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FALL/WINTER 1982/83

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Chinook Fall/Winter 1982/83 Volume 5 Numbers 1/2

Articles

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THE COVER

Hoar frost on the fronds of a coniferous tree can make a very pretty picture, but under other circumstances this type of phenomenon can turn ugly. The build-up (accretion) of ice can, for example, be of sufficient thickness to alter the aerodynamic response of airplane wings and propellors causing a pilot to lose control, or of sufficient weight to cause structural damage to towers. For more about icing, see pages 4 and 5.

NEWS AND NOTES

1982 WAS COLD AND WET

According to records of the **Canadian Climate Centre** of Environment Canada 1982 was overall a cold year; temperatures were below normal in virtually all of the country. It was also a dull year, with more of the country wet than dry.

The year was not all gloomy, however, ample amounts of rain and sunshine contributed to record grain production on the Prairies and bountiful fruit and vegetable harvests in Ontario, Quebec and the Maritimes. An end of year mild spell in Eastern Canada lessened the demand for heating fuels and delayed the inevitable start of winter.

The Canadian Climate Centre uses data collected by an army of weather observers across Canada, many of whom are volunteers. These observers take daily measurements, often in their own backyards, of temperature, precipitation etc. These measurements are recorded, archived and used to develop 30-year climate normals for thousands of Canadian locations. Some of the more significant weather events recorded in 1982 were:

1. Much of Canada experienced its severest winter in many years. Record low temperatures were set in many localities. The space heating requirements in most population centres in British Columbia, Alberta and eastern Canada were four to eight percent above normal. Weekends in January were particularly cold and stormy in southern Ontario and Quebec and in the Maritimes.

2. In February, a series of intense storms lashed the Maritimes with strong winds, snow and freezing rain. On February 14 and 15 a storm battered the Atlantic provinces with winds in excess of 100 km/h and high seas above 20 metres. During this storm, the world's largest oil rig, the **Ocean Ranger**, sank with a loss of 84 lives.

Another storm which struck on February 21 and 22 caused near-zero visibility and deep snowdrifts and isolated parts of Prince Edward Island for almost a week.

3. In mid-April, heavy rains and fast-melting snow spelled disaster to the Eastern Townships and the Beauce region of Quebec. Flooding in the area was the worst in 42 years, and in Sherbrooke alone damage to the central business area ran to about $4 million.

4. A late spring snowstorm battered southern Alberta and Saskatchewan on May 29 and 30. Strong winds whipped up to 60 centimetres of snow into drifts which were 2 metres deep in some places. Thousands of people were without power for up to 12 hours. Several highways were blocked, campers stranded, and many newborn calves died.

5. June brought record high temperatures

Continued page 27

P.J. Elms

ICING

A Photo Feature

The photographs on these pages illustrate a meteorological phenomenon, namely icing, dreaded by all who have to deal with it. In many parts of Canada, particularly the eastern half, what motorist has not had to contend with treacherous roads covered by a slick of "black ice" due to freezing rain. The enchanting crystal quality of ice encrusted trees so frequently seen in the bright cold sunshine of the day following the storm has also earned it the old fashioned name of "silver thaw". Besides freezing rain or freezing drizzle, icing also results from the accretion of wet snow, and in clouds of supercooled water droplets (i.e. liquid water droplets which exist at temperatures below freezing). Depending on the temperature range, in-cloud icing can be of two types; (a) glaze, a clear layer of ice formed by large droplets at near freezing temperatures which spread over a surface before they freeze, and (b) rime, a porous opaque layer formed by small droplets at much colder temperatures which freeze instantaneously upon contact with surfaces such as aircraft wings, hydro-electric towers and wires.

The picture on the facing page illustrates glaze which has been pushed away from a fence by the wind as temperatures rose above freezing. The almost unrecognizable tree, below left, is entirely covered by a heavy layer of glaze ice. Below, right, a hydro-electric transmission tower in Québec has been crumpled by the weight of ice. Measurements of ice loading on hydro-electric transmission lines have been made and thicknesses of 20 to 23 cm of ice around conductors are not uncommon. A major line failure which occurred in the Gaspé Peninsula (Québec) during the winter of 1956 was the result of ice accumulations up to 33 cm in thickness.

Icing conditions occur in any country which experiences sub-freezing winter temperatures and is also exposed to winds laden with moisture from ocean sources. Damage due to severe icing has been reported from parts of the world as diverse as California, France, Spain, Norway and Russia.

Photos courtesy Environment Canada

BOOK REVIEW

THE WEATHER BOOK by Ralph Hardy, Peter Wright, John Gribbin, John Kington. John Wiley & Sons Canada Ltd, Toronto, 1982. 224 pages. Hardcover, $29.95

Perhaps this book should be called ***The** Weather Book* to distinguish it from another by the same name which was written by a different author and published in 1980. ***The** Weather Book* is a delight in every way (except perhaps the price). Technically, it has been beautifully produced and edited, with clear and varied illustrations on every page, most of them in colour.

A reading of the contents of the book, for example the fundamental forces governing global weather patterns, the seasons, atmospheric composition, the Earth's radiation balance, fronts and frontal systems, might lead to the conclusion that here is another of those dull tomes full of incomprehensible graphs, charts and equations. Nothing could be further from the truth. What it in fact contains is a lively presentation of what makes weather, its effect upon us, and its interaction with the world around us. To illustrate and amplify the chapter dealing with natural phenomena, there are pictures of things such as the prints of hailstones fossilized in shale dating from 160 million years ago, and lightning explosively striking the sea surface. A number of fascinating old prints have also been included, one of which (reproduced here) shows the effects of a violent hailstorm in Saxony, Germany, in AD 837 which killed several people.

In the words of Nigel Calder, who wrote the foreword, "the invitation from the author-experts of this book is to a keener awareness of the daily drama in which all of us participate willy-nilly. They explain basic principles and tour the boundaries of present understanding..." A highly recommended book for the general reader. Worth it just for the pictures alone.

ENERGY BRIEF

The close, two-way relationship between energy and the environment makes it imperative that environmental capabilities and factors be given full consideration from the start in selecting and developing energy sources and technologies.

In the fall of 1980 the Department of the Environment presented a brief to the Parliamentary Special Committee on Alternative Energy and Oil Substitution (Mr. Thomas H. Lefebvre, Chairman). This brief was well received and its contents were reflected in the Committee's final report.

The purpose of the brief was to communicate to the Committee the Department's views on a range of considerations having to do with energy. The compilation of the brief involved the participation of many elements of the Department, and ultimately it amounted to a compendium of information and data that is not ordinarily undertaken. It was published in 1982 and what follows is an abridged version dealing with those elements judged to be of most interest to the readers of ***Chinook***. The complete version is available from the Minister of Supply and Services, under catalogue number En-21-35/1982E.

Given the pervasiveness of energy use in our industrial economy, it should be apparent that it is very difficult to identify optimum mixes of energy supplies and that there are no obvious solutions. It is also hoped that the reader will appreciate the need to evaluate environmental effects as a critically important part of the task of designing least-cost energy supply systems.

The brief demonstrates that the one energy "source" that can be encouraged without fear of hidden side effects is conservation. Clearly, the use of energy is at the root of many environmental concerns and using less energy to provide the same level of service is almost always environmentally beneficial.

ENERGY AND THE ENVIRONMENT — A PERSPECTIVE

Energy and the environment interact with each other in several ways. First, components of the natural environment provide energy, not only in the form of wind and solar energy, but also in the form of forest biomass and hydraulic power. Such sources of energy are thought of as renewable and are therefore particularly appropriate replacements for finite energy sources such as fossil fuels. Canada's rich endowment of renewable resources offers substantial potential for meeting future energy needs.

While the assimilative capacity (capacity to absorb pollutants) of the environment up to a certain stress level is recognized, beyond this level the exploitation and use of both renewable and non renewable energy resources can generate irreversible and adverse environmental impacts. Some of the impacts are quite apparent such as air pollution in urban areas. Others are more subtle such as climatic change induced by CO_2 increases in the upper atmosphere. There can be substantial effects on other uses of the affected environmental resources (air, water, wildlife, land, climate, etc.). Significant environmental and economic disruption can occur locally (e.g. due to oil spills or the siting of a power plant), regionally (e.g. effects of acid rain on tourism in Central Ontario), or nationally and globally (e.g. CO_2, acid precipitation, climatic change).

In turn, climate and environmental conditions affect the availability and accessibility of energy sources. Hydro-power, the water cycle and forest biomass are mutually interdependent. The environment is a major concern in exploiting northern and off-shore oil and gas resources.

The environment and, in particular, climate also affect energy demand. For example, a one degree fall in average annual temperature for locations in southern Canada will produce a 10% increase in space heating energy demand.

The close, two-way relationship between energy and the environment makes it imperative that environmental capabilities and factors be given full consideration from the start in selecting and developing energy sources and technologies.

POTENTIAL OF ALTERNATIVE ENERGY RESOURCES

The full energy potential of Canada's renewable energy resources has begun to receive attention only recently. In several cases, associated technologies are new or unproven in the Canadian context, and estimates of their potential are only tentative. However, one can make several general statements concerning the availability of renewable resources to meet Canadian energy needs.

Renewable resources are a practical alternative to oil and other conventional energy sources and they can play a significant role in an oil substitution program. Renewable energy resources such as forest biomass, hydropower, solar radiation and wind could meet most future transportation, heat, and electricity needs in both urban centers and less populated regions of the country. As with any resource, the amount of energy available depends on the price, the efficiency of the technology, and the time required for development. Given concerted priority through R&D funding, tax and other financial incentives, and the removal of major

TABLE 1

ESTIMATES OF ANNUAL ENERGY THAT COULD *REASONABLY* BE EXPECTED FROM RENEWABLE RESOURCES AND ENERGY CONSERVATION BY THE YEAR 2000

ENERGY SOURCE	DATA SOURCE	AMOUNT OF ENERGY PER YEAR (bbls of oil equivalent x 10^6)*	
Solar Radiation:			
passive solar	National Research Council (NRC)	**29**	(1)
domestic hot water	NRC	**2**	(2)
ind. process heat	NRC	**15**	(2)
space heating	NRC	**3**	(2)
Solar sub-total			
Wind	NRC	**3**	(3)
Alternate Hydro (small scale, etc.)	Dept. of Environment (DOE)	**20**	(4)
Tidal	DOE	**24**	(5)
Wave	DOE	**Nominal**	
Ocean Gradients	DOE	**Nil**	
Biomass (forest) to Methanol	DOE	**180**	
Municipal Solid Wastes	DOE	**7**	
Geothermal	NRC	**Nominal**	
Peat	Energy, Mines, and Resources (EMR)	**0.5**	(6)
Sub-total		283.5	
Conventional hydropower		**353**	(7)
Total from *renewable* sources by 2000		**636.5**	

(1) Ref. NRC Presentation to the Special Committee, July 9, 1980, p. 11 — 2% of National Energy Use — taken as 1470 x 10^6 bbls oil/year for the year 2000.
(2) Ibid — assumed 10% of the potential quoted would be achieved by 2000.
(3) Ref. NRC Presentation to the Special Committee, July 2, 1980, p. 13 — Tabulation gives 20 PJ (petajoules) by 2000.
(4) Best available estimate of alternate hydro potential is 180 million bbls oil/year. It was assumed that about 10% of this would be developed by 2000.
(5) This assumes that the oil would be used in a conventional thermal generating plant to produce the same electricity available from tidal power.
(6) Private communication from Coal and Peat Resources Evaluation Branch, Energy, Research Laboratory, EMR.
(7) The 1980 National Energy Program says that hydro now contributes 24% of Canada's energy. This same ratio was assumed to apply in 2000.

*Note:
(a) The figures used are indicative only and in many cases will require further analysis. Actual availability obviously will depend on many factors.
(b) The basis of barrels of oil equivalent has been used for convenience. It should not be assumed that direct substitute for oil is possible in every case.

ENERGY CONSERVATION GOALS FOR 2000*	AMOUNT OF ENERGY PER YEAR (bbls of oil equivalent x 10^6)
— Space heating	**221**
— Industry	**180**
— Transportation	**43**
Total from *conservation* by 2000	**444**

*Source:
Private communication from Conservation and Renewable Energy Branch, EMR.

Note:
Due to possible overlaps and mutual interrelationships (direct and indirect) between the use of renewable energy resources and the conservation of energy, the above 2 sets of figures should not be added. The actual total of the contribution is probably significantly less than the addition of the 2 respective contributions would indicate.

institutional barriers, it would not be unrealistic to see renewable energy resources, excluding conventional hydropower, providing up to 20% of Canada's total annual energy needs by the year 2000 (Table 1). If the potential for conventional hydropower is included, the contribution of renewable energy resources could exceed one third of total energy consumption by that time (taken as 1470 × 10^6 bbls oil/year).

The energy available from renewable sources is widely dispersed geographically (Table 2). Thus, unlike most non-renewable energy resources, renewable sources of energy can be developed in the the region of energy demand. This has obvious implications in equalizing opportunities available to all regions of Canada to share in the economic benefits that may be associated with energy resource development. It also has implications related to the transportation or transmission of energy. Because of their dispersed nature, renewable resources also offer considerable advantages as sources of energy for the many small and isolated communities in Canada which currently face very high energy costs.

Supply cycle characteristics (Table 2) vary greatly among renewable energy alternatives. Solar energy fluctuates daily, seasonally (radiation for the worst winter month can be 1/6 of that for the best summer month) and according to local climate and weather, but within generally known limits. Wind energy also has considerable daily and short term fluctuations, but is generally less variable than direct solar energy on a longer term basis. Energy production from other renewable resources is less variable than are solar and wind sources. Problems of supply fluctuations can be mitigated through the use of energy storage systems and by drawing on various mixes of energy supply alternatives which in aggregate, smooth out energy supply over time.

Alternate energy sources and technologies have widely varying environmental implications, ranging from mainly beneficial or benign, to substantially damaging. Limitations can be in terms of (i) location (in regard to environmental sensitivity or other uses of the environment), (ii) scale, or (iii) rate of energy production or use. Limitations can occur in the form of regulations, decisions by environmental assessment panels, societal resistance or high costs.

SOLAR RADIATION

Despite its northern location, Canada possesses an abundant supply of solar energy. The annual amount of solar radiation received is approximately 6000 times the annual Canadian consumption of all forms of energy. Figure 1 shows that the southern sections of Canada up to the latitude of 55° N, which are also the most populated, have the highest potential for solar energy utilization. Useful application of solar energy also may be possible in the far northern sections of the country during the long period of daylight experienced in the spring and summer months. The distribution of solar energy can partially offset the less convenient geographical location of some other sources of energy relative to their major Canadian markets. Canadian energy sources with potential are located in more northern areas (e.g. hydropower, oil and gas) or in the east or west (coal, hydropower), hence requiring long distance energy transmission and transportation systems.

The development of solar energy has a number of constraints. The diffuseness of the resource necessitates large capture areas for industrial or utility exploitation. For example, a 1000 Mw solar electric power plant could require a collector area equivalent to a square with sides 8 km long. Also, the solar radiation received fluctuates greatly between summer and winter. For cities, even in southern parts of the country, the worst month may receive only one-sixth of the solar radiation of the best summer month. Thus, the seasonal fluctuation of solar radiation received is completely out of phase with the demand cycle for space heat.

It is clear that, for Canada at least, the key to fully harnessing this vast natural flow of energy is efficient storage – storage to bridge seasonal gaps and to overcome the handicap of its diffuse nature.

Close to one-third of energy consumed in Canada is used for low temperature heat needs such as domestic and industrial space heating, and domestic hot water. Solar energy, with storage for backup, is particularly suited to meet geographically dispersed, low quality heat requirements of this nature. Already, solar radiation, through passive solar gain, is providing about *12%* of Canadian residential space heating needs without any conscious exploitation.

One recent study reports that direct solar energy could provide from 3 to 8% of total U.S. energy consumption (assuming this to be 100 quads) by the year 2000. Although such estimates are rarely voiced for Canada* it is interesting to note that solar radiation received over the most heavily populated part of the U.S. (eastern U.S.) is within 25% of the solar radiation received over the southern part of Canada where demand for space heating is also concentrated. This comparison is based on the amount of solar radiation received on a horizontal surface *inclined* from the horizontal at an angle approximately equal to the local latitude. (Regional climatic conditions are the primary influencing factor.) Ignoring the effect of climate, an inclined solar collector located in Winnipeg can receive, over a one year period, about the same radiation as an inclined collector in Florida. However, the effect of latitude on solar radiation received increases rapidly as one moves northward from Winnipeg into the northern Territories. Thus, the potential contribution of solar energy for Canada is not substantially different from that available for the U.S.

Longer term records (more than 30 years) of solar radiation exist for only a few major Canadian centres. There are now over 100 locations in Canada for which at least 10 years of data exist. Although these data are based on radiation hitting a horizontal surface, steps have been taken to derive data for various inclined surfaces and with various azimuths for most of these locations. Radiation data compiled on this basis will facilitate the effective design of both passive and active solar energy systems for any geographic and climatic situation across the country.

In response to the need for more appropriate solar energy data, Environment Canada is developing existing and new solar radiation data files, and is conducting solar spectrum and site specific solar studies. This program will lead to a more accurate picture of the solar energy potential in various locations across the country. It will also provide design parameters essential for solar technology and applications design.

Clearly, Canadian climatic and energy demand characteristics pose major problems. However, the most significant problem, at least initially, is one of attitude. Improved understanding of a relatively unique Canadian situation vis-à-vis this somewhat novel but potentially large energy source will do much to bridge this attitudinal gap.

Technology is the key to solar energy transformation and application, at an acceptable price. The Canadian energy demand and solar radiation patterns, and the country's extremes of climate and geography, are sufficiently unique that total reliance on foreign technological transplants would significantly retard the development of this potential. Particular R&D emphasis should be given to solar energy storage, both short and long term, and to energy back-up systems, as well as to climatically appropriate building design which taps the full potential of passive solar heating and reduces extremes in space heating demands. Through appropriate incentives in these areas, Canadian industry could build a significant comparative advantage in a very promising growth industry.

ENVIRONMENTAL IMPLICATIONS OF USING SOLAR ENERGY

The use of solar energy reduces the demand for fossil fuels and, hence, leads to the conservation of such non-renewable energy

*We note that the presentation by the National Research Council to the Committee on July 9, 1980 suggested the following approximate solar energy potentials could eventually be realized under appropriate conditions (percentages based on total national energy consumption): passive solar – an additional 2% by the year 2000; domestic hot water – potential impact 1½%; industrial process heat – potential impact up to 10%; space heating (active solar) – potential impact 2%.

TABLE 2

POTENTIAL OF ALTERNATIVE ENERGY RESOURCES

RESOURCE	GEOGRAPHIC (LOCATIONS OF GREATEST POTENTIAL) AND SUPPLY CYCLE CHARACTERISTICS	STATE OF TECHNOLOGY	MAJOR END USE APPLICATION VIS A VIS MARKET (MATCHING SUPPLY TO DEMAND)	ESTIMATES OF ENERGY POTENTIAL (BARRELS OF OIL EQUIVALENT; ANNUAL BASIS)
Solar radiation	***Geographic:*** Across southern Canada, up to 55° N. latitude ***Supply Cycle:*** Regular daily and seasonal fluctuations (radiation for worst winter month can be 1/6 of that for best summer month). Fluctuations affected by local climate and weather (cloud cover, etc.) and by air pollution	Relatively new in Canadian context. Passive solar building design, materials durability, and storage (short and long term) are important areas for R&D emphasis in a Canadian context.	Space and water heating (active and passive): Geographic match is good Supply cycle match is poor (highest demand is in winter when radiation is least), therefore storage or backup is required. *Electric Power* (photovoltaic) As above	NRC (1980) estimates: Passive solar: **2% of total national energy consumption (TNEC)** by 2000 (additional to 12% current Domestic hot water potential impact **1½ of TNEC.** Industrial process heat: potential impact of **10% of TNEC.** Space heating: potential impact of **2% of TNEC.**
Wind	***Geographic:*** East coast, Gulf of St. Lawrence, Hudson Bay and S.W. Alberta Numerous local pockets of high potential across the country ***Supply Cycle:*** Energy generally available on year round basis with much less seasonal fluctuation than for solar. Short term fluctuations (daily, weekly) can be substantial.	Relatively new in a Canadian context (except for windmills	*Electric Power:* Good potential for coastal regions and for smaller pockets. Especially attractive for off-grid communities but storage or backup is essential.	**300 million barrels** (60,000 MWh) potential (optimistic scenario by Templin of NRC). **3.3 million barrels** (20×10^{15} Joules) for the year 2000 (NRC projection, 1980).

Alternate hydro	***Geographic:*** Alternate hydro is available throughout Canada. Quebec, B.C. Alberta and north of 60° are areas of greatest undeveloped *total* hydropower potential (breakout for alternate hydro not available). ***Supply Cycle:*** Can be substantial seasonal fluctuations for example due to spring run-off, summer dry spells. Fluctuations due to climatic factors can be significant (e.g. prolonged drought).	Technology is relatively mature.	*Electric Power:* Good potential for many small communities, especially "off-grid" communities. Fluctuation problem can be substantially overcome through dam and pumped storage (also hydrogen and battery storage may become feasible). Significant potential to supply grid either for base load or peaking demands. Sites that are remote from both grid and demand centres may eventually be feasible sites for hydrogen production.	**180 million barrels,** assuming only one-half of the present hydropower capacity represents the potential for alternate hydro.
Tidal	***Geographic*** Bay of Fundy Region. ***Supply Cycle:*** Daily tidal cycle permits harnessing of incoming and out-going tides. Relatively constant and completely predictable source of power seasonally and annually.	Technology is reasonably advanced and no major technological problems exist. Demonstration in a Canadian context and some development is required.	*Electric Power:* Good potential for Maritime Region. On the basis of systems studies, the output from the Bay of Fundy development can be absorbed without difficulty into the utility grid.	**24 million barrels** ($16 = 10^6$ Mwh) by 2000 for total Bay of Fundy potential considered economically feasible (25% of this amount could be available by early 1990's).
Wave	***Geographic:*** East and west coast off-shore regions. ***Supply Cycle:*** Fluctuation with wave frequency.	Technological development is being initiated elsewhere.	Electric Power:	Only limited commercial application for Canada.
Ocean thermal energy gradients (OTEC)	Likely not feasible for Canada.	No producing plants yet. U.S. is developing OTEC technology.	Electric Power:	Likely little if any commercial application for Canada but will be international potential.
Salinity gradients	Large estuaries, e.g. St. Lawrence, Frazer, Mackenzie.	Technology could be available by the year 2000	Electric Power:	Only long term potential for Canada.

sources and to the reduction of their accompanying negative effects.

Environmental impacts vary substantially among the various solar options. These impacts fall into two categories: (i) land use requirements, which could compete with other uses of land, especially near urban areas and (ii) emissions associated with the mining and production of the materials required to manufacture solar equipment.

The passive solar energy option is the most benign from an environmental point of view since special materials requirements or land use implications are relatively minor, if significant at all.

Community-based (decentralized) solar collection could affect land use patterns. Proper orientation of buildings for solar energy purposes could increase the cost of houses in the community. For example, services for providing utilities might have to cover greater distances, or the land developer might not be able to achieve maximum utilization of his land (fewer lots per acre). Utilization of solar energy could also influence residential and commercial architectural styles and require changes in building codes. Multi-unit structures would present fewer problems of this nature. Solar space heating using seasonal hot water storage appears economically feasible for such structures at the present time.

Land use requirements for a large scale solar thermal or photovoltaic generation plant would be substantial, and likely to be prohibitive close to urban areas. However, the spatial requirements are probably comparable to those required by conventional fuel options when their total fuel cycle requirements for extraction (e.g. surface coal mining), processing, transportation, combustion or conversion plant and waste disposal, over an equivalent life cycle period are considered. In addition, the solar energy option would, in most cases, be less disruptive to land use and could offer some opportunity for multiple use of the land (e.g. underground developments).

The environmental impacts resulting from production of materials for solar equipment on a large scale could be substantial when cumulated. While the additional impacts arising from producing, for example, copper for solar panels may be a small portion of the total impacts associated with the copper industry, they are significant when compared to impacts arising from conventional heating systems. For example, the production of copper, aluminum and steel for a solar heating system would emit much more particulates and sulphur oxides than would the *annual operation* of a domestic oil or gas heating system with equivalent energy output, and somewhat more than the annual emissions produced by a coal-fired generating station in providing the same energy output for electric space heating.

However, it is important to note that the solar heating system causes pollution only during the mining, processing and production phases of the material for the equipment, but not during its operating life. In comparison, the operation of a conventional system produces pollution not just at the combustion or conversion stage but throughout its fuel cycle, and on a continuous basis throughout its life cycle. In addition, recycling of materials after the useful life cycle would be much more feasible for solar equipment than for conventional plants. Material recycling would substantially reduce energy input requirements and pollution for succeeding life cycles.

As with other power generation options, centralized solar thermal power generation

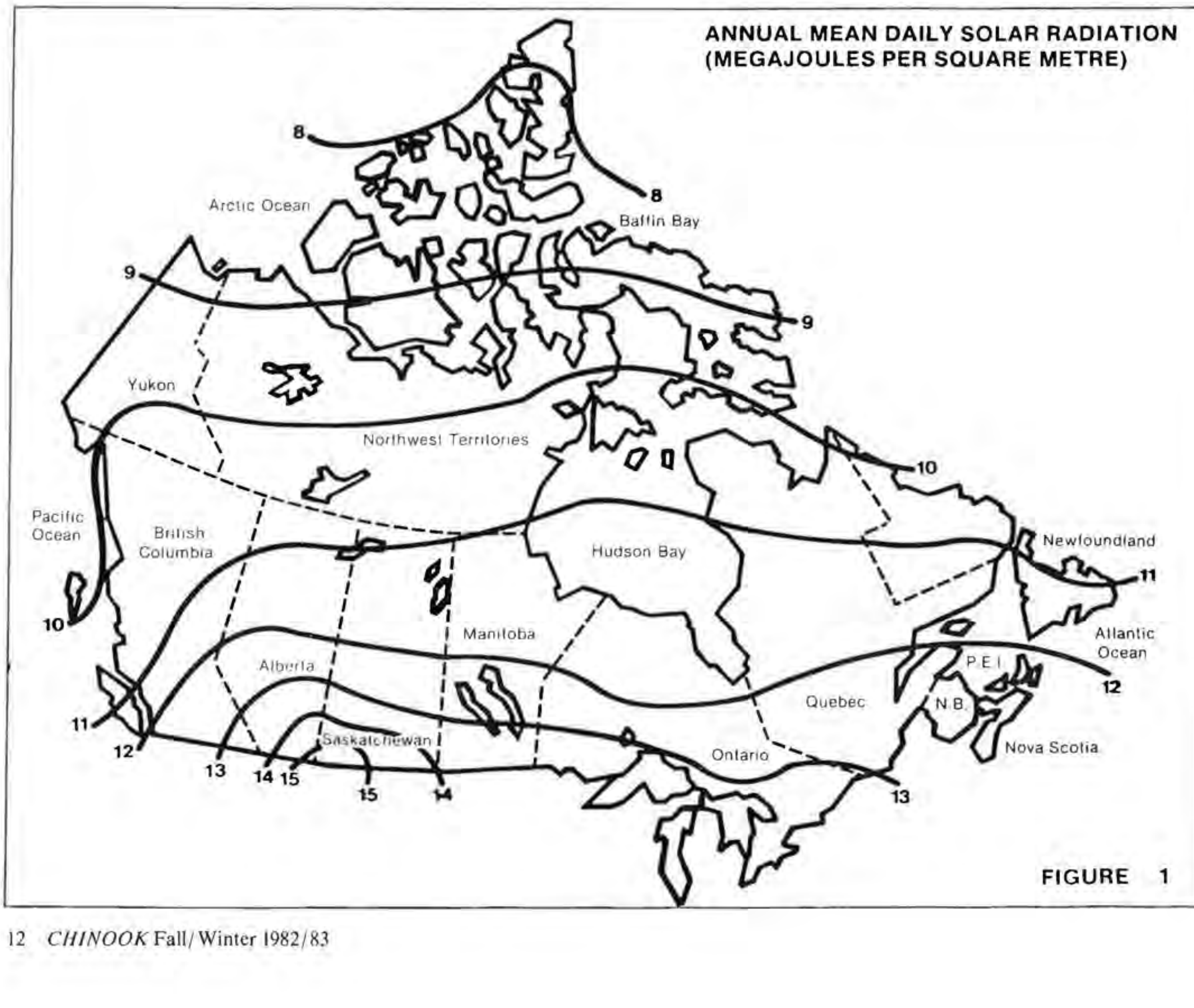


FIGURE 1

would require water and would produce waste heat. This problem does not occur in the case of solar photovoltaic plants.

WIND

It is convenient to consider wind generation of electrical power in three categories:

1) Small and medium Wind Energy Conversion Systems (WECS) of rated power 1-100 kw for individual households or farms and small isolated communities;
2) Wind farms of 10-100 WECS, total installed capacity typically 100 Mw, probably on land, but possibly offshore.

Small and medium WECS could make a contribution to national energy requirements provided agreements could be reached between electricity supply agencies and machine owners. The U.S. Dept. of Energy anticipates approximately 10% of their wind power coming from such machines by 2000. Many areas of Canada would be suitable for installation of such machines if the economics relative to other energy supply options were favourable (say approximately 5 cents/kwh for a 6 metres/second annual average windspeed at hub height). If a substantial contribution to national energy requirements is to come from wind power, however, it will most likely be based on clusters and farms of large WECS. The limitations to wind power will be primarily those imposed by economics, and in particular, the economics of integrating a variable wind power component into a fixed electrical network.

Although the total wind power potential in Canada is very large, it is highly variable across the country (see figure 2). The annual amount of wind energy potential available has been estimated, optimistically, as 60,000 Mwh, which is close to the current total installed electric power generation capacity in Canada (77,600 Mw in 1979). Preliminary surveys suggest the Atlantic Seaboard including the Gulf of St. Lawrence, the region around Hudson Bay, and SW Alberta as areas of high wind energy potential. Coastal sites (including coastal hills) are most suitable for single machines or small clusters, while large wind farms may be viable in southern Alberta and Saskatchewan, and even in the Great Lakes region.

The Department is currently conducting more detailed national and regional wind resource mapping, and is developing techniques for the evaluation of specific turbine sites. We anticipate no difficulty in finding meteorologically suitable sites for the 3200 Mw of wind power that NRC suggests could be installed by the year 2000.

ENVIRONMENTAL IMPLICATIONS OF USING WIND

Wind energy is generally considered to be environmentally benign as a source of electric power. There are neither water requirements nor direct air, land, water or thermal pollution impacts.

For a large scale centralized wind power development, however, land requirements would be substantial. Nevertheless, they would be comparable to more conventional power generation options if the total fuel cycle land requirements of these options were considered. Furthermore, wind turbine arrays lend themselves to multiple use opportunities such as agriculture, which would effectively reduce the land requirements. Also, since Canada's areas of high wind potential are generally removed from high population densities, the chance of land use conflict at the generation site would be reduced. But the accompanying transmission

ANNUAL AVERAGE WIND ENERGY DENSITY AT 50m ALTITUDE

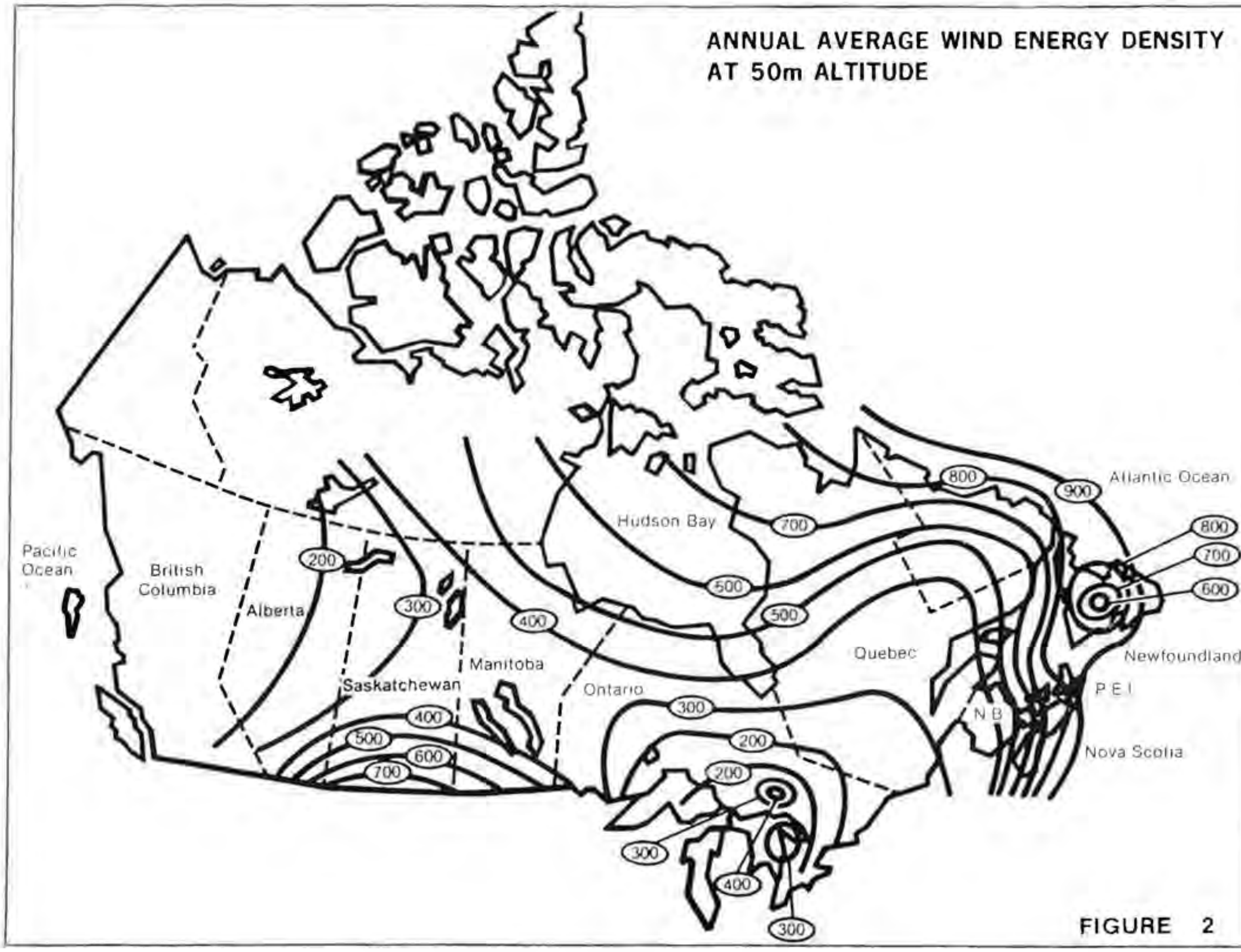


FIGURE 2

corridors over long distances would have to be considered (as with transmission from large scale hydro power developments, or gas or oil pipelines from frontier locations).

The visual impact of large numbers of large wind turbines (with typical heights of up to 150m) on coastal hill sites could be substantial. (One is attractive, one hundred are an eyesore!). The British Central Electricity Generating Board regard this as a major obstacle to siting wind turbines along the west coast of the United Kingdom, but the eastern seaboard of Canada is longer and not so heavily used for recreational purposes. Both visual and land use concerns could be mitigated through locating wind farms well off-shore.

Local interference to TV reception and some noise problems (infrasound) have been caused by two of the American Department of Energy turbines. The television interference is very local (1-2 km area around the turbine) as are most of the noise problems. Cattle graze contentedly near the base of the 630 kw wind turbines at Nibe, Denmark, where one hears only a gentle "swish, swish" within a few hundred metres of the machine.

Bird strikes are a potential ecological impact, primarily in relation to night migration, but studies in Batelle-Columbus, Ohio, suggest that most birds and insects will avoid the turbine. However, the hazard is likely to increase with increases in height and clustering of turbines. Installation on known key migration corridors of birds and insects should be avoided. Ice, or even blade shedding is a hazard which needs to be considered in the safety aspects of turbine operation.

The environmental impacts of producing material requirements for a large scale wind energy program could be substantial, but not likely as great as for an equivalent solar program. Materials impacts also would be much less than impacts associated with more conventional power generation options when the pollution from their total operational life cycle is considered. Wind components, as with solar, should lend themselves to recycling which would further reduce the material impacts.

TIDAL POWER

Figure 3 shows those locations around the globe which offer potential for tidal power. For Canada, there are 3 locations: The Bay of Fundy, Ungava Bay and the B.C. coast.

Changes in energy economics have increased Canadian interest in the potential of tidal power, particularly in the Bay of Fundy. The latest reassessment study conclusively demonstrates the fundamental economic feasibility of developing the energy of the Fundy tides, and the technical and economical feasibility of its integration into the projected generation supply systems of the Maritimes Provinces. The economic tidal potential of the Bay of Fundy is estimated to be 16×10^6Mwh. However, development of tidal power in Ungava Bay and on the British Columbia coast are not considered feasible because they are either too distant from major load centres or too expensive relative to other generations options available for the foreseeable future.

During the past two to three decades there have been a number of technological innovations in turbogenerating units, in marine construction and in the mathematical understanding of tidal cycle variations. It is now clear that major technological problems formerly associated with large-scale tidal power developments have been resolved. Canadian development in the area will pro-

LOCATION OF POTENTIAL TIDAL POWER SITES

Source: R.H. Clark, Inland Waters Directorate, Environment Canada, "PROSPECTS FOR TIDAL POWER", Conference on Long-term Energy Resources (UNITAR), October 31, 1979

FIGURE 3

vide good opportunities for the export of both Canadian expertise and equipment to assist in the exploitation of this resource on a global basis.

ENVIRONMENTAL IMPLICATIONS OF USING TIDAL POWER

The exploitation of tidal energy, given the nature and scale of the work involved, will necessarily give rise to social and environmental impacts requiring appraisal on a broad scale. Although tidal energy may be pollution free in that it does not add pollutants either to the atmosphere or to the water, it will cause ecological changes in its tidal basin and, to some degree, may also affect the tidal regime on the sea side of the development. For instance, the changes in suspended sediment patterns from the existing regime may affect marine organisms. Changes may also occur in the system of currents, for example around the southwest coast of Nova Scotia. There could be changes in upwelling of cold water from the bottom which would, in turn, affect nutrients in the water and thereby affect fish stocks. The extent of this effect would, of course, depend on the magnitude of the tidal development. Some of the detrimental effects on ecosystems attributable to river hydro plants would be applicable also to tidal power plants. The location of important habitat for seabirds and for fish species would have to be considered before the choice for the site were decided.

WAVE ENERGY

There is only a limited commercial potential in Canada for wave energy. However, the Department may undertake testing of a private wave generator in the near future.

The environmental impact of wave energy is expected to be minimal but no research has been done on it. Shore based installations which, for example, convert electricity to hydrogen could have some impact. Near-shore wave action, or suppression of it, could change mixing and water temperature thereby affecting habitat for wildlife. Also environmental impacts could be produced by shore-based installations directly converting wave action into electricity.

THERMAL AND SALINITY GRADIENTS

Ocean thermal energy conversion (OTEC) requires the existence of a large temperature difference between near surface and deeper waters. In Canada, where the vertical temperature gradients of lakes and coastal waters is generally less than 10°C, the development of OTEC is not practical with present technology. Currently, no power-producing OTEC plants exist which could provide data under actual conditions of the environmental effects of harnessing this potential. Predictions indicate that the impact of individual plants will be modest. However, the environmental effects of large-scale operations could be significant. Potentially significant effects may arise from the very great flows of water required and include releases of toxic chemicals during accidents, some entrainment of marine organisms in the heat exchangers, upwelling of deep nutrient rich ocean water, and releases of substantial amounts of carbon dioxide to the atmosphere.

The application of salinity gradients for energy conversion is currently not considered to have commercial potential in Canada although technological advances by the year 2050 could allow large scale, commercially viable development. Environmental impacts would be serious since sources of power from salinity gradients would be concentrated in the mouths of such large rivers such as the St. Lawrence, the Fraser and the Mackenzie. The effects on estuary ecosystems could be severe. Also, fresh water requirements for the power plant to provide the necessary salinity gradient would be substantial.

ROLE OF RENEWABLE SOURCES OF ENERGY

With the exception of hydroelectricity, which already provides one quarter of our energy needs, Canada's diverse renewable energy resources are still largely unutilized. There is enough solar, wind, tidal, forest-biomass and hydro energy available in Canada to meet one third of the energy needs of our industrial society by the year 2000.

Our analysis shows that solar energy has an appreciable potential in southern Canada where population and industry is concentrated. Wind energy can be harvested along the east and west coasts, the Gulf of St. Lawrence, Hudson Bay and SW Alberta. Alternate sources of hydro (e.g. low-head, small scale), yet to be harnessed, are available throughout Canada. The off-shore regions of the east and west coast have been recognized to have potential in tidal and wind power. Biomass from the forests of the coastal B.C., southern Ontario and Quebec has an important potential for energy generation, either by direct combustion or by conversion to liquid fuels.

In many cases, the technology is already available in Canada or can be imported and adapted to Canadian conditions. In other cases, such as the use of salinity gradients in large rivers (e.g. St. Lawrence, Fraser and Mackenzie), technology is expected to be available only by the year 2050.

Many of these renewable sources of energy have already been put to use and their practicality has been demonstrated. Most of them are either environmentally benign or their significant environmental impacts can be mitigated through improved technological design and resource management practices. In the face of declining reserves of finite resources and demonstrable environmental problems flowing from fossil fuels, renewable resources appear very attractive. Furthermore, a greater utilization of Canada's renewable resources will provide economic benefits nationally, regionally and locally.

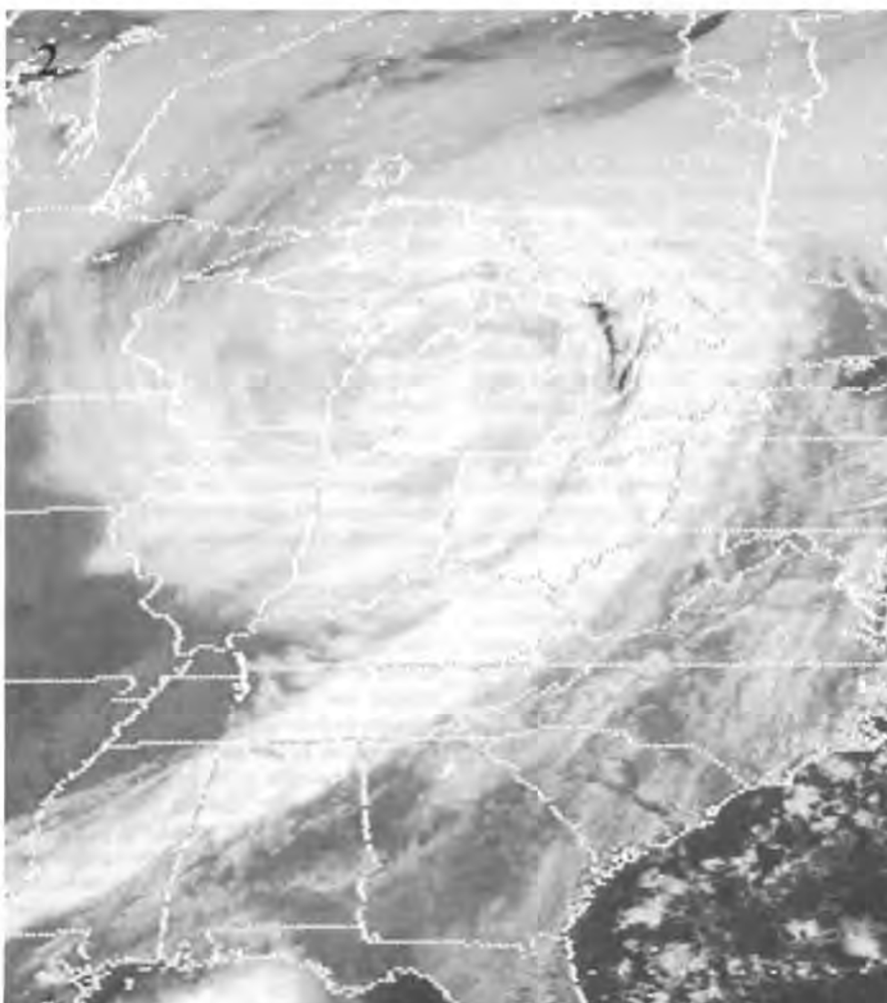
It should be recognized that some of these renewable energy sources are only appropriate for certain applications in Canada. The use of solar power for space heating, especially through the more systematic use of passive solar gain, and for hot water in residences and commercial buildings, or the use of wind power in our more sparsely-populated areas seem practical. The transformation of forest-biomass to liquid fuels is also attractive particularly for transportation fuel.

While the most effective use of renewable energy will be to meet new energy needs in the industrial, transportation and residential sectors, it would be prudent to build new plants and facilities from the outset with renewable energy in mind. For instance buildings should be oriented to take maximum advantage of the sun. Sites uniquely appropriate for wind power plants should not be allowed to be used in ways that preclude later development. In general, new plants should either start on a renewable energy base or at least be able to change to renewable sources with a minimum of alteration or equipment replacement. Renewable energy should therefore figure prominently in industrial, economic and energy strategies at national and regional levels.

The justification for the development and use of renewable energy sources necessarily involves the consideration of costs and benefits in a broader context than is conventionally used in considering fossil fuels. Such factors as security of supply, environmental effects, capital costs, social impacts and net energy factors, among others, should be taken into account when evaluating and comparing the potential role of renewable sources with the conventional. If these same factors were considered for all energy sources, the advantages of renewable energy sources over non-renewables are likely to be much more apparent than is shown by the present accounting system.

PLANNING MUST BEGIN NOW

Evaluation of various energy options should take into consideration such factors as sustained availability of resources in Canada, capital and energy inputs, environmental impacts and the use of the energy produced. An analysis based on these factors would show the benefits to be gained through the use of renewable sources of energy. We should also focus on managing the future demand for energy and encourage energy-efficient technologies and energy conservation. Renewable resources, including conventional hydro, have a potential to contribute nearly one-third of the anticipated demand for energy by the year 2000. But planning must begin now if we wish to attain that goal.



Environment Canada

BORNE MÉTÉOROLOGIQUE

par Don L. Gary et Yolande Stroobants
Université Nicholls de l'état de Louisiane

Je crois qu'un mot du rédacteur français semble tout approprié comme introduction à cet article. Lors de l'introduction de la section française dans la revue ***Chinook***, les membres de l'équipe ***Chinook*** croyaient que l'on pourrait rejoindre les francophones en provenance du Québec et peut-être même ceux des autres provinces canadiennes. Après un peu plus d'un an d'existence, nos attentes ont été comblées et même dépassées comme le prouve l'article suivant. Sans plus tarder je vous laisse à la lecture de cet article mais avant de vous quitter je voudrais vous poser cette question: où pensez-vous que cette plaque (photo 1) est située?

Cette plaque historique commémorant le passage de l'ouragan dévastateur de 1856 se trouve sur la rue du Moulin à sucre, à Houma dans le sud-est de la Louisiane. Cet ouragan d'une force inattendue a éclaté sur l'île côtière de l'Isle Dernière*. Le 10 août (érronément la plaque indique 'le 10 juin'), l'oeil de la tempête, en provenance du nord, est passé à l'ouest du centre de villégiature estivale de l'Isle Dernière; les vents violents ont soulevé le niveau des eaux du golfe du Mexique qui ont dévasté à leur tour aux environs d'une vingtaine de camps d'été, causant la mort de la moitié des 450 personnes isolées sur l'île. Par la suite, les vents de plus de 85 kilomètres à l'heure et les pluies intenses associées à la tempête changèrent de cap, vers le nord, en direction de Bâton Rouge, mais pas avant d'avoir fait chavirer ou endommagé de nom-

*Ainsi nommée originalement parce que localement cette île était la dernière île barrière à l'ouest de l'embouchure du Missisipi. Aujourd'hui le nom est 'Isles Dernières' parce que les tempêtes ont fragmenté l'île originale.

breux bateaux en mer. Le nombre de morts en mer, quoique non confirmé, était probablement égal à celui de l'Isle Dernière.

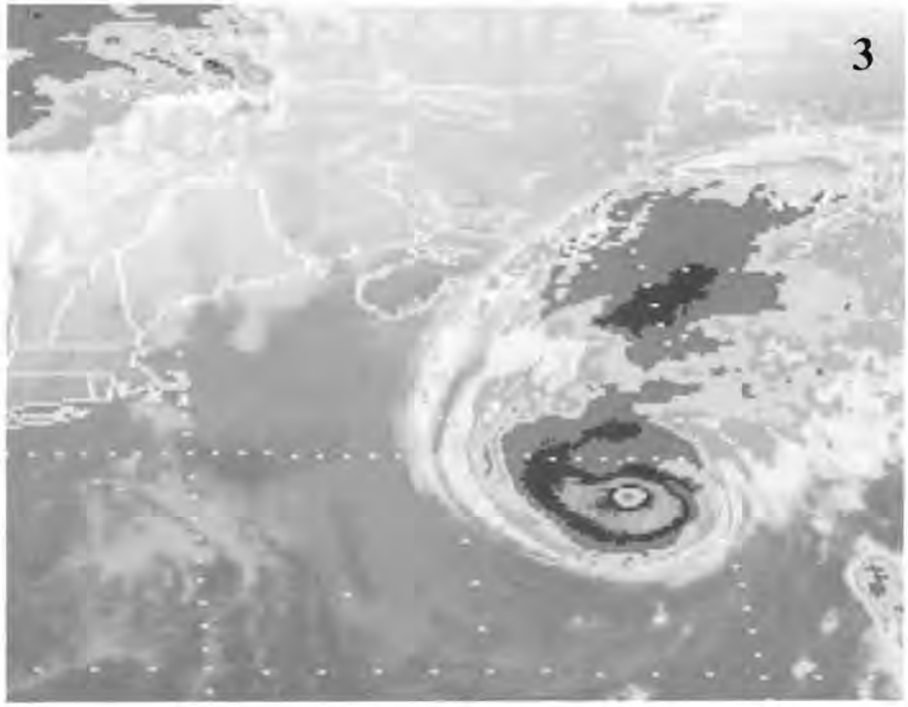
Après ce désastre les facilités récréatives de l'Isle Dernière n'ont jamais été reconstruites.

Dans ce numéro de ***Chinook***, on y a décrit des phénomènes météorologiques de nature violente tels que les cyclones intenses, les ouragans et les tornades. Si on y regarde de plus près ces trois mots sont utilisées pour y décrire une masse d'air en rotation. Pour expliquer cela, il faut vous donner un bref aperçu de la classification des phénomènes météorologiques selon leur échelle de grandeurs.

Les processus thermodynamiques et dynamiques qui régissent le comportement de l'atmosphère sont très complexes et conséquemment difficiles à analyser. Dans le but de simplifier leur analyse, on étudie et classifie les phénomènes selon leur échelle d'étendue horizontale ou verticale ainsi que leur temps de vie.

Par exemple, un spécialiste de la dispersion atmosphérique de la pollution de l'air, cherchant à connaître les caractéristiques de la turbulence atmosphérique à un site donné, mesurera les variations tridimensionnelles du vent à chaque seconde pour indentifier des fluctuations de longueur caractéristique de 1 à 10 cm. Dans le cas de la prévision météorologique à moyen terme (24 à 48 hres), le météorologiste étudiera les phénomènes météorologiques d'échelle synoptique (200-1000 km) tels que les dépressions, les creux barométriques, les anticyclones ect ... Ces systèmes météorologiques étant d'une telle échelle, ils sont susceptible d'être détectés par les réseaux d'observations météorologiques en surface et en altitude existants. Par la suite, le déplacement et le développement de ces systèmes pourront être prévus avec une précision acceptable par des modèles numériques de l'atmosphère faisant appel à des ordinateurs puissants.

Les trois photos ci-jointes, vous montrent des exemples de phénomènes météorologiques d'échelles de grandeur différentes. Sur la photo 2, on voit un cyclone (500-1000 km) qui a atteint son développement maximal avec son onde frontale occluse. Ces cyclones se retrouvent généralement aux latitudes moyennes affectant les régions à climat tempéré. Photo 3: l'ouragan Debby (100-200 km) que l'on aperçoit avec sa forme caractéristique en spirale. Ces ouragans se développent au-dessus des mers chaudes des tropiques d'où ils puisent leur énergie. Ils se situent généralement dans la bande de vents d'est localisée de 5 à 15 degrées de lattitudes de part et d'autre de l'équateur. Les tornades (photo 4) sont facilement identifiables par leur entonnoir nuageux qui peut mesurer de quelques mètres à ½ kilomètre. Elles peuvent parcourir de quelques mètres à plusieurs kilomètres. Elles se retrouvent associées aux orages violents ou bien même à l'intérieur d'ouragans.



Environment Canada

Wide World Photos

THE NIAGARA RIVER ICE BOOM

An example of international co-operation in attempting to minimize Lake Erie shoreline property damage and hydro-electric power losses. The 1981-1982 severe winter season illustrates some of the difficulties of managing ice flows.

Although some reduction in hydropower generation from the Niagara River is experienced each year due to ice problems, it is estimated that the average annual savings to the existing hydropower facilities resulting from the use of an ice boom at the mouth of the river, are approximately 414,000 megawatt-hours of hydroelectric energy.

During the 1981-82 ice season the loss of hydroelectric power generation due to ice was approximately 113,000 megawatt-hours. This is about 3½ times greater than the previous year and approximately 20 percent higher than the average loss experienced over the past 7 years.

It would require the consumption of 185,000 barrels of oil or 49,000 tons of coal to produce an equivalent amount of power. The 113,000 megawatt-hours of hydropower would be enough to supply the 24,000 residents of the Town of Fort Erie, Ontario for 8 months or the 53,000 residents of Hamburg, NY, for 3½ months.

The ice boom accelerates the formation of the natural ice arch that forms near the head of the Niagara River every winter, and stabilizes the arch once it has formed. It reduces the severity of ice runs from Lake Erie into the Niagara River, and thereby lessens the probability of large-scale ice blockages in the river which can cause reductions in hydropower generation and flooding of shoreline property along the Niagara River. In addition, it reduces ice damage to docks and other shore structures.

Once the ice arch is formed, it bears the pressure of upstream ice. Subsequent storms may overcome the stability of the arch and force large masses of ice against the boom. The boom was designed so that when this occurs, it submerges and allows the ice to override it until the pressure is relieved. Once the storm subsides, the boom resurfaces and restrains ice which otherwise would flow downriver. In the winter season this facilitates stabilization of the broken ice cover during the refreezing process. In the spring it minimizes the severity of ice runs by preventing the loose ice floes in the lake from adding to the ice accumulation in the river.

Figure 1 shows a plan view of the ice boom. When in position, the 2,700-metre (8,000-foot) boom spans the outlet of Lake Erie. It consists of 22 spans, each with a series of 13 floating timbers, anchored to the bed of the river.

Problems began when a severe storm occurred on 10-11 January 1982 causing heavy ice runs out of the lake before the ice was consolidated behind the boom and before the natural ice arch had formed. The snow from this storm caused snow-slush ice to form over the lake surface which affected the quality of the ice for the remainder of the winter. This storm produced a large buildup of ice in the Chippawa-Grass Island Pool and also in the Maid-of-the-Mist Pool. It was necessary to reduce diversions of water to the Niagara River powerhouses and the Power Entities' ice breakers were in continuous use.

Another storm struck on 16-17 January causing the water level at Fort Erie to rise 1.8 metres (6 feet), however, the ice cover at the boom remained intact and no ice was discharged into the river. River ice was produced each day adding to the stoppage in front of the Robert Moses Power Plant Intakes and keeping the Canadian Niagara forebay plugged with ice. This condition persisted from 10 January through 18 February when the ice jam at the Robert Moses Power Plant Intakes was cleared. Canadian Niagara was only able to generate power intermittently throughout the winter season.

There were no significant changes in ice conditions during the rest of February and the first three weeks of March when the ice in the western basin of Lake Erie started to dissipate.

On Saturday and Sunday, 3 and 4 April 1982, a severe storm with winds up to 84 kilometres (52 miles) per hour passed over the lake causing a massive run of ice into the Niagara River estimated to be 50 square kilometres (20 square miles) during the two-day storm. The storm caused the water level at Fort Erie to rise 1.8 metres (6 feet), producing flows in excess of 8,500 cu.m/s (300,000 cfs), the peak flow being 10,100 cu.m/s (357,000 cfs). The ice completely filled the Tonawanda Channel and the excess was forced down the Chippawa Channel. By dawn on Sunday, 4 April, the Chippawa-Grass Island Pool and the Maid-of-the-Mist Pool were jammed with ice. Diversions to the Moses Plant were reduced by 50 percent and the Canadian Niagara Plant was inoperable. The water level in the Chippawa-Grass Island Pool reached an elevation of 172 metres which is 0.8 metre (2.5 feet) above normal. With all 18 gates in the Control Structure open, the flow over the Falls was 4,860 cu.m/s (171,700 cfs). Considerable flooding occurred in the Town of Wheatfield, and to the east side of Grand Island, and to Cayuga Island, NY. In Ontario, the Niagara Parkway was flooded under the Peace Bridge. There was flooding along the tributary streams and in particular along Black Creek. The Welland

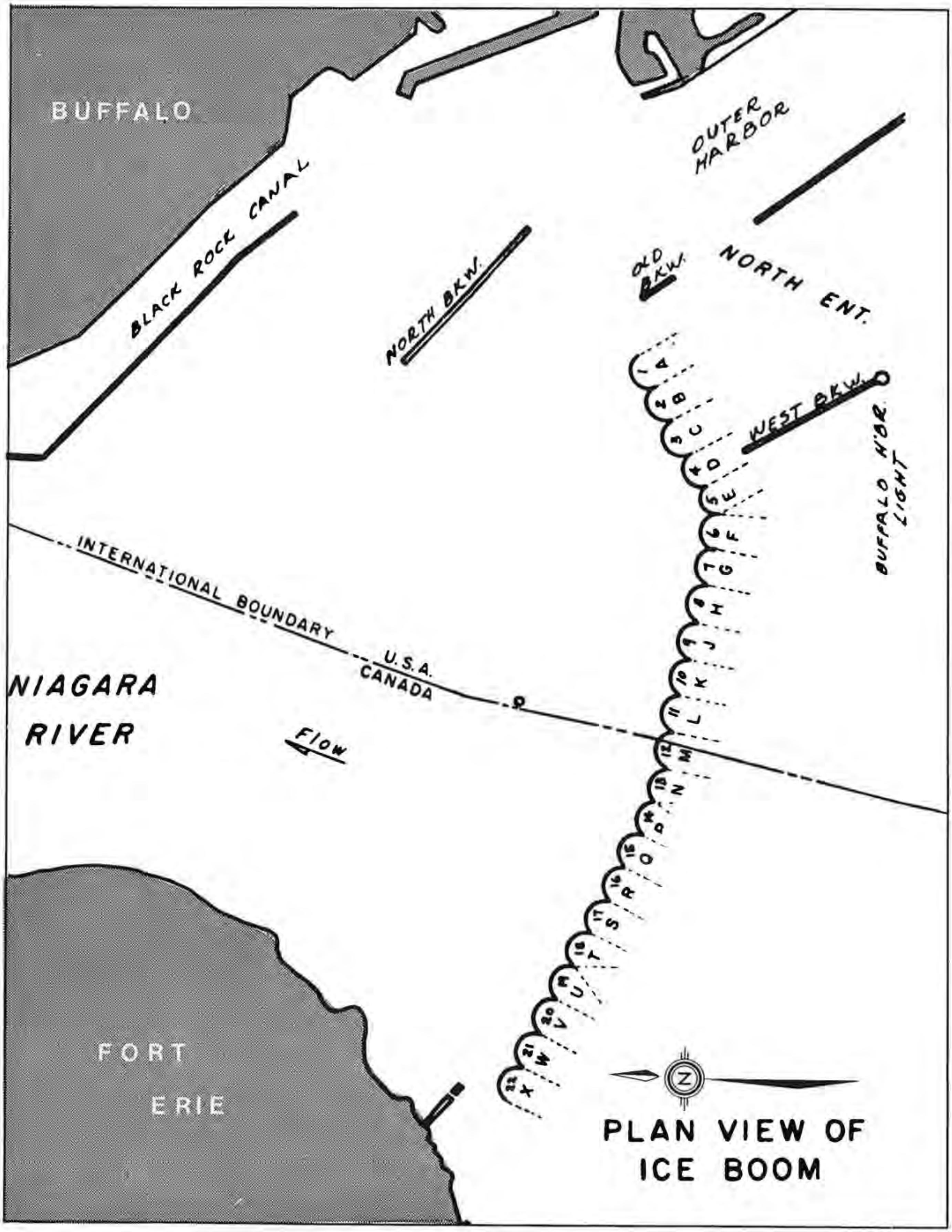

BUFFALO
BLACK ROCK CANAL
NORTH BKW.
OLD BKW.
OUTER HARBOR
NORTH ENT.
WEST BKW.
BUFFALO H'BR LIGHT
INTERNATIONAL BOUNDARY
U.S.A.
CANADA
NIAGARA RIVER
FLOW
FORT ERIE
PLAN VIEW OF ICE BOOM

FIGURE 1

U.S. Army Corps of Engineers

FIGURE 2

Power Authority of the state of New York

FIGURE 3

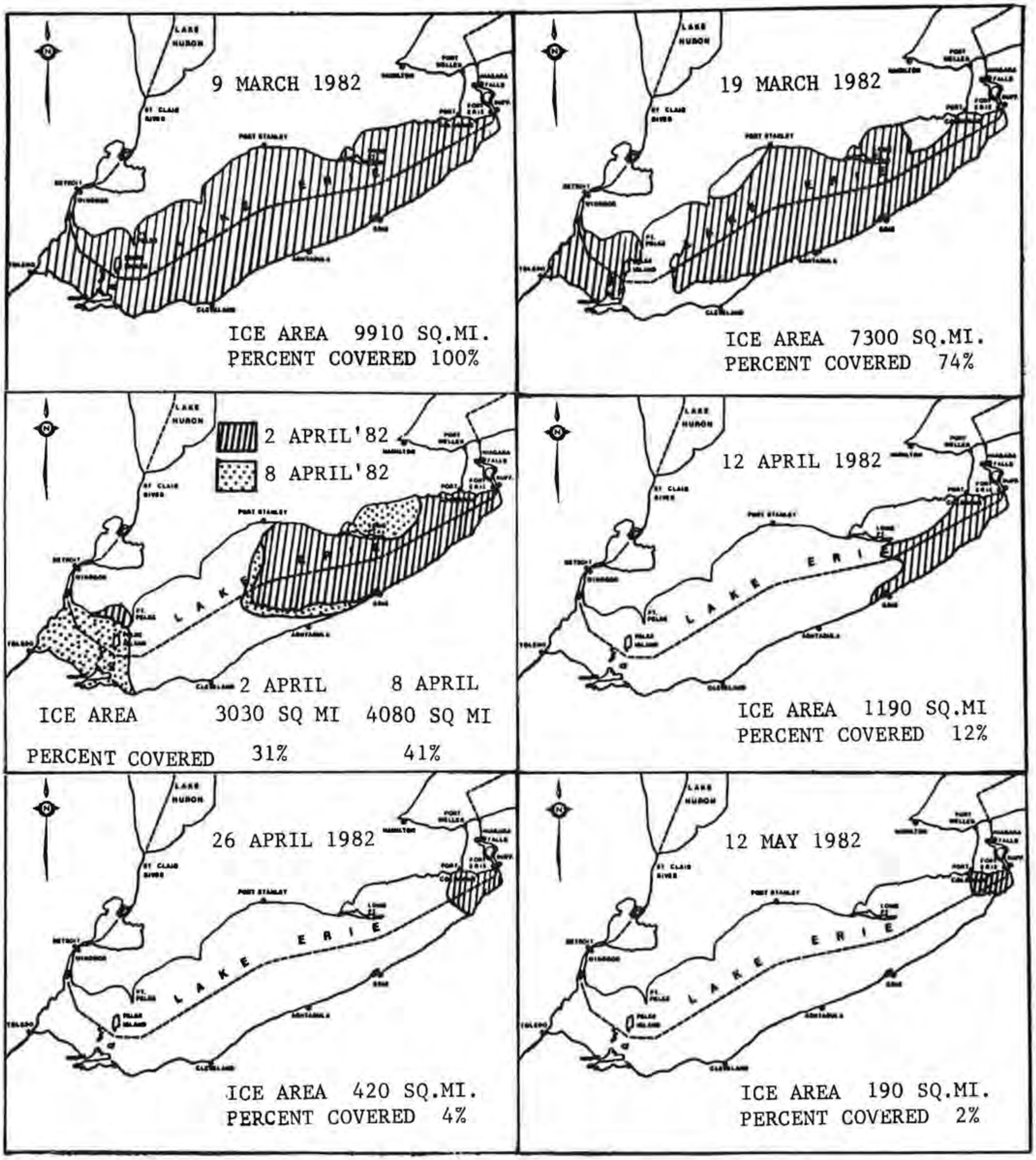


FIGURE 4

Opposite page, top. Ice damage to a dock on Cayuga Island, New York following the 3-4 April 1982 storm. **Bottom**, view of ice entering the Niagara River on 10 May 1982. **This page**, the changes in the area of ice in Lake Erie during March-May 1982.

River was over its banks west of the city of Welland. The wind-driven ice caused considerable damage to docks along the Niagara River as shown in Figure 2. Serious dock damage was caused at Isle View Park and in the Tonawanda Channel in Tonawanda, NY. The seawall at Fort Erie was damaged in three places. Two spans of the ice boom were broken during the storm and were not repaired for the remainder of the ice season. Portions of the boom resurfaced near sundown on Sunday, 4 April, when the winds began to subside and a combination of this action and the massive ice groundings on the


Power Authority of the state of New York

FIGURE 5 View of ships in the Lake Erie ice field off Port Colborne, Ontario on April 22, 1982.

reef at the lake exit cut off the ice flow. Although the boom acted as a deterrent to ice discharge into the river it still allowed some 50 square kilometres (20 square miles) of ice to pass down the river during the two-day storm.

Although substantial damage occurred along the river, little damage was noted on the Lake Erie Shoreline. The presence of the ice cover dampened wave action, thus reducing shoreline erosion.

Following the storm, a cold front moved into the area and produced subfreezing air temperatures for five consecutive days. This period temporarily stopped the melting of the ice cover and caused a considerable amount of thin ice to form. An evaluation of ice conditions on 8 April showed that ice coverage of the lake had increased to 10,600 square kilometres (4,080 square miles), an increase of about 25 percent.

A warming trend began on 9 April with air temperatures reaching 27.2 degrees Celsius (81 degrees Fahrenheit) on 16 April. By 14 April, the ice field had reduced to 2,460 square kilometres (950 square miles), all in the eastern basin. Although winds were from the west and southwest and two spans of the boom were open, very little ice entered the river.

After examining ice conditions in the Niagara River, consideration of the 5-day weather forecast, determining the quality of ice remaining on the lake, and the lateness of the season, all boom spans were opened and removed by 2 May.

Ice discharged into the river in varying amounts (Figure 3) during the 3-week period from boom opening to end of the ice season causing problems at the power plant intakes. Figure 4 indicates the estimated ice coverage on Lake Erie for six different days during the period 9 March through 12 May 1982.

The navigation season at Port Colborne, Ontario, was opened by the vessel "Algobay." The upbound ship transited the Welland Canal on 5 April 1982, 11 days later than the first ship the previous year. Navigation at Port Colborne was hampered by two problems with the ice. One was its quality, which was a slush ice; icebreakers would open a path for a ship and the ice would immediately close the channel behind it. The other problem was ice entering Lock No. 8 at Port Colborne, making it necessary to keep clearing the lock. As a result of this problem the St. Lawrence Seaway Authority installed an air curtain immediately upstream in April, which assisted in keeping some of the ice out.

On 23 April, there were 14 ships waiting off Port Colborne to enter the canal, as shown in the photograph, Figure 5. There were also approximately the same number of ships off Port Weller in the open water of Lake Ontario waiting to enter the canal. This situation continued until early May when four icebreakers, two Canadian and two from the United States, assisted them in entering the canal and Buffalo Harbor.

Since 1965 when the first boom span was opened, the ice boom has functioned as intended by minimizing power losses and damage to shore property on the Niagara River without measurable effects on navigation, recreation, and the environment.

CLIMATE CHANGE — THE PUBLIC'S PERCEPTION

The belief that the climate is changing, and that man-made causes are to some degree instrumental, is commonly held as an accepted scientific view by urban and rural residents, men and women alike.

by Anne V. Whyte and Michael R. Harrison

Climatic change is now a recognised environmental problem of global dimensions and of international concern. Scientific interest in the issue has escalated in recent years with an observed increase in the carbon dioxide concentration in the atmosphere of the order of 0.3% per annum, and with models of atmospheric systems that predict an average surface temperature increase for the world of 1°C. within the next 50 years.

The social, economic and political repercussions that are expected to result are considered sufficiently grave that major interdisciplinary and international scientific programmes have been established and several international symposia have been held specifically to discuss the impacts of climatic change.

The issue of climatic change is characterised by high scientific uncertainty about the causes, processes and impacts. The best scientific statement that can be made at this time has been prepared jointly by a group of experts convened in November 1980 by the International Council of Scientific Unions (ICSU), the United Nations Environment Programme (UNEP) and the World Meteorological Organization (MWO).

Their statement is summarised as:

"Of the five gigatons of carbon released to the atmosphere each year as a result of the consumption of fossil fuels approximately one-half remains in the atmosphere. The other half is partitioned between the ocean and the biomass. The details of the partitioning are only partially understood but it is believed that the ocean is a major sink, while the biomass may serve as either a source or a sink.

In any case, the increase in carbon dioxide changes the atmosphere's energy balance resulting in a temperature rise at the earth's surface and in the lower layers of the atmosphere. Experiments carried out with global atmospheric models strongly suggest that the carbon dioxide concentrations that might be reached early in the next century as a result of the projected consumption of fossil fuels would increase global average surface temperature by 1° C. or more. This temperature change would be significantly greater in high latitudes of the northern hemisphere and slightly less than the global average value in the tropics. Continued growth in fossil fuel consumption, particularly by drawing upon the earth's very large coal resources, could produce still greater increases in carbon dioxide concentrations and climate changes in the future. The more vigorous the growth in energy and fossil fuel use, the more accelerated this process would be.

Since it is the temperature difference between poles and equator that helps to drive the weather systems which influence temperature and rainfall patterns, it is probable that regional ecosystems and hence agricultural production and water supply will be materially affected. Because ocean currents and upwellings, upon which fishing production depends, are largely wind-driven, protein harvest from the sea could also be affected. Finally, significant warming in the Antarctic could, during future centuries, result in the disintegration of a part of that glacier, raising global sea level by several meters. However, there is general agreement that such an impact on sea level is not imminent."

(ICSU, 1981)

Climate can be directly perceived by human senses, unlike many other hazards including acid rain and nuclear power. Unfortunately, what is able to be directly perceived – snowstorms, unusually hot or dry periods – constitutes the noise in the climatic system rather than the significant trends (such as changes in the chemical composition or physical properties of the atmosphere). The information about climatic change that people receive directly as a result of their own experience is therefore misleading. It focusses their attention on extreme weather events such as floods and droughts, and persistent periods, in which within-year events recur consecutively.

Several aspects of the scientific perspective on climatic change are likely to exert a profound influence on the way in which it is perceived. The first is that, so far, scientific discussion of the issue has emphasised the high uncertainty surrounding any predictions about whether the problem is a real one; how soon it will affect us; how large the expected changes will be; which areas of the world will be affected most; and what impacts can be anticipated. Perhaps the most influential aspects of the scientific uncertainty for public perception and concern has been the contradictory predictions about whether the world temperature is getting warmer or colder.

Scientific discussion has also emphasised the low probabilities of the most dramatic and easily conceptualised impacts of climatic change – the melting of the Polar Ice Caps and subsequent flooding of coastal areas (together with many major cities) or a new Ice Age bringing colder winters to energy-harassed cities and shorter growing seasons to major food producing regions. People tend to be generally insensitive to the differences between low probabilities such as .001 and .0001; that is, they tend to ignore the differences or to exaggerate them.

The low probabilities and conflicting scenarios in the scientific literature have until recently been accompanied by time horizons measured in centuries rather than decades. A hazard which will not take effect until after most people living today are dead, has less of a chance of arousing their concern than an immediate risk of a tornado or even a 'lifetime' risk of cancer from asbestos. Two changes have occurred in relation to climatic change as a hazard. The consensus of scientific opinion now puts the time horizon for significant impacts to be felt within 50 years which is of the same order (20-40 years) as the latency period of many carcinogens of which people do show concern about the risks.

The receptivity of the public towards an appreciation of the risks of climatic change has also been enhanced by a general increase in concern about our present activities leading to future risks for the next generations. This growth in public sensitivity towards longer term risks is documented in social surveys in both Canada and the USA. In Canada, awareness of the environmental damage produced from burning fossil fuels through acid rain has now reached 70% of the population (Gallup Report, October 15, 1980). The stage seems set for climatic change becoming a highlighted environmental issue in the public consensus.

Table 1 lists some of the main factors that have been reported in the literature as influencing people's receptivity to recognising that a problem exists. It can be seen that the characteristics of climatic change fit almost entirely with the factors tending to reduce perception of risk.

Nevertheless, there is evidence from a pilot survey of public perception, that today many people are at least aware of climatic change, and that media attention to the problem is increasing. A recent comparison of environmental students' assessments of global environmental problems in September 1980 and March 1981 shows an increase in the priority given to climatic change which moved from 19th to 12th place in Table 2.

The pilot survey of public perception of weather variability and climatic change was conducted in two areas of Southern Ontario; one rural and one urban. These were matched as closely as possible for climate and socio-economic characteristics except for population density and farming activity. A third small sample of snow plough operators in Metro Toronto were also interviewed.

The study has been developed because:

(a) there is a growing scientific and political awareness and concern with climatic change as an environmental process with profound social and economic consequences, particularly in a northern country like Canada;

(b) climatic change can be regarded as an environmental hazard. The study of these hazards, which include meteorologically caused phenomena such as snowstorms, floods and tornadoes, has developed over the last decade as the costs of these hazards on society has escalated.

IS THE CLIMATE IN CANADA CHANGING?

When participants in the survey were asked if the climate in Canada is changing, 66% of the respondents answered 'yes' and only 21% said 'no'. There were no strong relationships between agreement that the climate was changing and the social variables measured. Sex was not significant and age was weakly related, with older people more likely to say yes. Rural dwellers were somewhat less likely to agree than urbanites. To judge from the two Ontario samples, awareness of climatic change seems therefore to be a general phenomena and is not restricted to any particular sector of the Canadian public.

IN WHAT WAYS IS THE CLIMATE CHANGING?

When asked the question "In what ways is the climate in Canada changing?" almost twice as many responses refer to winter compared to summer weather. The winters are generally seen as getting warmer with less snow while the summers are regarded as getting cooler and shorter. These perceptions are not in accord with the recent winters over the last 10 years in Toronto prior to the survey which were colder than average, but they might reflect the even shorter time span of the previous 12 months during which Toronto experienced a cool wet summer and a mild winter.

Some people referred specifically to trends, with a common response that the climate was less predictable now. Only two of those asked couldn't suggest in what ways they thought the climate was changing. Responses did not vary significantly according to age or sex, nor whether the person lived in the rural or urban area. Perception of climate change is most commonly expressed in terms of temperature changes (60% or responses) rather than of variations in precipitation (16%).

WHAT IS THE CAUSE OF CLIMATE CHANGE?

The two main groups of responses to this question are specific references to man-made causes (139 responses: nuclear tests, pollution and space exploration) and general references to trends, variability and global changes (98 responses). The impact of volcanic eruptions on climate, although widely discussed in the media following the eruption of Mt. St. Helen in 1980, was mentioned by only 8 people. Teleological explanations; that is, 'God's Will', were offered by only 2 people, despite the sample bias towards older people. Only two people expressed the problem as largely a perceived one of people now paying more attention to the issue.

A second group of questions asked specifically whether people had heard about loss of ozone, the 'green house effect' or an increase in CO_2. These processes of climatic change have been mentioned frequently in Canadian media.

More people have heard about loss of ozone than about the increase in CO_2, whether or not the latter is expressed as the 'greenhouse effect'. However, the number believing that loss of ozone or an increase in carbon dioxide are involved in climiate change are about the same (approximately 33% of all respondents). These results suggest that the publicity of a few years ago surrounding possible loss of ozone and the involvement of freon from aerosol cans, etc. has had somewhat more impact on the public's awareness than has the more recent media attention to CO_2. This may be partly attributed to a more clearly defined cause (aerosol cans) and/or to a time lag between media attention and widespread public awareness. Some people, however, seem to have heard of loss of ozone without understanding (or believing) in its role in climatic change.

The data also show some interesting differences between men and women, and rural-urban residents. Reasons given for why the climate is changing are more frequently attributed to man-made causes in the urban area. Similar urban-rural differences are seen in the numbers who have heard about loss of ozone or increase in carbon dioxide especially when expressed as the 'greenhouse effect'. In each case, the rural dwellers are more likely to say that they have heard of the specific change mentioned.

Urban-rural differences are stronger when the question relates to belief that the process (loss of ozone or increase in CO_2) is involved in climatic change. Again, the rural dwellers appear to be more convinced of the relationship between the physical process and the phenomenon of climatic change.

Although no relationships are seen between age or length of residence and knowledge about processes involved in climatic change, sex is a highly significant factor in whether people have heard about the process. In each case, men are more likely to say that they have heard of the process but they are not more likely to believe that it is related to climatic change. Similar differences between men and women are found for expressed knowledge of other environmental hazards in Canada and elsewhere.

Thus, a belief that the climate is changing and that man-made causes are to some degree instrumental, is commonly held by urban and rural residents, and men and women alike. In contrast, awareness of particular processes of climatic change, is more likely to be found in men and among rural dwellers. Even so, people do not necessarily make the connection between a process such as CO_2 increase and 'climatic change'.

MEDIA COVERAGE OF CLIMATIC CHANGE

Although variations in weather can be direct-

FACTORS TENDING TO INCREASE RISK AS PERCEIVED	FACTORS TENDING TO REDUCE RISKS AS PERCEIVED	EXAMPLES
Immediate	Latent or delayed	Tornado—drought Fire-asbestos
Direct	Indirect	Flood—drought Bridge failure— Mercury in lakes
"Dread" hazards	Common hazards	Cancer—influenza
Large number of fatalities per event	Small number of fatalities per event	Air crash—auto crash Avalanche—snowstorm
Fatalities grouped in space and time	Fatalities scattered or random in space/time	
Mechanisms or process not understood	Mechanism or process understood	
Uncontrollable	controllable	
Involuntary	Voluntary	Food additives—smoking Radioactive fallout—
Children at risk	Children not at risk	DDT in human mother's milk
Identifiable victims	Statistical victims	In-plant workers— Cancer from environmental radiation
Lack of education	Education	
Lack of belief in authority of source of information	Belief in authority of source of information	Private industry— University Scientists
Much media attention	Little media attention	PCB's—Liquid Natural Gas (LNG) transport
Unfamiliar	Familiar	Nuclear accident—
Major accident	No major accident	Thousand Mile Island Reactor —Pickering Flixborough—Dow Plant at Sarnia—Mississauga chlorine derailment —Liquid Natural Gas (LNG) transport

TABLE 1 FACTORS IN PUBLIC RISK PERCEPTION

ly perceived, longer term patterns on a scale to produce climatic change cannot. At an intermediate level, a run of recurrent extreme years, can and are, perceived and noted by people. It is expected that, for the public, the concept of climatic change is largely derived from articles and programmes in the mass media.

To document the degree of media attention to climatic change, a content analysis was undertaken of leading Anglophone national newspapers in Canada; USA and UK (The *Globe and Mail; New York Times* and the *London Times*).

The *Globe and Mail*, based in Toronto, does not have an index. Articles in past issues were retrieved through files held in the newspaper's own cuttings library. The files date back to 1946 and all articles on file were included in the analysis.

For the *New York Times* and *London Times*, indices are available summarising when articles appeared on different topics. A simple count of articles per year was therefore relatively easily achieved.

From our results, the 1970's are seen as a time of dramatic increase in media attention to climatic change compared to the 20 years before. Within the 1970's, a peak in the number of articles on the issue of climatic change appears around 1974-6 in three countries. In the UK, this peak in media coverage coincided with the droughts in England of the mid-70's.

Interest still runs high, especially in North America and the period 1979-81 also witnessed another peak in media coverage. In 1979, the *New York Times* included considerable space devoted to the World Climate Conference with few articles dealing specifically with climatic change. Five other articles reported on the damage of increased use of fossil fuels leading to an accumulation of CO_2 in the atmosphere, and to a possible change in the global climate. Another article

TABLE 2

**RANKING OF GLOBAL ENVIRONMENT PROBLEMS
THE CHANGE IN STUDENT'S EVALUATIONS FROM SEPT. 1980 TO MARCH 1981**

SEPTEMBER 1980 N=60	MARCH 1981 N=60
1. POPULATION GROWTH	1. POPULATION GROWTH
2. NUCLEAR ENERGY	2. PUBLIC HEALTH
3. ENERGY	3. SOIL DEPLETION
4. WATER POLLUTION	4. NATURAL RESOURCE DEPLETION
5. NATURAL RESOURCE DEPLETION	5. ENERGY
6. PUBLIC HEALTH	6. DESERTIFICATION
7. WASTE DISPOSAL	7. PESTICIDES AND FERTILIZERS
8. AIR POLLUTION	8. WASTE DISPOSAL
9. URBAN ENCROACHMENT	9. DEFORESTATION
10. OZONE DEPLETION	10. NUCLEAR ENERGY
11. ACID PRECIPITATION	11. ACID PRECIPITATION
12. DEFORESTATION	12. CLIMATIC CHANGE
13. SOIL DEPLETION	13. WATER POLLUTION
14. DESERTIFICATION	14. NEW CHEMICALS
15. ENDANGERED SPECIES	15. AIR POLLUTION
16. NEW CHEMICALS	16. ENDANGERED SPECIES
17. NATURAL DISASTERS	17. OZONE DEPLETION
18. PESTICIDES AND FERTILIZERS	18. NATURAL DISASTERS
19. CLIMATIC CHANGE	19. URBAN ENCROACHMENT
20. FOOD ADDITIVES	20. FOOD ADDITIVES

discussed other man-made causes of climatic change including synthetic fuels and the impact of aerosol spray cans on the atmospheric zone.

By contrast, in the 1950's, articles were less focussed on the causes of climatic change (particularly the man-made ones) and were more descriptive of the evidence for the changes occurring. For example, in 1952, three articles in the *New York Times* reported on new evidence that the climate was warming, one suggested that temperatures were levelling off, and one discussed data indicating that Antarctica formerly enjoyed a warmer climate.

Media concern with weather modification is less than it used to be in the 1950's and 1960's. In Canada, the peak of interest occurred in 1965-66. This was the time of several American attempts at cloud-seeding. In the *New York Times* for 1965, 18 articles were written on cloud-seeding; 5 of them dealing with attempts to weaken or divert hurricanes and 13 described other experiments to increase rainfall in drought stricken areas in the mid-west. Only one article discussed the possible impacts of weather modification. A similar concern with cloud-seeding experiments dominates the large number of articles (27) in 1950 in the *New York Times*.

Thus, it appears that significant evolution has occurred in the focus of newspaper articles on climate in North America in the last 30 years. At the beginning of the period, reports concerned observations that the global climate may be warming. By the 1960's, attention was focussed on American cloud seeding experiments to deliberately change local weather. Through the 1970's, concern has again moved to climatic change but this time not so much as a hypothesis but as an accepted scientific view, and with more discussion of its possible causes, particularly the man-made causes.

At the outset of the study, it was not clear whether the public was sufficiently aware of climatic change that a conventional social survey approach could be used. One of the purposes of the perception survey was to test this. The results indicate that awareness of climatic change is widespread among the Canadian public and that further study could be made to find out how far the public are concerned about the problem and how much of it they understand. The current work on impacts of climatic change and weather variability may indicate ways in which public awareness and understanding may be increased.

(The complete report, of which this article is an excerpt, is available from Dr. Anne V. Whyte, Institute of Environmental Studies, University of Toronto, Ontario. M5S 1A4. Ed.)

Continued from page 3

and hours of sunshine in northcentral British Columbia and the driest June in 20 years was reported in areas of Alberta and Saskatchewan.

6. By contrast, in the east June was the wettest since the 1960's and the coldest ever in some locations. Overall, southern Ontario experienced its coldest summer, based on temperatures averaged over June, July and August, since 1929. Toronto's highest temperature in the summer was 30°C, the lowest maximum value in a century.

7. The Holland Marsh vegetable growing area of southern Ontario was hit by a severe hailstorm on June 22. The estimated loss to vegetable crops was about \$2 to \$3 million.

8. On July 1 a severe thunderstorm dumped 63.5 millimetres of rain in less than one hour on Lethbridge, Alberta, causing several million dollars worth of damage to crops in the area.

9. July brought near normal temperatures to all of southern Canada although there were no real heat waves. July provided the best vacation weather in eastern Canada. August was again cooler than average over most of the country.

10. On August 14, baseball-sized hail caused \$10 million damage to vehicles, buildings and crops in Prince Albert, Saskatchewan. On the Great Lakes, marine accidents claimed the lives of 4 Ontarians when an intense line squall struck small boats on August 28.

11. Some of the earliest widespread frosts in several decades occurred in the eastern agricultural areas of the Prairie Provinces on the morning of August 27 and in southern Ontario and Quebec on the morning of August 29. Damage to cereal crops in the west and tobacco crops in the east was extensive and losses totalled several million dollars.

12. The generally wet cool weather had a positive effect on forest fires, keeping them to a minimum in eastern Canada, Manitoba and Saskatchewan. However, major fires did occur in Alberta, British Columbia and the territories. Overall, total forest area burned in 1982 was well below that of the previous two years.

13. Despite localized losses due to severe or unusual weather, Canadian production of major grains and oilseeds increased eight percent over 1981 – which had been a record year. The Ontario fruit yield was up 21 percent over 1981 while in the Maritimes, tobacco crop sales were the highest ever and apple harvest was above average.

14. Unseasonably mild weather covered eastern Canada in early December, causing tree buds to swell. Record high temperatures were recorded at many localities including Hamilton where the mercury soared to 22.5°C!

Highest temperature 30.5°C, Boston Bar, B.C., July 27

Lowest temperature -58.5°C, Ross River, Yukon, January 4 & 5

Warmest month July, 23.7°C, Pelee Island, Ontario

Coldest month January, -41.9°C, Ogilvie River, Yukon

Wettest month October, Hartley Bay, B.C. 827.8 mm.

Heaviest snowfall in 1 month January, Glacier National Park, Mt. Fidelity, B.C., 389.2 cm.

Sunniest month May, Alert, N.W.T., 464.1 hours.

SCIENTISTS MONITOR ARCTIC HAZE

Department of Environment (DOE) atmospheric scientists have made some startling discoveries about the state of the air in the Arctic. During three years of sampling air at three northern stations, Mould Bay, Igloolik and Alert, scientists discovered a seasonal arctic air pollution which forms a haze over most of the Arctic north of 60 degrees latitude. The pollution has its source in the U.S.S.R., Europe and to a lesser extent, North America.

Arctic haze is caused by suspended particles which scatter light and reduce visibility horizontally, from 300 kilometres to 30 kilometres and to a height of several thousand metres above the ground. Particle levels in the haze are 20 to 40 times higher in winter than in summer.

The suspended particles consist of contaminants from coal and oil burning industrial areas and smelters in the mid-latitudes (30 to 60 degrees north). The particles are picked up by prevailing winds and deposited in the Arctic air mass. In fall and winter, the prevailing winds carry particles from the Soviet Union into the Arctic air mass. Late winter and early spring, particles are carried to the Arctic in prevailing winds blowing over western Europe, and to a lesser extent in North American wind systems.

North American airborne pollution is generated mainly in the eastern part of the continent and is generally blown out over the Atlantic Ocean. U.S.S.R. pollution sources are either upwind or within the Arctic airmass and have a direct effect on the arctic atmosphere. European pollution enters the Arctic by travelling northward over Scandinavia or the U.S.S.R.

The most obvious effect of arctic haze is the extreme reduction in visibility during the most serious pollution periods. Arctic haze particles are acidic, but the levels of acidity are at least ten times lower than those of acid rain in eastern Canada. In most polar areas, the acidic particles are effectively buffered by the Arctic's acid neutralizing soils.

Scientists are concerned that arctic haze will have a warming effect on arctic climate. The magnitude of such an increase is unknown at present but a slight warming effect in March, April and May is expected. More detailed impact assessments are currently under way.

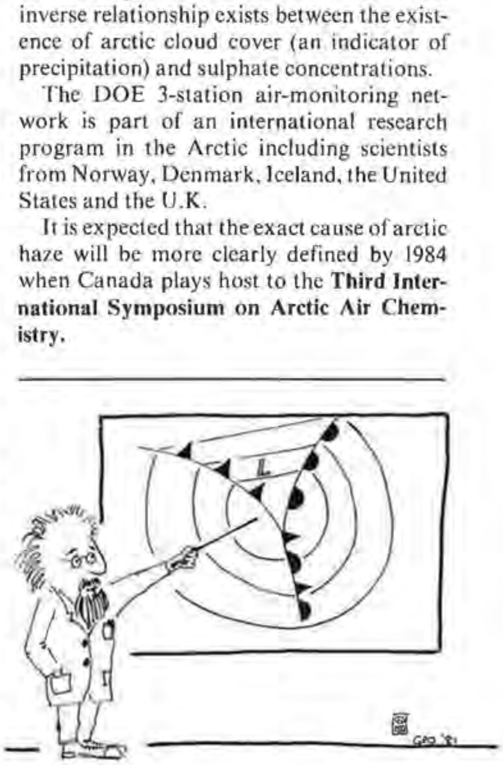
Samples of suspended particles are collected weekly by the DOE network on filters mounted on high power vacuum lines. Major ions, trace elements, pollen and the darkness of the particle deposits on the filters are then measured. Particle light scattering is recorded every ten minutes and averaged on an hourly, daily and weekly basis.

Sulphates comprise 30% of the total aerosol mass. Other components of arctic haze are soot, organic compounds, wind blown dust and sea salt. Man-made pollutants compose about 80% of the haze in winter and spring.

It is thought that precipitation plays an important role in reducing the pollution levels in the haze by removing the particles from the atmosphere. Results have shown an inverse relationship exists between the existence of arctic cloud cover (an indicator of precipitation) and sulphate concentrations.

The DOE 3-station air-monitoring network is part of an international research program in the Arctic including scientists from Norway, Denmark, Iceland, the United States and the U.K.

It is expected that the exact cause of arctic haze will be more clearly defined by 1984 when Canada plays host to the **Third International Symposium on Arctic Air Chemistry.**



...Another theory suggests that this low pressure region acts in conjunction with the wrath of the gods.

A VISIT WITH WEATHER CONSULTANTS OF CANADA

by Scott Sommerville

During the past decade Canada has witnessed the development of several new private companies which provide meteorological services. One of the earliest such firms is **Weather Consultants of Canada** which dates back twenty-seven years to 1956. ***Chinook*** interviewed the president, **Morris Kestin**, who operates his one-man company out of his fashionable townhouse located in the central core of Toronto. Since the inception of the company, its business has been specialized short term and long range weather forecasting for just about every conceivable type of client.

Morris Kestin established his credentials before founding the company. He graduated in physics and geology from the **University of Toronto**, then joined the **Canadian Meteorological Service** (now the Atmospheric Environment Service), completed his M.A. degree, and was posted to Gander. At the end of three years in Newfoundland he fled to the warmer climate of the **University of California at Los Angeles** to engage in post graduate work and teaching. Following a two year stint there he returned to Toronto to start Weather Consultants.

Although it is only a one-man operation, his firm has grown to provide many types of weather services. A number of clients are furnished with forecasts tailored to their specific needs on a regular basis each day. These customers are also assured of receiving updates to the forecasts if the weather changes from what is expected. Some companies are concerned with the fine details of such elements as temperature, wind, cloud, sunshine and precipitation amount, and receive micrometeorological forecasts. Others receive a special alert when a certain weather type is threatening, for example, snow alerts, alerts of thunderstorms, heavy rain or whatever type of warning the client may desire. If, for instance, a snowstorm is imminent, Weather Consultants warns its snow removal clients and reports to them with details of when the storm will strike, what type of precipitation is expected (snow, freezing rain etc), how much and when the storm is expected to end. Throughout the storm, Weather Consultants maintains a weather watch, monitoring the storm's progress and changes, and reports anything significant to the client.

Another service for which the company is well known, is its long range forecast. This is presented in a glossy pamphlet format which is published twelve times a year, and summarizes the forecast for the next month in various regions of Canada by means of temperature and precipitation pictographs and maps. It includes climatic summaries of these elements for selected Canadian cities, as well as extended weather outlooks for the following two months. Among the clients who subscribe to this long range forecast, Weather Consultants includes oil drilling companies, public utilities, beverage firms and department stores. Even a store located in Toronto's exclusive Yorkville district which is in the business of selling bras, however, Morris Kestin didn't explain what this client's reaction would be if his forecast was a "bust".

Weather Consultants claims that its long range forecast is in the ballpark about seventy-five percent of the time. The company's clients must agree since there is an eighty percent renewal rate. Some customers have been regulars for as long as fifteen years.

Another facet of Weather Consultants' services is the provision of climatic advice and statistics. The company engages in extensive work with the film industry since they have a great demand for weather information. For instance, a film company may need a comprehensive briefing before going on location because certain types of weather are necessary in order to shoot certain scenes. Companies filming television commercials are a good example. Such a company may require the special circumstances of a snowy landscape matched with a Quebec style background for a mid-April shooting date. Other customers relying on advice from Weather Consultants include construction companies and trucking firms. As Kestin says "there are few things which aren't weather dependant".

Because Weather Consultants has essentially been a one-man operation, it has allowed Kestin to locate within a major client's business from time to time. For five years he was at radio station **CKEY** in Toronto where he delivered his weather forecasts over the airwaves. He can now be heard on **CKFM**. At another time he was at a commodity house where he was not only a consultant but also had a broker's licence. Much of his work there was concerned with weather sensitive commodities, for example he could gain substantial profits for clients trading in oranges if he made a correct forecast of a hard winter freeze in Florida.

As always with an eye on the future, Morris Kestin expects to hire meteorologists to tap the expanding market of weather consulting in Canada.

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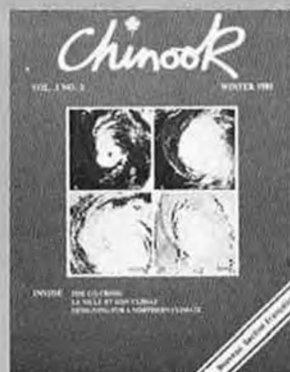

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