility for archiving is at Toronto.

Although there are over 500 full-time AES employees participating in data collection operations, this service receives considerable help from other cooperating agencies. The synoptic weather stations are manned by staff from Atmospheric Environment Service (AES), Ministry of Transport (MOT), Department of National Defence (DND) and personnel employed through individual service contracts. In addition, 330 merchant and Canadian Coast Guard ships supply occasional information to the system.

2.1.2 Climatological Data

For climatological studies, a dense network of relatively simple observing stations is required; data provided by the synoptic stations are not enough. Thus an additional network of approximately 2,250 climatological observing stations is used to measure primarily temperature extremes and precipitation, including snowfall data, twice a day. Most of these stations are operated by volunteers, but several hundred are manned by such cooperating agencies as provincial forestry and hydro services, federal agricultural and transportation agencies, industrial and commercial companies, etc. In a manner similar to that used for the synoptic data sheets, the observational report forms from the climatological stations are sent each month to Regional Data Processing Centres and the AES Headquarters for final quality control processing, publication and archiving.

2.1.3 Upper Air Observing Network

Whereas the two previously mentioned networks are concerned entirely with ground-based data acquisition a separate system has

been set up to monitor the upper atmosphere twice daily. At 38 stations, located principally in the North, radiosonde instruments are released and rise through the atmosphere, making continuous readings of pressure, humidity and temperature to heights of 30,000 metres. Data are transmitted to a tracking station below and, by plotting the drift of the balloon, wind velocity can also be calculated.

The materials which are expended in making an upper air observation, including the radiosonde instrument, balloon, battery, hydrogen gas, etc., cost approximately $40 for each ascent. Very few instruments are ever recovered. In order that maximum value may be derived, each ascent is carefully prepared and the data are accurately computed. It takes two men working approximately five hours to complete one upper air observation including the preparation of hydrogen, monitoring the signals, computing and coding the data and finally checking the computations to make sure no errors have been made.

The resulting information is sent by a sophisticated radio and landline communication network to a meteorological computer and to forecast offices where the results are analyzed and interpreted. The information provides essential facts which are used in the preparation of weather forecasts. Upper air data are also used for research into atmospheric processes and for studies of climate. All upper air data are subsequently collected at AES Headquarters, processed, quality controlled, and archived, and a selection from the data is published.

2.1.4 Radiation

Currently 52 stations with a total of 81 recording instruments (approximately $2,000 each) take continuous readings of the direct solar radiation, radiation scattered from the sky, and radiation re-emitted from the ground. Recently most of the new stations have been co-located with the upper air observation stations, partly for reasons of economy, and partly to obtain continuous upper air radiation readings. Personnel are required to collect the daily readings and submit them to AES Headquarters at the end of each month for processing, analysis and eventual publication. The *Monthly Radiation Summary* lists the hourly recorded values at each station for that month. This information is then passed along to an international commission which collects, processes and publishes worldwide data.

The data, at present, has no direct operational value; however universities and agricultural interests have requested the information for research studies.

2.1.5 Ozone

By measuring the amount of ozone in the stratosphere it is possible both to identify atmospheric circulation patterns and to study the ultra-violet radiation absorption in the stratosphere.

As part of an international commitment to collect data in support of ozone research, AES measures total ozone at five meteorological locations across Canada. It requires one full-time technician to take daily measurements with sensitive instruments which cost more than $10,000 each. The vertical distribution of ozone is measured by ozonesondes at two of these locations, in conjunction with the radiosonde equipment used in the upper air observing network. Although the ground-based stations do record vertical distributions of ozone, the accuracy of the technique employed is limited, whereas the ozonesonde is capable of taking continuous measurements.

As in the case of the radiation data, the ozone information is collected continuously; however it serves no direct operational requirement, and its sole use is to feed research studies.

AES has been charged with the task of publishing all world ozone data in cooperation with the World Meteorological Organization (WMO). The World Ozone Data Centre in Toronto has been established to collect, quality control, process, archive and publish the data in a bi-monthly report *Ozone Data for the World*.

2.1.6 Radar and Remote Sensing

AES operates five special weather radar probes, four of which are at major Canadian airports, as well as several other less powerful ones throughout the country. The radar, which is able to scan the sky for up to 200 miles, allows the forecaster to detect and locate areas of precipitation; to follow the motion, direction and velocity growth and dissipation of storms; to determine the melting level in some cloud systems; and to estimate the variability, extent, intensity or relative severity of weather systems. This information is particularly valuable in providing first-hand observations and in the preparation of short period forecasts of from about one to six hours.

The data which are also used for research and experiments have shown that radar also promises to provide a means of estimating

the amount of water within a storm or a section of a storm, and the total rainfall from a storm over a particular area.

The three main operational applications by AES of remote sensing from aircraft and satellites are weather forecasting, ice reconnaissance and surface temperature measurements of lake and coastal waters. Ice Reconnaissance is described under the acquisition of Ice Data.

The Central Services Directorate uses airborne radiation thermometer (ART) surveys to obtain the lake surface temperature charts for the Great Lakes. These flights are made at regular intervals and the data are published by the AES.

2.1.7 Ice Data

In order that shipping or other types of aquatic travel may be carried on in the most economical and efficient manner it is essential that information be readily available as to the whereabouts of ice, the type of ice to be found, how the ice will move under the prevailing weather conditions, when ice will form or melt, and on many other questions. With these needs in mind, the Atmospheric Environment Service has a data collection network which is a direct operational service to the Marine Branch of MOT (who provide about $4 million in support for these activities). It was set up and charged with the responsibility of collecting information on the concentration, thickness, age and snow cover of ice, as well as any leads, rafting, ridging or melt which might be present in any of the flows. In addition, AES operates an Ice Forecasting Central to analyze these data and forecast future ice conditions.

This type of information collection has proceeded for about 15 years, and efforts are now being made to process and analyze the last 10 years of data. Most information is recorded by visual observations from aircraft patrol, supported by conventional radar, laser and infra-red measurements. Additional observations are provided by shipboard ice observers assigned to eight Canadian Coast Guard ice breakers, and by the operation of 120 ice reporting shore stations and 60 weekly reporting stations where ice thickness is measured. Supplementary observations are also provided by military aircraft. Efforts are being made to obtain these data through satellite remote sensing techniques, however there are difficulties in meeting requirements for observations through low cloud and in darkness. The satellite system provides excellent coverage of the entire Arctic but coverage is periodic, 1-3 consecutive days then a 15-17 day gap, and the data is not available immediately.

Ice observations are taken by a team of 22 specially trained men, who send all their recorded data either to the Ice Forecasting Centre in Ottawa or, on occasion, directly to icebreakers. Icebergs are noted as to size and location, and this information is passed along to the International Ice Patrol. The Ice Forecasting Central prepares analyses of existing ice conditions and forecasts of anticipated ice conditions for transmission to ships by radio facsimile, using the communications network mentioned in section 2.1.8, and to shipping companies, fisheries, and others concerned via mail and/or message.

In the winter, operations are centered around the navigable waters of the Gulf of St. Lawrence, the Seaway, the Great Lakes and the coast of Labrador, while in summer they shift northward to take in Hudson's Bay and its approaches and the Arctic Shipping lanes.

2.1.8 Dissemination

As mentioned previously, all measurements taken at the 2,500 synoptic and climatological observing stations eventually reach AES Headquarters, where they are archived in their original monthly report form and on punched cards or magnetic tape for subsequent manipulation.

Throughout the year, requests for information specific to a variety of user groups, including aviation, construction, agriculture, planning, research, recreation, shipping, etc., are made available in both the real-time sense, and by publication programs involving both historical data periodicals and statistical publications.

Ice data is disseminated in two publications. One of these is a compilation of the past year's observations and the other a forecast of expected current season conditions - *Seasonal outlook of ice conditions in northern Canadian waters*. This latter publication, while not intended for operational use, provides some guidance as to the deviations from the normal break-up pattern which might be expected and is thus a forewarning of troublesome areas or a prediction of more favourable conditions.

The most useful periodicals, reports, articles, papers and circulars available and pertaining to the climate of Canada are listed in an AES circular, *A Selected List of Canadian Climatological Publications*, which is updated each year.

About eight or nine of the more popular monthly data periodicals published by AES have distribution lists of up to 1,000

each. These periodicals meet the immediate user demands and can be obtained for research purposes through various libraries.

The majority of the specific inquiries, often up to 200 a day, are handled manually while some of the more complex ones are serviced with the aid of the computer.

A vast communications network supports AES's efforts in handling its data collection and subsequent analyses. By using two parallel but independent communications systems, 300 weather offices are linked to each other and the world. The first of these networks is a computer-controlled teletype system running year-in-year-out, 24 hours a day. The second of these two parallel systems is a special circuit designed to transmit pictures and maps. Each day, approximately 50 maps of the national weather picture are transmitted to the weather offices, along with a number of smaller pictures sent from each regional office for local interests.

Radio is the key link to aviators and ships' navigators, giving them the opportunity of receiving the latest weather forecasts and map facsimiles. However, the principal means of directing weather weather forecasts to the public is through the news media, namely radio, television and newspapers. Teletype machines facilitate the delivery of information to these sources.

2.2 Atmospheric Research Directorate

The Atmospheric Research Directorate currently has one program to collect data on a continuous basis, and three other programs are in the planning stage. Although the latter programs do not at present constitute part of any on-going data collection program it might well be worth mentioning their activities, for provision has been made to establish two of these networks as part of an international commitment to the WMO. This commitment was reaffirmed by the Minister of Environment at Stockholm in June, 1972.

The first three of the following networks are now in the planning stage; the fourth is in operation:

1 the WMO baseline network;
2 the WMO regional network;
3 the urban background reference stations;
4 Canadian meteorological tower network.

It is planned to establish the regional network by April, 1974. In the meantime, the baseline stations will be constructed when suitable sites have been located and the parameters to be measured have been specified. The extent of the observational measurement may be

restricted in the beginning, because the technologies needed to measure low level concentrations of some components of the ambient air have not yet been developed.

2.2.1 WMO Baseline Network

Baseline air pollution stations are designed to measure the "background" composition as far removed as possible from man-made or natural sources of pollution. A 10-station global network is envisaged, of which Canada has agreed to provide three. The minimum program at baseline stations includes the measurement of carbon dioxide concentration and turbidity (particulate loading), the chemical analysis of precipitation and dry deposition, and climatic records of wind, temperature, and amount of precipitation. The need for comparative data that will be representative of background pollution levels on a global scale demands very restrictive siting criteria for these stations. A station set up to take the minimum number of observations could cost up to $50,000. Each additional parameter monitored would raise the cost. Attempts are being made to do the required chemical analyses in existing laboratories.

2.2.2 WMO Regional Network

Regional air pollution stations are designed to detect long-term changes in atmospheric composition related to regional land-use practices and other activities. Canada has agreed to provide seven stations in a world-wide network of about 100 stations. The initial program at each station involves turbidity measurements, the chemical analysis of precipitation and climatic records.

These regional stations will operate out of the same facilities as the existing meteorological stations, with the additional manpower requirements covered by overtime. Although the maintenance of the equipment can be contracted out, some additional manpower requirements will be necessary in order to maintain calibration of the delicate instruments. It is envisaged that all seven stations will be operating on a full-time basis in selected rural areas by April, 1974. Monthly summaries of all precipitation samples and turbidity readings will be sent to AES Headquarters for analysis, and these results will subsequently be forwarded to the WMO data collection centre in Asheville, N.C.

2.2.3 Urban Background Reference Stations

Plans call for the establishment of fifteen urban reference stations across Canada during the next five years, designed to provide long-term high quality records of air quality and meteorological parameters on urban areas for research purposes. Present

activity in this field is restricted to the evaluation and development of instrument systems.

These stations will be located in major metropolitan centres across Canada, each of which will take measurements of radiation, turbidity, particulate matter, the chemical constituents of precipitation, and some trace gases.

2.2.4 Canadian Meteorological Tower Network

The Air Quality Monitoring Program has for some time provided data on wind and temperature profiles from 15-17 large towers across Canada. Up to $15,000 has been spent on each existing tower (mainly radio towers) to outfit the tower with instruments at two or three levels and to maintain these instruments. While most of the instruments record only meteorological parameters, some towers do take readings of ambient air pollutants. After the data is collected by AES Headquarters, the results are published in the Quarterly Tower Bulletin.

2.2.5 River Basin Studies

The Hydrometeorological Section of AES administers a program to study the long-term natural changes occuring in river basins which are isolated from the influence of man. Because this Section is not concerned with the short-term variability in the river basin changes, it is inherently necessary to collect data over a long period of time in order to detect any significant changes in the natural surroundings.

Between 10 and 15 basins have been outfitted with instruments (about $4,000 each) that can record temperature, precipitation and humidity for several months at a time before servicing is required by the regional inspectors. At present the data has been collected, quality controlled and archived for the past 4-5 years and no attempt will be made to analyze it for another five to ten years.

Studies of the natural water balance and evapotranspiration in the river basins require much more information before the results would be meaningful. Work is being conducted in co-operation with the Water Survey of Canada. By co-locating the meteorological gauges with the Water Survey's stream gauges, the Hydrometeorological Section is able to study the climatological aspects of the river basin. By co-ordinating the eventual results, a more comprehensive study will be possible.

Despite the fact that this information is just being collected and archived at present, the precipitation data is published in an annual document - *Supplementary Precipitation Publication.*

2.2.6 Hydrometeorological Automatic Recording and Telemetering System (HARTS)

The Hydrometeorological Section is also attempting to supplement the work of the Snow Survey of Canada by introducing recording stations in remote and poorly accessible regions of the country where the snowfall is heavy and the conventional manned stations are uneconomical. This enables a better forecast of the spring run-off to be made, aiding those clients concerned with flood control, water supply and power generation planning.

Presently two experimental stations - one in British Columbia and one in northern Ontario - are in operation. These are co-located with two of the transmitting antennae the Water Survey of Canada have constructed for remote data transmission. Information on precipitation, temperature and wind run, which are necessary for daily operational planning, are transmitted to the Earth Resources Technology Satellite (ERTS), and then collected at the Canada Centre for Remote Sensing (CCRS) roughly 12 hours later. Development is currently proceeding on additional sensors to measure radiation/sunshine and humidity. As resources become available both these extra sensors as well as entirely new stations could be established for the development of a more comprehensive program.

3.1 Canadian Forestry Service

The wealth of Canada's forests depend to a large extent on their proper management. Various programs have been developed throughout the years to ensure that maximum benefit is derived from our forests.

3.1.1 Forest Insect and Disease Survey

The Canadian Forestry Service (CFS) has operated a continuing program of data collection on the status and movement of forest insects and diseases in Canada since 1936. Initially maintained through the support of seven regional offices, the Forest Insect and Diseases Survey consolidated its operations to six regional centres in 1970, while still achieving the stated objectives of: the detection and appraisal of insect and disease outbreaks and the subsequent dissemination of this information promptly to all interested parties; and the cataloguing of all diseases and disease organisms found on trees in Canada.

This survey is performed with the co-operation of the provincial forest authorities and industries. However, the CFS has a staff of 125 professional and technical employees and a budget of $1.7 million for administering this program.

It is the provincial forest authorities and private industries who are the principal users of the collated data; minor users include officials from the national, provincial and municipal parks and research institutions such as universities.

The principal publication employed for dissemination of the collected data is the *Annual Report of the Forest Insect and Disease Survey*. This is a collation of the annual regional reports submitted to the CFS and contains maps for illustrative purposes.

3.1.2 Annual Forest Pest Control Forum

The CFS, through the auspices of the Annual Forest Pest Control Forum (formerly the Interdepartmental Committee on Forest Spraying Operations), maintains an inventory on the extent, distribution, formulations and types of insecticides applied to the forest regions of Canada in pest control operations. The Forum brings together representatives from Environment, Agriculture, National Health and Welfare, as well as representatives from provincial forestry departments and forest industry. The specific functions of the Forum are to:

1 Review and report on recent forest pest control operations in Canada.

2 Discuss research and trials bearing on forest pest control.
3 Review pest conditions that may require future control action.

The reports and records from this Forum have provided a chronology of events in forest spraying operations in Canada over the past two decades.

3.1.3 Remote Sensing

Remote Sensing is a high priority program within the Canadian Forestry Service. Their involvement in this field has developed out of the extensive use of aerial photography in forest inventory during the last three or four decades.

The CFS remote sensing program, which is largely concentrated in the Forest Management Institute, is one of the largest in Canada. The Canada Centre for Remote Sensing, for example, has calculated that during 1972 the number of aircraft missions and line miles flown by CCRS for the Forest Management Institute exceeded those for any other Canadian agency and surpassed the combined totals for all other units in Environment.

Among the operational programs which the CFS is now conducting are vegetation mapping in the north, vegetation damage surveys and forest inventory surveys.

The ERTS satellite could be used as a tool for environmental monitoring, but it is still basically in the research and development stage. Tests are being made to determine the feasibility of collecting data by this method. However, the reliability of these tests, the exact parameters which could be effectively monitored and the requirements of the users are all, at present, uncertain.

3.1.4 Forest Inventories

The Canadian Forestry Service aggregates provincial data on forest inventories in order to present an annual national picture of forest cover. Figures on present cover, growth, harvest, losses due to fire, disease and insects and areas of cover withdrawn from productive use, such as rights-of-way, are gathered as the first step in analysing the extent of the Canadian forests. Projections and trends of supply and demand in the Canadian perspective are derived from this type of inventory system and are made available to individuals of the forest product industries, government officials and other interested parties. It should be pointed out that this exercise in data gathering is the by-product of a larger commitment to supply information on Canadian forest cover to the FAO.

3.1.5 Forest Fire Data

In Canada each province has the responsibility of administering its own forests, including both protection of the forests and prevention of fires. However, the Forest Fire Research Institute, besides doing basic research, collects the provincial data on the current fire situtations and combines this with the prevailing weather conditions supplied by AES to produce a daily forest fire danger forecast. The resulting forecast is retransmitted to the appropriate regions in the form of facsimile maps and accompanying interpretation.

Each year during the fire season the Institute collects the provincial data on the number of forest fires and their combined acreage destroyed during the previous month. This information is then passed along to the Canadian Press for release to the public. At the end of each year the Institute publishes the annual statistics on the losses and associated costs in terms of fire control and foregone timber revenue. This information tends to be used primarily by economists in the federal, provincial and private sectors of the economy.

3.2 Canadian Wildlife Service

3.2.1 Waterfowl Breeding Pair Survey

The Canadian Wildlife Service (CWS) is charged with the responsibility of administering the Migratory Birds Convention Act. In undertaking such a task, several annual surveys are undertaken to determine the extent of the various species' populations.

Although these surveys tend to be relatively costly because of the postal charges and the processing costs, revenue is received through the sale of migratory game hunting permits to offset these costs.

Throughout the entire month of May each year, the Waterfowl Breeding Pair Survey is conducted as part of a Canada-U.S. participatory agreement aimed at studying migratory birds.

Aerial photographs and visual records are taken throughout western and northern Canada, as well as sections of the U.S., on predetermined flight patterns. U.S. planes are used for these surveys and are manned by 20 U.S. and 10 Canadian biologists. From these photos and visual observations, the numbers and the ratio of the various species of the birds can then be estimated. However, this type of survey is not entirely accurate; thus a ground-based survey is used to back-up the aerial reconnaissance in a smaller number of the sampling strips and adjustments are made accordingly.

Aerial operational costs are handled by the U.S. while the CWS pays its own staff salaries and travel allowances amounting to around $50,000 per annum.

Besides making annual counts of the number of game birds in the various western provinces, records are also made of the number and classification in northwestern Ontario; however, bird counts there are very difficult.

The survey is initiated by calculating the extent of the snow cover (and thus the amount of snow available for spring run-off) from the annual AES snow survey publication. The visual inspection then starts sometime in early May when spring and the mating season begins. This information will later be used to set the start and the length of the various provincial hunting seasons.

The second part of the survey is conducted again in July to examine the ponds once more and determine to what extent rainfall or dryness has been introduced into the game birds' habitats. At that time a survey is undertaken to count the number of young birds, thus determining the success of the spring breeding. This, too, is fed into the federal-provincial consultative meetings held later on in July for the purpose of setting the start and the length of the hunting seasons. Data on the number of hunters, the number of water bodies, a forecast for the expected number and distribution of birds for each species, and the ratio of immature to adult birds are the determinants in calculating the surplus waterfowl which can be harvested during the hunting seasons. By starting the hunting season later in the year, fewer of the vulnerable young birds will be immature, and by varying the length of the season the total number of birds shot can be controlled.

In late summer, just before hunting seasons open, CWS, the U.S. Fish and Wildlife Services, Ducks Unlimited and provincial wildlife agencies all cooperate in banding waterfowl trapped at various locations throughout the breeding range. Recovery of bands by hunters in various regions tells us where the birds go after breeding and indicates how changes in hunting pressure affect waterfowl across their breeding range. Because birds of certain maturities and species differ in their vulnerability during the hunting season, the recovery of these bands is of prime importance as back-up information to the various surveys.

At present approximately 35,000,000 records of banded birds are on tape with an additional 300,000 being added each year.

The Waterfowl Breeding Pair Survey is published each year in a pamphlet form by the U.S. Fish and Wildlife Service and later distributed to all provincial and state authorities concerned with migratory bird regulations.

3.2.2 Migratory Game Bird Harvest Survey

While the Waterfowl Breeding Pair Survey is mainly concerned with forecasting the populations of birds expected for the fall migration, a second set of surveys is conducted to determine the number types and distribution of birds shot by hunters in the fall under a certain set of regulations. This information is then used as input when setting the length of hunting seasons in the future years.

The CWS keeps a demographic record of all hunters who have been issued licences throughout Canada (421,000 in 1972) and each year over 30,000 of these hunters are sent questionnaires for which the response rate is close to 20,000.

Information is sought as to the number, kind, location and date of all game birds shot and retrieved.

3.2.3 Species Composition Survey

As well as the Migratory Game Bird Harvest Survey questionnaire, the 30,000 hunters are each sent a package of ten large envelopes as a part of the Species Composition Survey so that they can return the wings of all ducks and the tails of all geese shot. These samples (for which about 44,000 are received) are sent to the four regional wing centres where they are stored. In January, analyses are done in order to determine the age, species and sex of the bird. This, combined with the location and time of the kill, will allow reasonable estimates of the density of the harvest. All information is then returned to Ottawa for storage and analysis.

The Migratory Game Bird Harvest Survey, Species Composition Survey, banding data and other minor surveys are all distributed through a series of Progress Notes put out by the CWS to the primary users of the information - the provincial regulatory authorities.

The Species Composition Survey costs close to $100,000 a year, most of which is put towards postage fees. The Harvest Survey is also faced with postal charges, however the total cost of the survey is somewhat less (around $25,000). The CWS secures annual demographic data from Statistics Canada so that valid comparisons can be made on each of the surveys.

All of these costs are offset by the revenue received from the sale of migratory game hunting permits sold each year.

3.2.4 Woodcock Singing Survey

Cooperation from provincial game agencies and interested individuals is used in the annual woodcock singing survey. In the spring of each year both predetermined transects and random survey routes are used to estimate the size of the woodcock breeding populations in the Maritimes. These reports are sent to Headquarters and are compared with the information gathered through the collection of wing tips as part of the Migratory Birds Harvest Survey. Because most of the help is of a volunteer nature, costs are minimal (around $1,000).

3.2.5 Breeding Bird Survey

Two surveys are conducted each year on the non-game birds in Canada. By following the nesting habits, populations and the diversity of bird species throughout Canada, some insight may be gained from yearly changes and their relationship to both the unseen changes in the environment, such as insidious pollutants, and those that are more obvious, such as land development.

The Breeding Bird Survey, which is coordinated by the CWS and the U.S. Fish and Wildlife Service, uses volunteers from federal, provincial and private agencies to detect and measure changes in bird populations or densities. Trend analysis can then be applied to determine changes in species diversity. Each year approximately 170 cooperators follow a predetermined route and fill out a detailed form which records not only the bird sitings, but also the time and the prevailing conditions under which they were seen. Because these people are all volunteers, the Department incurs no cost in conducting this survey. All the data is stored on magnetic tapes in Washington, D.C.; copies of these are supplied to the Department.

As the number of impact studies conducted by this Department increases, the requests for information on species composition and diversity also increase. The Toxicology Section also finds these surveys to be a useful source of information. Outside requests come from the provinces and universities as well as international sources for use in impact studies, crop degradation and recreation studies.

3.2.6 Nest Records Survey

Nesting data on non-game birds are collected annually through a group of provincial coordinators who enlist the services of about 700 cooperative volunteers. These people are given cards to fill out for each nest spotted. These cards, which record the

nesting success, surrounding habitat and the general climate of the area, will eventually be used as a back-up to the Breeding Bird Survey. Although these cards were previously stored in their original form in the six Regional Offices (approximately 25,000 new cards in 1972), it became necessary to centralize the information for easier manipulation. Thus, the data is now being transferred to magnetic tape for use at Headquarters while the original cards remain in the regions. The cost of operating this survey runs around $1,000 per annum.

3.2.7 Mammalogy

In order to adequately assess the population size of individual animal herds which fall under federal jurisdiction, the CWS undertakes regular population studies which not only include herd counts but also incorporate measurements as to herd dynamics, mortality, vitality and other relevant data. Management programs have been established, as the result of background research studies, to fulfill various operational requirements. The CWS administers research and operational programs in the Yukon, NWT and national parks, and acts as an advisor for those species which migrate across provincial or territorial boundaries.

By using a combination of several estimating techniques, caribou herd population sizes are determined each year. Every few years these running totals are supplemented by actual counts to try and keep material up to date. For these surveys, aircraft are chartered and trained observers make visual counts which are supported through photographic counts. Specific areas are covered in an orderly fashion; however several passes may be made on any one herd to increase the validity of the count. Unfortunately this study is restricted to the open areas of the north and cannot yet accommodate the wooded areas.

Of the three herds located in the NWT, two migrate south into the provinces of Manitoba and Saskatchewan each fall. Because these migration routes transect territorial boundaries, the studies aimed at determining population size have been divided between the Territories and the individual southern provinces in these cases.

The NWT government is responsible for estimating the size of the spring herd, including an approximation of the success of the spring calving. In the fall of the same year both Manitoba and Saskatchewan have the responsibility of making a further study to determine the calving survival rate for those herds that enter their respective provinces. The NWT does a similar study for the herd that remains in the Territories.

After the size of the fall herd has been established, quotas are set for the total number and distribution of caribou allowed to be harvested by the provinces and Territories during the winter.

While native peoples have the right to kill according to their needs (unless the species is endangered), white residents may only kill a limited number per licence.

Two other herds, one which migrates from Alaska's north slope, and one in the George River area of northern Quebec, are counted annually. However management discussions involving the allocation of quotas involve CWS, the U.S. and Alaska in the case of the former herd, and Newfoundland, Quebec and the CWS in the case of the latter.

For those herds which are found in and around the NWT, a count of the current harvest is maintained by the local conservation officer. If the quotas have been reached, he would inform each settlement involved in caribou hunting that the season is closed. Close watch on the kills is facilitated by the fact that most harvesting is done by hunting parties which emanate from several established settlements.

The George River herd presents a different problem. Because of the access to the migration range by miners and other established settlements through local railways and snowmobiles, the number of kills has increased. Although the harvest does not as yet present any regeneration problem, a close watch must be kept on all the kills. House to house surveys are undertaken to determine the number of seasonal kills.

A combination of investigative research and seasonal monitoring of herd kills is required to make yearly estimates of herd sizes so that the operational requirement of quota allocations can be established.

Intermitent tagging operations which are conducted on an irregular basis are used to lend support to the herd size estimates. Information can also be gathered on migration pathways, herd affinities and interchanges. Besides this direct input to quota allocations, the information is used in individual research papers. Both provincial and university researchers make numerous requests for this type of information.

A five-year research program was established to do population studies on bighorn sheep. This study was initiated to determine the optimum size of a herd which could be adequately supported in a predetermined restricted area. Once this study has been completed it will be turned over to an operational branch which will maintain that level. Annual data on calving success and age and sex segregation will be required in order to fulfill this operational requirement. Both the techniques and the criteria are established during the research program so that management practices will ensure its future well-being.

Aerial surveys by helicopter, accompanied by ground surveys, give population densities in the summer grazing lands and again in the winter range. Changes in population, reproduction patterns, mortality and vitality are recorded and used to prescribe the optimum density for a specific area.

A management plan to study the dall sheep in the Mackenzie Mountains has been devised whereby population counts and migration paths are recorded each year. Because of the value of this highly prized horned animal, special attention must be given to the preservation of this species.

Population counts present special difficulties because of both the treacherous terrain and the long distances that must be travelled in undertaking the measurements. However these counts are necessary in order to determine the number of sheep that can be hunted without endangering the species.

During the month of June each year a program is undertaken with the aid of the Pathology Section of CWS and the National Parks Branch of the Department of Indian and Northern Affairs to determine the current health status of the western bison. Besides this status report, a parallel program aimed at preventing the spread of disease is conducted at the same time. After corralling as many bison as possible, they are studied and vaccinated to help prevent the spread of the infectious disease, anthrax.

Besides the program of studying corralled animals, continued surveillance of their grazing grounds is maintained. To control the spread of the disease it is assumed that all dead animals found on the range had at one point contacted anthrax. They are then destroyed by burning. This program has proved to be successful during its ten-year operation and plans are to continue running it.

For the fiscal year 1973-74 salaries, operation and maintenance, and capital expenditures amounted to approximately $250,000 for the caribou, bighorn sheep, dall sheep and bison programs. In all, about six professionals are involved in these studies plus support staff.

3.3 Inland Waters Directorate

3.3.1 The Water Survey of Canada

Federal responsibilities in the field of water surveys started in 1912 in the Prairie Provinces. These responsibilities increased with time to include surveys in the other provinces. Transfer of natural resources to the provinces took place in 1930, although the federal government continued to do the surveys. During the depression years, when the federal government notified the provinces that agreements would be terminated, work was continued under letter arrangements. These arrangements are still in force.

Negotiations are presently being carried out with the provinces to bring their monetary contributions to the over-all program more in line with present-day costs, and to arrange formal agreements with each province to cover federal-provincial responsibilities for water surveys. Recently a review of the water survey program was undertaken to designate those stations of prime interest to Canada. The remainder of the stations presently operated would then become the responsibility of the provinces, although Canada will be prepared to operate the stations and share in the cost of those which are of substantial interest to Canada.

The Water Survey of Canada presently operates about 2,400 gauging stations throughout the various provinces and territories. The purpose of the survey is to provide continuing information of the point source supply, availability and run-off of water throughout Canada.

In order to fulfill this purpose the levels of lakes and the levels and flow of rivers are recorded daily to determine the quantity of water available at any given time. To supplement the water quantity data collected, a sediment survey is conducted at about 150 of the gauging stations to determine the physical characteristics of sediments (e.g., particle size and concentrations).

At over 300 of the gauging stations, monthly water samples are taken and sent to the Water Quality Branch for testing.

The Water Survey also takes snow samples at up to 200 points about six times a year for all provinces except British

Columbia and Quebec. These data are used to determine the supply of water which will be available for various rivers in the spring run-off. This information is forwarded to AES, the agency responsible for publishing all snow survey data. Publication, distribution and archiving follow the receipt of the data from its varied sources.

A permanent mailing list of 400 clients receive copies of all the recorded data. Four publications serve both this group and other interested parties who request the information periodically.

The *Surface Water Data Papers* is an annual publication which lists the daily Water Survey data for all provinces except Quebec (which publishes its own). The *Historical Stream Flow Summary* is put out about every five years and records the updated monthly records of gauging stations presently in service. A complete list of the stations in operation in Canada is documented in an annual volume entitled the *Surface Water Data Reference Index*. As well as recording the locations, types of equipment, and parameters measured at each gauging station, maps are periodically included for the users' reference. Not only does this inform the user of what is available, but it is economically beneficial since it enables him to define the limits of his request more precisely. Finally a sediment survey publication, *Sediment Data for Canadian Rivers*, is produced annually to list the amount of sediments which occur at each of the sediment gauging stations.

Primary clients of the Water Survey of Canada are the federal and provincial governments, power companies, and to a lesser extent universities. These data are used in areas such as environmental impact assessment, flood control and forecasting, water supply, power development requirements, industrial and residential requirements. Irrigation, navigation and fisheries programs also benefit from the collection of this data.

Since it is the policy of the Water Survey of Canada to review periodically the continuing need for each station, some 2,200 gauging stations have been discontinued after having served their purpose in support of user projects.

The Water Survey of Canada is responsible for 140 permanent tide gauges at locations along Canada's coast and throughout the Great Lakes-St. Lawrence system. The Marine Sciences Directorate prepares analyses on the data from these gauges and makes the information available to the public. Management of the Great Lakes system is by international boards of control. The control of the Great Lakes-St. Lawrence waterways is dependent on these water level data

together with river flow data. Lake levels are monitored automatically at least at one point on each lake and these data are available on a real-time basis. The levels of Lake Ontario and Lake Superior are artificially controlled.

During 1972-73 a total of $6.4 million was spent on the operations of the Water Survey. Of this total, $3.4 million was allocated for the salaries of 318 staff members, $1.9 million towards operation and maintenance, and capital expenditures amounted to just over $1 million.

3.3.2 Hydrology Research Division

At two areas in Canada - Ottawa and Winnipeg - approximately twenty observation wells have been established and fitted with automatic recorders (costing about $300 each) to take continuous measurements of the water levels in the wells.

Once the data has been collected, well hydrographic charts are made and the results are fed into the GOWN information retrieval system. The GOWN system was set up and is presently operated by the Hydrology Research Division as an information retrieval system for all types of hydrogeologic data including maps and charts. In several of the river basin studies mentioned in this report, groundwater data are collected and fed into GOWN. These data are of particular interest to the Hydrology Research Division.

The GOWN information storage and retrieval system is an applied research project within the Hydrology Research Division. Since the management of the groundwater resource is a provincial responsibility it is not intended that data be centralized in a federally run facility. Rather the system is being developed in Ottawa and will be made available to interested provinces. The Ottawa system stores some data from research projects of the Division as well as some data made available by the provinces. These data are used primarily to test the system as it is being developed. Three types of data are stored in the system: basic engineering information such as the location, diameter, depth of observation wells, the type of casing used etc.; a geologic log of the types of material penetrated in drilling the well; and time-series water-level data. At present only the first two types of data are stored; the time-series data system is not yet operational.

The Hydrology Research Division has also participated in the NTA monitoring scheme described under 3.3.6 and, in particular, was responsible for the selection of groundwater sampling areas and densities and for the time scheduling of these observations.

3.3.3 Applied Hydrology

The Water Survey of Canada, in conjunction with the Hydrology Research Division and the AES, has selected several river basins throughout Canada to be studied as part of its continuing work. These basins will be studied to determine whether any changes have occurred as the result of natural phenomena, exclusive of the influence of men. Because only those changes which are natural are of interest, several years work in data gathering will be necessary before the actual water balance and evapotranspiration studies can be conducted.

The Applied Hydrology Division takes regular measurements of seven Canadian glaciers every second year (two one year and five the next). Terrestrial photogrammetry is used to map the tongues of the glaciers. From these maps any forward or backward movement as well as thickness changes in the front of the glaciers can be detected. This information enables predictions of trends for the output of run-off water to be made. Each year a report is produced with accompanying maps describing both the past and present conditions of the glaciers.

3.3.4 Glaciology Division

Six glaciers in the Cordillera region and one in the north are studied by the Glaciology Division. The entire glacier is studied for the amount of snow added in the winter, snow and ice lost in the summer, and the run-off from the glacier determined. Initially all glaciers were examined intensively; now data is collected from five of these glaciers at monthly intervals, and more frequently from two glaciers still being examined intensively. Measurements are made of snow depth and density, and ice thickness as well as wind speed, temperature, humidity, precipitation, solar radiation, reflected radiation and run-off. These parameters are used to develop and validate models to predict run-off from glaciers in alpine regions. When these models are developed the monitoring of a smaller subset of the parameters will enable run-off to be predicted and so aid in the management of the water resource.

3.3.5 Water Quality Branch*

The Monitoring and Surveys Division of the Water Quality Branch, Environmental Management Service, has the role to plan, implement and operate national water quality monitoring and survey

---

*Extracted from: A Position Paper - The National Water Quality Monitoring and Survey Program, Water Quality Branch.

programs on surface waters in Canada and to develop a central data bank from which information and interpretative reports are supplied to water resource managers and users.

The water quality programs are essentially designed to detect and quantify water quality parameters, determine pollution trends on a national and regional basis, to measure the effectiveness of remedial measures to control pollution, and to understand better the pathways, behaviour and fate of pollutants in the environment and their effect on physical, chemical and biological systems and, through better understanding, contribute to improved water resources program planning and implementation.

The Water Quality Branch through its regional offices, operates on Canadian lakes, rivers and streams, 536 water quality sampling stations (Atlantic region 185, Quebec 22, Ontario 51, Western 214 and the Pacific region 64). These are sampled either by trained technicians or by lay collectors under contract and samples are analysed in one of the branches' four laboratories, Moncton, Burlington, Calgary and Vancouver.

Samples collected by lay collectors, usually on a monthly basis, plus a sample at annual high and low discharge periods (a total of 14 samples per station per year) are analyzed for major ions, colour, turbidity, pH, specific conductance and suspended solids. These samples require no special treatment in the field and may be collected by untrained personnel with a limited amount of instruction.

Samples collected by trained technicians, usually four times per year at most stations, are analyzed for a special group of constituents which, when present in certain concentrations, seriously degrade the quality of surface waters and inhibit the uses of these waters. These constituents include heavy metals, trace elements, nutrients and organochlorides. The samples require special handling in the field, including filtering, cooling, preservation, etc., and hence trained technicians are required for this work. In addition, the technicians perform a number of field tests on many samples including colour, pH, specific conductance, dissolved oxygen and temperature. All water quality data are stored and processed on the branches' computerized data processing system (NAQUADAT).

The Water Quality Branch receives many requests for water quality data and related information. Between January and June, 1973, 114 data retrievals were made from NAQUADAT to meet specific requests as follows: Water Quality Branch, 53; other services in the

department, 13; other federal departments, 6; provincial and municipal agencies, 21; universities and associations, 5; and private sector organizations, 16. These data retrievals were used for special water quality studies and report preparation.

Water quality data series reports have recently been prepared and are now in preparation for general publication. These reports will contain water quality data, interpretative information, graphical displays and maps showing locations of sampling stations. A questionnaire forwarded by the Branch to about 1,900 addresses (Inland Waters Directorate publications mailing list) revealed that 700 agencies and other prospective clients are interested in receiving the data series reports as they are published.

In addition, a listing of water quality sampling stations in Canada is contained in the publication *Index of National Water Quality Monitoring Stations*. This list contains both active and discontinued stations.

Consideration is given in continuing program reviews to the scope of the national water quality monitoring and survey program, and whether there is a need to expand or modify the program by installing more sampling stations or adding more parameters, or indeed, by eliminating or changing certain stations or parameters. In the light of these uncertainties, and the scarcity of information, planning is now under way to conduct, through a consultant, a user requirement survey to identify what agencies and organizations have a need for water quality data, how the data will be used, how frequently they are needed, where and what data are required, and how much the user is prepared to pay for data. The study should also provide information on major problem areas in Canada which will form a good base on which to plan expansion and/or modifications to the national water quality monitoring and survey program.

The emphasis on the water quality monitoring and survey program is changing from the collection of baseline chemical data to the acquisition of information on pollution in Canada's surface waters. Analytical programs are being modified to increase measurements of nutrient materials, organics, organochlorides and many of the trace elements and to decrease measurements on major ions and natural chemical constituents except in areas where little or no background information on these parameters exist. The change in this program requires an increase in field staff, particularly trained technicians to collect the samples which require special handling. It is envisaged that the role of the lay collector will decrease and, in many cases, disappear.

Based on the findings of the consultant study referred to above, and as water quality management programs develop (including the setting of water quality objectives and standards and the development of water quality and environmental indices), it is anticipated that the need for expansion of water quality monitoring and survey programs will continue to increase. In the years ahead, it is certain that more comprehensive data, encompassing a wider spectrum of measurements with improved interpretation, will be required to support water quality management decisions.

In the Ontario Region, for example, there have been specialized intense studies on the St. Lawrence and the St. Mary's River in which a team of researchers concentrate on a particular area for about a week of observations. These studies have been carried out in relation to the International Joint Commission (IJC).

Plans are to repeat these studies in the future, but perhaps not as intensively. It is anticipated that they would lead to two types of publications: one aimed at the scientific audience, and the second at the general public through the IJC. This second publication would attempt to tell the IJC and the public whether the channels are in fact deteriorating or improving. The programs are closely tied to those of the Ontario Water Resources Commission and CCIW will quality control both sets of data collection. This is part of a monitoring program to fulfill terms of the Canada/U.S. Agreement on Great Lakes Water Quality.

3.3.6 Canada Centre for Inland Waters

Although the central services of CCIW are provided by the Inland Waters Directorate, the Centre also contains components of the Fisheries and Marine Service and the Environmental Protection Service. These groups all have responsibilities for provision of information needed for effective management of Canada's fresh water resources. As well, the Inland Water Directorate, Ontario Regional Headquarters is based at CCIW. It has the responsibility of administering that portion of the Water Quality Network which lies in the Ontario Region. Other monitoring-type programs at CCIW include Great Lakes Water Levels, NTA monitoring, the Great Lakes Surveillance Program, and rainwater chemistry. However, most of these are at present research programs which might lead to monitoring.

The Great Lakes Resources Subdivision is currently carrying out research to determine what parameters need to be measured in order to more effectively monitor the states of the Lakes as part of activities under the Canada/U.S. Agreement on Great Lakes Water Quality. Baseline data is being gathered for the upper Great Lakes

at present, and baseline data is available for the lower lakes for all environmentally important parameters.

Extensive ongoing data collection on the Great Lakes has continued since 1965. Ships cruise through the Lakes gathering information at a large number of stations largely to meet the requirements of research programs. The data are archived and are also used to look at long term trends.

NTA in tap water is monitored at present, although the final form of this program has not been decided. Early in 1973 samples were collected from a number of localities, and an initial screening was done; however little NTA was found. Another screening was performed a couple of months later on 175 samples. If NTA is found, 30 places will be selected and sampled as frequently as once a month or perhaps as often as once a week.

Samples are collected in Lake Ontario and Hamilton Harbour once a month. Plans are to cut back on sampling in the Lake since no NTA has yet been found there and to concentrate on the Harbour where NTA has been found. The attempt is being made to guard against a build up of NTA in the environment.

In addition samples are collected on the east and west coast in particular in the Halifax-Dartmouth area and in the Vancouver Harbour to check for NTA.

Groundwater is being monitored for NTA in two or three different locations and some NTA has been found.

The CCIW is performing quality control for Proctor & Gamble, who are examining a river above and below a sewer outfall. In addition samples are being analysed from some universities in the United States. Universities are undertaking sampling for NTA at 13 locations in southern Ontario and preparing a comprehensive study on one river. All of these samples are being analysed for NTA at the laboratory at the CCIW.

The Water Quality Branch is now planning to undertake NTA sampling as part of the regular national water quality monitoring program.

The rainwater chemistry program is another example of a research program soon to become a routine monitoring program. Analyses for constituents of rainwater are performed at the CCIW. It is planned to select about five stations in Ontario where samples

would be gathered. Cooperation is taking place between CCIW and AES to reduce duplication and increase information exchange. The Water Quality Branch is undertaking this as a regular monitoring project.

4.1 Water Pollution Control Directorate

The principal function of the Water Pollution Control Directorate (WPCD) is the establishment and application of effluent quality requirements for the purpose of reducing and controlling to the maximum practical extent, waste discharges to Canadian waters.

Although the WPCD is still in its infancy, it has initiated two programs to collect data on industrial effluent discharges. While these programs differ as to the point source from which the samples are taken, they are both concerned with waste effluents - the first with respect to volumes allowable under existing legislation and the second concerning the effect these effluents have in the zones of influence of the discharge.

Data is not collected regularly at each sampling location at the present time; however it is planned to eventually have a system set up which will collect the pertinent data regularly as well as providing for more intensive studies when necessary.

4.1.1 Waste Volumes

Up to the present time the WPCD has established the amount of allowable waste-loading for two industries - pulp and paper and chlor-alkali.

Approximately 150 pulp and paper plants will take daily samples of their effluents as the regulations are applied to them and the results will be submitted to Environmental Protection Service (EPS) at the end of each month. These results are compared with spot-checks made by regional EPS staff at regular intervals.

The chlor-alkali plants on the other hand are under a different form of control. Every month an audit is made of all mercury purchased by each of the fifteen plants. Because mercury is supposed to be used in a closed system it can be assumed that all purchases are used to replenish materials discharged in the plant's effluents or emissions, except when new cells are brought on line.

At present EPS is the main user of the raw data. However, it is hoped that a federal-provincial exchange program will be set up during the course of operations to avoid duplication of work. While the WPCD has no plans to publish the raw data (primarily because of an anticipated lack of public interest) it does visualize the data being analyzed and presented in some other format by the department.

4.1.2 Zone of Influence

Environment Protection Service gathers information with respect to water pollution on a wide variety of parameters in the zones of influence (up, mid and down stream) at several hundred plants throughout Canada. The parameters vary depending to a large degree on the circumstances surrounding the individual industries. In the case of the pulp and paper industry, BOD, suspended solids and toxicity are measured. Although legislation regarding the amount of waste-loading allowed for a certain industry may not yet be enacted, EPS still gathers the data for baseline studies.

Before any new plant is established, extensive measurements are taken to determine the state of the receiving water prior to the introduction of effluents. Once the plant is in operation, samples are taken either to make sure the plant adheres to the established regulations or to be used as input in establishing regulations for new industries. In either case monthly samples will follow the plant's progress. However, more intensive analysis may be undertaken if the prevailing circumstances warrant it.

The zone of influence is also monitored at existing plants to determine over a period of time whether the plant is improving or degrading the quality of the receiving water.

As with the measurement of waste-loading, the data which is presently collected is not published but merely stored and retrieved as required.

4.2 Air Pollution Control Directorate

4.2.1 National Air Pollution Surveillance Program

The National Air Pollution Surveillance Program is a joint project based on the cooperative efforts of both the federal and provincial levels of government.

A knowledge of the nature and extent of air pollution across Canada is fundamental to the sound planning of control and abatement programs. In its broadest context, therefore, the purpose of the National Air Pollution Surveillance Program is to monitor and assess the quality of the ambient air in the populated regions of Canada on a continuing basis. In addition, however, the program serves a number of other needs and in this respect will become increasingly more useful as data accumulates. For example, it will be possible to detect trends in the levels of pollution with the passage of time and with respect to changing industrial activity, population density and air pollution abatement progress. Information

collected by the program can be used in epidemiological studies and to provide background for the development of air quality objectives.

The data reported in each monthly summary have been gathered by cooperating agencies across Canada and forwarded to the EPS Headquarters for compilation. In some cases analyses of the raw material may precede delivery; in others the raw material may be sent to Ottawa to be analyzed in the headquarters laboratories. Any exceptional results are rechecked for validity. Once the data are summarized, key-punched, processed and quality controlled, they are then published in a monthly summary, distributed and archived. There are currently about 500 subscribers on the mailing list - most of whom include the clients and agencies that aided in the collection of the data.

As of September, 1973, the program consisted of 347 sampling instruments in 42 cities across the ten provinces. However, the program is continually expanding to other cities and additional stations are being included and reported upon as they become operational.

Measurements are being made for sulphur dioxide, particulate matter (including dustfall, suspended particulates and the coefficient of haze), carbon monoxide, hydrocarbons, nitrogen oxides and total oxidants. Hydrogen sulphides are also measured in certain local areas.

The federal participation is primarily directed towards the supplying of both technical knowledge and sensory equipment. The provincial government knows where the problems originate. As a result in cases where no federal support is forwarded, the provincial governments may undertake the responsibility themselves.

EPS and AES have begun a co-operative program whereby the two Services in consultation with the provinces select sites for future stations. Once the problem area has been designated, a certain degree of convenience (availability) enters the selection process in that governmental buildings are given priorities over other forms of accommodation. The stations are generally placed in those areas with the greatest impacts and densest populations. It should be pointed out that the equipment employed varies from station to station and city to city depending upon the immediate needs of the locality.

5.1 Fisheries Management

Three types of information-gathering programs have developed in Fisheries - one dealing with quantities of fish caught, another monitoring the quality of both the catches and the resulting processing, and the third with more general biological oceanography.

5.1.1 Quality Programs

The Department has a statutory obligation to ensure that production and distribution of wholesome, good quality fish products to consumers is maintained and that fair trade practices are implemented within the industry, including prevention of fraud and deception. It is Departmental policy to assist the fisheries industry in the development and application of methods, techniques and processes to prevent contamination, and to maintain product quality through all levels of production, distribution and sale.

There are 130 inspection centres, supported by 22 strategically located laboratories. Across Canada, there are over 50,000 vessels involved in commercial fishing operations. These vessels supplied fish products to 281 fresh and frozen processing plants, 86 canneries and 234 curing plants during 1972.

The Inspection Branch employs 221 personnel in the field inspection group and an additional staff of 138 to support all phases of the laboratory operations.

The operating budget for 1973-74 is as follows: product inspection, $3.1 million; processing and plant inspection, $1.8 million; and vessel certification, $1.1 million. The laboratory personnel are all involved in the product inspection, while the field inspection personnel are primarily concerned with vessel, processing and plant inspection, and to a much lesser extent, product inspection done in the plants.

The Inspection Branch, through its Departmental Headquarters and five Regions, provides an integrated and uniform fish inspection program throughout Canada, functioning in all ten provinces and the territories. For several years, the Inspection Branch has conducted a program of upgrading fish processing plant standards as part of its over-all program to protect the wholesomeness of fish and fish products. All fresh, frozen, canned or salted fish products entering the export or interprovincial trades are now required to be processed in plants which meet registration requirements for construction, equipment, and operation, as set forth in the Fish Inspection Regulations.

Weekly and biweekly inspections are made at each of the processing plants for primary quality inspection: weight, product identity, and labelling compliance. Samples of finished products are taken for laboratory inspection.

The Field Inspectors also make routine inspection of both processing plants and fishing vessels. In both cases, the equipment used and procedures employed in the operation of the plants and vessels are checked for cleanliness and sanitation practices. The operating and manufacturing techniques employed by the vessel and plant owners are kept under close scrutiny by the Field Inspectors to ensure that the Fisheries Inspection regulations are observed so that an acceptable standard of wholesomeness will be maintained for the finished products.

Each year a variety of fresh fish, as well as imported fresh, frozen and canned products (including special samples submitted from other Departments and provincial agencies) are sampled from various locations and tested for the presence of potentially hazardous substances.

Fish Inspection Laboratories across Canada continued monitoring programs to detect potentially hazardous substances in fish. The substances monitored included mercury, lead, cadmium, arsenic, selenium, polychlorinated biphenyls (PCB's) and pesticide residues.

These programs are meant to establish the present background levels and check their increase or decrease. The results are forwarded to Ottawa; however no plans have been made to publish the data.

In order to prevent hazardous shellfish from entering the market, bacteriological tests are made both before and during the harvesting season in order to detect any changes in shellstock quality. This program has been continuing since 1967.

5.1.2 Quantity Programs

Because fish stocks have, in recent years, been harvested to the point that some species have become economically unexploitable, various commissions and programs have been established to study and control these species off the Northwest Atlantic coast. The problem of quantities is two-fold - maintaining adequate fish stocks to ensure economical harvesting in the future, and allowing enough fishing to continue to provide the fishermen with a basic income.

An abundance of economic and statistical data which covers a wide range of east coast fisheries operations is collected each year. As well as being used for immediate operational needs this data is available for international quota setting. Canada, as one of its obligations to the International Commission for the Northwest Atlantic Fisheries (ICNAF) serves on scientific committees with fifteen other member nations to determine the available resource base of all commercial fin and shellfish species.

Several times a year, depending on the prevailing conditions, field samples are taken of all the species, emphasis being put on the more economically important ones. From these samples, the age and size of the fish are determined, and the number of fish in each age group can then be ascertained.

This information is forwarded to the data processing centre of ICNAF, located at the Bedford Institute in Halifax, where it is combined with the inputs from other member countries. The scientific committees in ICNAF then prescribe the amount of fish which can be harvested by each country in predetermined areas.

The ICNAF is used primarily as a forum for assessment and management of those fish stocks which are now in international waters. Canada is the main contributor to this Commission, and provides it with computer support for data processing purposes at Bedford.

Information on the cumulative catches for each species in each area is recorded by the Resource Management Branch, and sent to the Fisheries Intelligence Services Division for processing. Details on the size, type, and location of the catch can be obtained from either the purchase slips that each processing plant fills out when purchasing fish from the fishermen, or the ship's log-book reports, which are voluntarily submitted at the end of each voyage.

Once the Intelligence Division notes that the cummulative catches are approaching their quota limits, a daily watch is kept on all landings until the quotas have been filled. The Resource Management Branch then closes the area and makes surveillance patrols at later dates using naval, research or other fishing vessels to ensure the closure is respected.

Each month, Fisheries sends out summaries, which include the amount of the fish caught during the past month and the amount of the quotas harvested to-date. However other data concerning fish landings, prices, numbers and types of boats, plants, fishermen, etc.

are published in one of several annual reports by either ICNAF, FAO or Statistics Canada.

Fisheries and the fish processors are the main users of size and species information, but regular requests do come from the provincial government, private consultants, international governments and commissions, and other federal government departments. The individual fisherman, however, is not a big user of the collected data.

The Canadian Atlantic Fisheries Information Service (CAFIS) was recently established, and is being further refined to provide pertinent fishing information on a real-time basis. It has been tested in the Gulf areas and along the Nova Scotian coast to try and provide fishermen with information concerning the best current fishing areas. This service could be useful for species of fish such as herring, which change location almost every day.

While CAFIS is striving to make the fishing fleet more economically efficient by providing up-to-date information, quota restrictions have been imposed by ICNAF for the amount of fish allowed to be caught.

5.1.3 Biological Oceanography

Although the chief emphasis of biological oceanography lies in research, a number of long-term time-series of observations are carried out. These include phytoplankton, zooplankton and primary productivity. In particular, data on plankton have been collected since 1956 at Ocean Station Papa in the North East Pacific. Vertical plankton hauls from 150 metres have been made at least weekly, and often daily in summer; C^{14} measurements are taken twice weekly at this site to update primary productivity estimates.

Also at Ocean Station Papa, fish samples are collected by the weather ship crew during their off duty hours. Crew members are encouraged to fish by the offering of prizes for the largest fish caught, the greatest number of fish caught by crew member during a cruise, etc. These fish are sent to the Fisheries Research Institute at Nanaimo for analysis. The crew are also asked to report bird sightings and counts, and this aids in study of species population diversity.

5.2 Ocean and Aquatic Affairs*

5.2.1. Tides and Water Levels**

Tide predictions can only be made and assessed effectively if data exists for an uninterrupted series of observations. Furthermore, to measure long-term changes of the water level relative to our coasts, many years of observations at strategic locations along our ocean shores are required. In addition, to provide tsunami and flood warning, to carry out surveys and dredging, and to enable efficient and safe navigation, certain tidal and water-level gauges must provide real-time data. Measurements of the water-level changes along our continental shelf are essential to compute the ocean geoid and to better understand tides in the offshore areas adjacent to Canada.

Some 140 permanent gauging stations are presently operated for the Ocean and Aquatic Affairs by the Water Survey of Canada to carry out these tasks. In addition, approximately 50-70 temporary stations are operated on a rotational basis from year to year by Ocean and Aquatic Affairs. These provide the same type of data at points not otherwise covered by the permanent stations.

The data gathered are made available to those having a recognized requirement in marine engineering, oceanography, earth physics, geodesy, limnology, hydrology, recreation, etc. To meet changing demands, the data have been disseminated in a computer compatible format as well as in weekly, monthly and annual data reports. These reports are compiled according to data requests which were analyzed over a period of several years.

Data from up to 130 gauging stations are processed on a monthly basis. These are almost equally divided between Tides and Water Level stations. Approximately 40 of these stations produce data on punched paper tape, the remainder are analogue chart gauges, which take continuous readings.

The activities of Tides and Water Levels consist of the processing of water level and tidal observations, computing tidal constituents, determining chart datum, publishing *Canadian Tide and Current Tables*, preparing various technical and scientific reports and the compilation of observed and filtered data.

All data is critically checked, and run through various programs to prepare the tables required by the three volumes of

---

*Formerly the Marine Sciences Directorate.
**Abstracted from the Tides and Water Levels 1972 Annual Report.

Water Level books produced by the Publications Unit. The data is also edited to produce the *Monthly and Yearly Mean Water Level* books.

The *Weekly Water Level Bulletins* are currently distributed to 21 agencies; the hourly height and daily mean listings for various stations are distributed on a monthly basis to approximately 65 different agencies. In addition, a great deal of both current and historic data is distributed to agencies and individuals on a request basis.

The announcing and telemetry system was expanded in 1972 and some thirty systems are now operational. The successful trial of real-time data acquisition, utilizing telex facilities and computer retrieval, has stimulated the interests of other agencies within and outside of Canada.

The transmission of simulated water level data, via the earth satellite system, has proven to be successful. Also, a Department of Communications study is now under way to explore the possibility for an all-Canadian satellite system to obtain hydrological and other data, especially from remote stations. The Section has submitted a proposal to participate in the GEOS-C satellite program. The objectives of this program are to compute tides, mean sea level and distortion of the sea surface during the passage of storms, using satellite-altimeter data. Since much more data is needed to assess numerical global tidal computation and to establish boundary conditions for the modelling of the Bay of Fundy and Gulf of Maine, Gulf of St. Lawrence, James Bay, Hudson Bay and Hudson Strait, Davis Strait and Strait of Georgia, satellites seem to be the answer for covering large areas of water. Tidal information is also essential for gravity measurement and offshore resources exploration and exploitation.

The Data Telemetry systems in the Tides and Water Levels Branch for the year 1972 had operating costs of $29,500 and capital costs of $137,600. Installation and maintenance of equipment required the employment of 1.7 man years at a cost of $20,400.

5.2.2 Wave Climate Studies

The Oceanographic Branch of Ocean and Aquatic Affairs currently operates three permanent (two on the east coast, one on the west coast) and 18 movable wave gauging stations for the purpose of studying wave climates in specific areas across Canada. Manpower problems will require the retirement of three of these rotating stations in the near future.

These studies support the Department of Public Works' coastal design and construction operations. Interest in wave climate of deeper waters is growing and a number of oil rigs located several miles off-shore are being instrumented to provide information on wave climates in the open sea areas.

The Oceanographic Branch, Department of Public Works (DPW) and National Research Council (NRC), all cooperate to produce impact studies for proposed harbour projects.

Another user of this data is MOT. They find the measurement of wave heights very useful for shipping navigational information.

Other studies at specific locations use both the wave climate data obtained by the Branch and the atmospheric data, for the same location, collected by AES. In this way an attempt is made to draw a relationship between the wind velocity and the height of the waves. AES and Marine Sciences are now cooperating in the planning and site selection of future wave and wind gauging stations.

The wave stations operate automatically for twenty minutes every three hours. The relevant data on periodicity and amplitude is recorded and sent to Ottawa where it is stored on magnetic tape. Because of the destructive environment, these gauges tend to be damaged easily; the life expectency of these $10,000 recorders averages about four years. One of these recorders is located on Ocean Station Papa, 500 miles off the western coast of Canada.

In 1972, 5-man years were employed for the operations of the Wave Climate Studies. Their salaries, and operational and maintenance costs amounted to $140,000, and capital expenditures were $82,000.

5.2.3 East Coast Operations

The Marine Sciences Branch administers the regional portion of those programs located on the East Coast which have been established for national implementation, e.g., Tides and Water Levels. These have been discussed under separate headings. Besides this regional aspect, other programs specific to the east coast have been established. Some of these have evolved out of the cooperation of staff involved in other programs.

For several years, quarterly observations for standard oceanic parameters, such as temperature, salinity and depth have been taken at a point off the Nova Scotian coast. These measurements

are taken by the vessel most conveniently available in the area. Recently this project was included as part of a research program which collected data on the line from Halifax to Bermuda. Other measurements, including mercury, petroleum and hydrocarbon traces, as well as the standard measurements of salinity and temperature as a function of depth (STD), were taken during the cruise. It is uncertain at present whether this program will develop into a continuous data gathering effort to study marine parameters on the east coast or will remain as a number of specific research projects.

Each year, water temperatures are recorded during the summer and fall months in the Gulf of St. Lawrence. The data, which is collected from ships of opportunity, as well as research vessels, is used to determine when and if the occurance of ice in the Gulf can accurately be forecast. One of the main drawbacks in such a program is the cost of obtaining a sufficient number of data points for significant results.

5.2.4. West Coast Operations

The Ocean and Aquatic Affairs regional office located on the West Coast has two long-standing data collection programs, both of which are unique to the west coast.

The first program involves the collection of daily temperature and salinity readings at 15 to 20 lighthouses along the coast. This data has proved to be very useful to Fisheries Research biologists in their study of aquatic life. However the program is now seriously threatened by plans to automate the lighthouses.

The second program of which the Ocean and Aquatic Affairs is an integral part is the operation of ocean station "Papa". Measurements which began in 1956 now include the standard temperature and salinity observations to depths of 4,000 metres every week and 1,500 metres twice a week. Every three hours, measurements of temperature versus depth profiles are made to depths of 200 metres.

Although some scientists believe it is impossible to monitor the ocean because of its many inherent idiosyncrasies and our primitive understanding of it, the collection of this data is extremely useful as time-series information that show changes in the ocean on many time scales and leads to a greater understanding of processes of work i. the ocean.

Besides these physical examinations, other chemical and biological data are recorded at regular intervals. These include very precise analyses of the CO_2 content in both air and water and

the alkalinity of the sea water. The oxygen content of water and the surface nitrate content are measured regularly, both at the station and along the line followed by the weather ship as it steams from Victoria to Ocean Station Papa. The incidence of tar balls in the area is now being recorded, and studies are under way to gain background information on fluorescence of sea water to investigate the use of this technique in detecting marine oil pollution.

Since nutrients are now considered to be of prime importance, more emphasis is being placed on obtaining comprehensive information about them. Surface silicate and phosphorus readings are taken daily at the station as well as along the line to Papa. Nutrient profiles from the surface to 500 metres are now being collected about eighteen times a year.

Radioactive carbon (C^{14}) has been measured two or three times a cruise since 1970 in order to assess the relative transfer of CO_2 into or out of the water. Sea water samples have begun to be collected and set aside for analysis of tritium (H^3), but it is not planned to analyze the samples until better laboratory facilities are available. This problem is also encountered in analyzing low levels of both lead and hydrocarbons, and has been delayed pending the establishment of precision laboratory facilities.

Biological data collected at Ocean Station Papa is primarily used by the Fisheries Management. These monitoring programs are described in section 5.1.3, Biological Oceanography.

AES, which has taken weather observations from Ocean Station Papa for several years, uses some of the physical data for its air-sea interaction studies to determine what role the ocean plays in affecting the concentration of CO_2. Ocean Station Papa is one of the few mid-ocean locations (the others are a few similar weather ships located in quite different marine environments) at which long-term studies have been made and so offers a unique opportunity to study ocean-atmosphere interactions far from the influence of land masses.

All marine data collected at Ocean Station Papa, while they may be used for specific research projects, are sent to the Marine Environmental Data Service in Ottawa for archiving. The atmospheric data are processed, analyzed and stored at the AES Headquarters in Toronto.