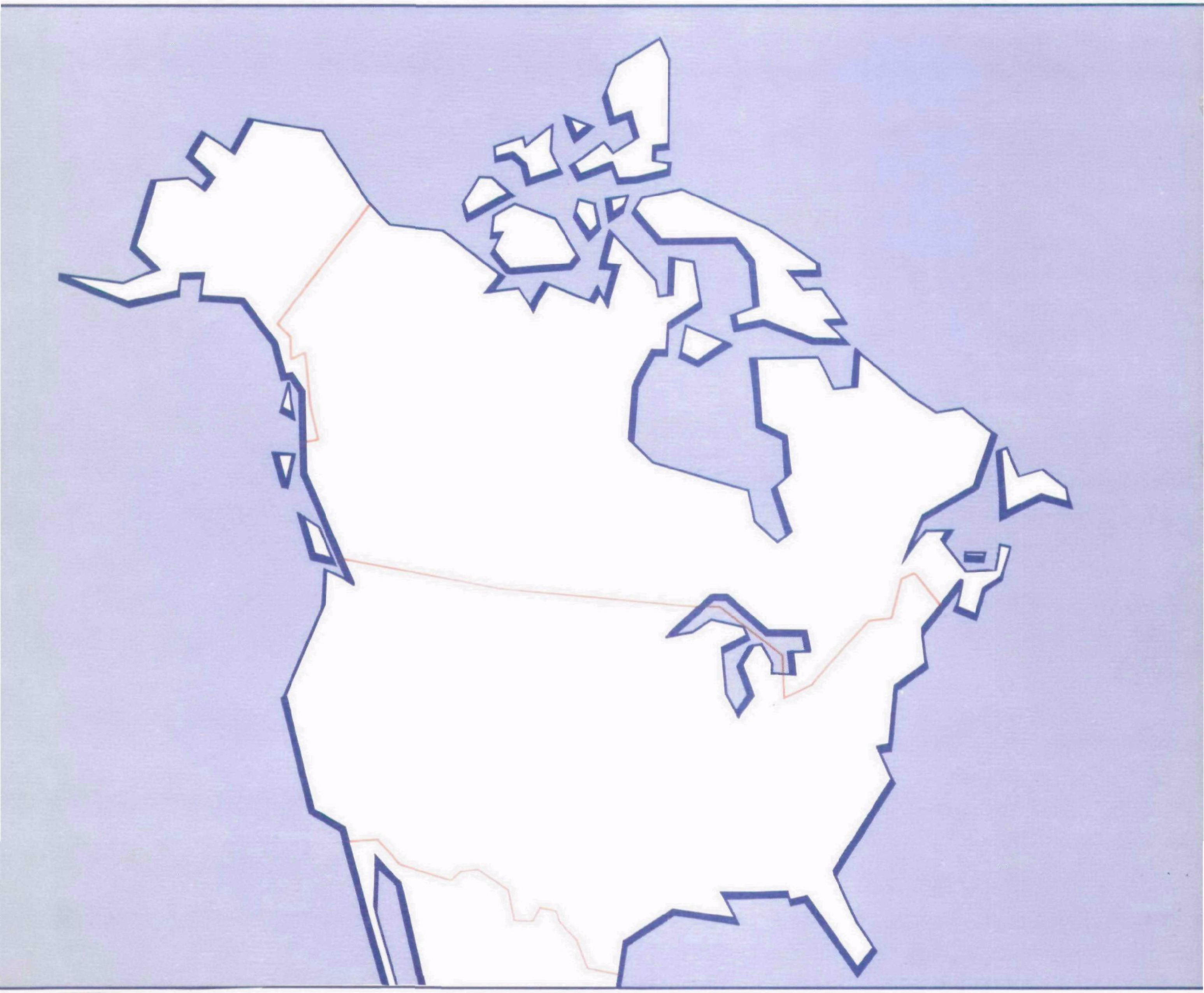
UNITED STATES - CANADA

MEMORANDUM OF INTENT ON TRANSBOUNDARY AIR POLLUTION



STRATEGIES DEVELOPMENT AND IMPLEMENTATION INTERIM REPORT

FEBRUARY 1981

This is an Interim Report prepared by a U.S./Canada Work Group in accordance with the Memorandum of Intent on Transboundary Air Pollution concluded between Canada and the United States on August 5, 1980.

This is one of a set of four reports which represent an initial effort to draw together currently available information on transboundary air pollution, with particular emphasis on acid deposition, and to develop a consensus on the nature of the problem and the measures available to deal with it. While these reports contain some information and analyses that should be considered preliminary in nature, they accurately reflect the current state of knowledge on the issues considered. Any portion of these reports is subject to modification and refinement as peer review, further advances in scientific understanding, or the results of ongoing assessment studies become available.

More complete reports on acid deposition are expected in mid 1981 and early 1982. Other transboundary air pollution issues will also be included in these reports.

JAN 15 1981

Ms. Sharon E. Ahmad
Deputy Assistant Secretary for
European and Canadian Affairs
Department of State
Washington, D.C. 20520

Mr. Edward G. Lee
Assistant Under Secretary for
USA Affairs
Department of External Affairs
Ottawa, Canada K1A 0G2

Dear Ms. Ahmad and Mr. Lee:

We are pleased to submit the Interim Reports of Work Groups 1, 2, 3B and 3A. In accordance with the coordinating function assigned to Work Group 3A in its terms of reference, we have reviewed and incorporated summaries of the Interim Reports of Work Groups 1, 2, and 3B in our interim report.

These interim reports are a first step in the preparation of technical and scientific groundwork for negotiation of a cooperative agreement on transboundary air pollution. In view of the importance and urgency of this problem, however, they may also assist in formulating the interim actions by both countries called for in the Memorandum of Intent to deal with the problem, pending conclusion of an agreement.

The information on what is known and hypothesized about acid deposition in the interim reports indicates that the problem is genuine and serious. It is a problem which could, if allowed to go unchecked, carry substantial economic and social costs. Further research must obviously continue, but solutions should be sought in the near term. As a practical matter, the only way to reduce acid deposition is to reduce the emissions of the polutants that cause the problem. Most existing air pollution legislation was designed to address the local impacts of air pollution. Although this legislation can be useful in addressing the phenomenon of long range transport of air pollutants and acid deposition, new legislation will likely be required to fully and expeditiously address this problem.

Concerning other matters, Work Group 2 has requested that their name be changed to "Atmospheric Sciences and Analysis Work Group" and that "evaluate and employ available field measurements, monitoring data, and other information" be added to their terms of reference. Work Group 2 believes that their terms of reference require them to consider in depth monitoring network results, experimental field studies, etc., in order to make comprehensive recommendations to the other Work Groups. Additionally, they believe that their recommendations must include both modeling estimates and/or predictions, as well as evaluations of experimental results, because an integrated analysis which incorporates both areas is crucial to understanding regional air pollution phenomena. We support these recommendations and urge you to approve these changes.

We believe that the Work Groups are in a good position to begin Phase II activities. We will be providing more complete reports based on these activities on May 15, 1981. Finally, we believe it would be appropriate and useful to release the interim reports to the public and urge that you approve this step following the formal review of the documents by the Coordinating Committee. This release should be accomplished as soon after the January 29, 1981 Coordinating Committee meeting as is practicable.

Sincerely yours,

David G. Hawkins
Assistant Administrator
for Air, Noise, and Radiation
U.S. Environmental Protection Agency

Raymond Robinson
Assistant Deputy Minister
Environmental Protection Service
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WORK GROUP 3A

STRATEGIES DEVELOPMENT AND IMPLEMENTATION

INTERIM REPORT

WORK GROUP 3A
INTERIM REPORT

I. INTRODUCTION

A. Terms of Reference

This Interim Report has been prepared in accordance with the terms of reference contained in the Annex to the Memorandum of Intent between the Governments of the United States and Canada, concerning Transboundary Air Pollution (MOI), signed August 5, 1980, in Washington, D.C. Specifically, the Annex to the MOI instructs Work Group 3A to:

A. Prepare various strategy packages for the Coordinating Committee designed to achieve proposed emission reductions;

B. Coordinate with other Work Groups to increase the effectiveness of these packages;

C. Identify monitoring requirements for the implementation of any tentatively agreed-upon emission-reduction strategy for each country;

D. Propose additional means to further coordinate the air quality programs of the two countries; and

E. Prepare proposals relating to actions each Government would need to take to implement the various strategy options.

The objective of performing these tasks is to enable Work Group 3A to "identify, assess and propose options for the 'Control' element of an agreement on transboundary air pollution". See Appendix A for the terms of reference given to other Work Groups.

This report has been prepared on a bilateral basis by United States and Canadian members of Work Group 3A. It gives an overview of

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transboundary air pollution including acid deposition in terms of its causes and effects. The report presents:

- An overview of the acid deposition phenomenon;
- A summary of three larger interim reports addressing effects, atmospheric transport, and emissions;
- The groundwork for preparing strategy packages and a listing of ongoing bilateral coordination activities; and
- Recommendations for additional study by the Work Groups and elaboration on uncertainties and data gaps identified in the reports.

These interim reports are the products of Phase I of a four phase process. They, therefore, contain some information and analyses that should be considered preliminary in nature.

A number of effects, concerns and relationships of potential importance in assessing strategies to deal with the acid deposition phenomenon are identified. Quantitative analyses have been performed on some of these issues during Phase I. Further quantitative analyses and assessments will be performed during Phase II. We believe that these Interim Reports accurately reflect the state of knowledge as of January 1981, on the issues considered; but any portion of these reports is subject to modification and refinement as further advances in scientific understanding or the results of ongoing assessment studies become available.

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B. Overview of Work Group Activities

The MOI and Annex require the submission of this Interim Report by January 15, 1981, and a final report by January 1982. Formal negotiations are to commence by June 1, 1981. Additionally, the Chairmen of Work Group 3A have requested all Work Groups to submit an interim report by May 15, 1981 to facilitate the initial negotiations. These milestones made it desirable to break the work activities into four separate phases. These are:

Phase I - September 10, 1980 - January 15, 1981

Phase II - January 15, 1981 - May 15, 1981

Phase III - May 15, 1981 - January 29, 1982

Phase IV - Post January 1982

The principal objective of Phase I is to allow each Work Group an opportunity to develop its required analysis procedures, identify and assess requisite data bases, and apply these analysis procedures in an initial effort to fulfill their terms of reference. Such activities should prepare each Work Group for extensive interaction with the other Work Groups by the end of Phase I.

The principal objective of Phase II is to provide the Coordinating Committee with the best available information on the emission sources of, atmospheric transport relationships for and likely long-term effects of transboundary acid deposition to enable constructive, useful negotiations to commence at the end of Phase II. While some aspects of the assessments to provide this information will be incomplete and tentative in nature, they will, nonetheless, be the most reliable statements of current knowledge about likely future consequences of transboundary acid deposition

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under a plausible range of future conditions. These analyses will assess the probable reduction in acid deposition required to protect identified sensitive areas affected by transboundary air pollution, and analyze the effectiveness and cost of the particular emission reduction measures selected to achieve the deposition reductions.

The principal objective for Phase III is to refine and expand the information provided to the Coordinating Committee at the end of Phase II. While the Phase II analysis will be specific to acid deposition, the Phase III analysis will include additional transboundary air pollution issues that are likely to be considered in the coming negotiations.

Analysis efforts during Phase III will be initiated by Work Group 3A under appropriate guidance from the Coordinating Committee. Strategy packages will be designed to reduce transboundary air pollution to selected levels. The other Work Groups will analyze the probable results of implementing these packages. The integrated Phase III report should provide the Coordinating Committee with substantially all the available technical information and analysis relevant to closing negotiations on a bilateral, transboundary air pollution agreement.

The principle objective for Phase IV is to provide continuing technical support to the Coordinating Committee as required to clarify remaining issues. No formal work program can be contemplated for this phase until after the submission of the Phase III report.

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II. EXECUTIVE SUMMARY

A. Overview of Transboundary Air Pollution

Transboundary air pollution covers issues ranging from (1) local situations where emissions from an identified facility on one side of the border can adversely affect human health or welfare on the other side of the border within a few tens of kilometers from its origin, to (2) mesoscale (intermediate) situations where one or several sources or an urban area in one country can produce discernible adverse effects in the other country up to many tens of kilometers distant, up to (3) regional and long range transport situations where many sources in one or both countries can in combination produce a regional air pollution problem that crosses the border, for example acid deposition or regional haze. Phase I and II Work Group activities are aimed at elaborating on the nature and extent of the acid deposition problem, which can result from one or more of these three scales of transport. Phase III and subsequent work will in addition address other additional transboundary air pollution issues of interest in the negotiations.

The activities of the Work Groups fall under one of two objectives. The first is to establish a mutual understanding of the causes and effects of acid deposition and the second is to describe and analyze a number of options to deal with the problem.

B. Acid Deposition

In Scandanavia and Europe, transboundary air pollution in the form of acid deposition has caused acidification of thousands of lakes resulting in reductions and losses of fish populations and other adverse impacts.

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Although not exactly comparable to North America, this experience provides insight as to how significant the problem can become and the factors that influence it.

Our knowledge of acid deposition is not complete. There are some general areas where we do not as yet have an adequate understanding. Several of these are noted in Chapter V of this report. Other areas for further study are listed in the Work Group work plans. However, significant conclusive and indicative information about acid deposition has been compiled in the Work Group Interim Reports. This is summarized in the following statements:

Effects

- there are several examples where dramatic changes in water quality believed to be directly attributable to acid deposition have occurred;
- acid deposition can and has severely altered lake and stream ecosystems, depleting and eventually extinguishing fish and other aquatic life;
- acid deposition may contribute to accelerated leaching of minerals and nutrients in some forest soils;
- long term growth of forests in acid sensitive regions may be adversely affected by acid deposition among other factors;
- some crops have been damaged by artificial exposure to highly acidic deposition under experimental conditions;
- the water and soils over extensive areas in North America are susceptible to acidification;

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- stone buildings, monuments and other building materials are eroded by a number of pollutants including acid rain;
- over the long term some drinking water supplies may be contaminated by toxic metals leached from the soil by acid deposition; however no adverse health impacts have been established to date; and,
- nitrogen compounds affect the acidity of precipitation, but their contribution to damages is uncertain, and is undergoing further analysis.

Transport

- models are useful tools in assessing atmospheric transport, transformation, and deposition of acidifying pollutants;
- long term, long range modelling results are being experimentally confirmed, but only partial validation is possible with existing data;
- short term, local models are well established and sufficiently reliable for regulatory use;
- the major precursors of acid deposition are the oxides of sulphur and nitrogen; the main cations and anions in acidic precipitation are hydrogen and ammonium, and sulphate and nitrate, respectively;
- pollutants, particularly acid precursors, are known to travel for distances of up to thousands of miles through the atmosphere, and thus, in North America, they frequently cross political boundaries;
- nearby emissions contribute more to deposition in a recepter area than the emissions from a similar distant source, but in many situations the total contribution of all distant emissions may exceed the contribution from nearby areas;

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- portions of eastern Canada and the northeastern United States are receiving wet acid deposition which is as severe as that in other severely affected areas of the world (e.g. Scandinavia); and,
- in eastern North America dry deposition of sulphur particularly as SO_2, is thought to be as great as wet deposition; the implication for acidification is not yet fully understood, however, it is cause for concern;

Emissions

- the major emitting source of SO_2 in the U.S. is the existing thermal power generation sector and in Canada is the non-ferrous smelting sector;
- the major emitting sectors of NO_x in both Canada and the U.S. are the transportation sector, the industrial fuel combustion sector, and the thermal power generation sector;
- current commerically available NO_x control technologies on stationary sources have limited effectiveness, however improved NO_x controls are being actively developed;
- control technology is available to reduce significantly SO_2 emissions from existing thermal power plants and analysis is underway to determine the most cost-effective application of this technology;
- process and control technology is available to reduce significantly SO_2 emissions from existing non-ferrous smelters and analysis is underway to determine the most appropriate application of this technology; and,

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- current national emissions of SO_2 and NO_x in both Canada and the U.S. are not expected to decrease significantly over the next two decades under current control requirements.

This summary of what is known about acid deposition indicates that the problem is genuine and serious. Damage to the environment in both countries has been documented. Acid deposition is a problem which, if it is allowed to go unchecked, could result in substantial economic and social costs. Research must continue in order to develop a clearer understanding of the acid deposition problem. As a practical matter, the best way to reduce acid deposition effects is to reduce emissions of pollutants that cause the problem. To this end, interim actions could be sought in the near term. Short-term mitigating measures also could be considered.

Efforts under air pollution control legislation in both countries and the commitment of some industries to implement control requirements have resulted in noticeable achievements in certain areas. However, most existing air pollution legislation was designed to address the local impacts of air pollution. Although this legislation can be useful in addressing the phenomenon of long range transport of air pollutants and acid deposition, new legislation will likely be required to fully and expeditiously address this problem.

Before the MOI was signed, both countries had initiated analyses of the economic implications of possible control measures to provide a better basis for any new domestic and international policy decisions proposed to reduce deposition. The U.S. analyses are determining the abatement costs likely to be incurred by new and existing industrial combustion sources for

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alternative control strategies including: changing to lower sulphur coals, coal washing, flue gas scrubbing, application of advanced nitrogen oxide control techniques, and other emerging technologies. Canadian analyses are focussing on alternative abatement options for the non-ferrous smelting and thermal power sectors. They are assessing the emission reductions which would result from the application of specific technologies and/or process changes and the social and economic consequences of these changes.

Both countries are especially interested in identifying feasible abatement strategies that will being the problem under control before more harm occurs.

Additionally, the U.S. has taken important steps to limit emission increases from new sources by adopting, under current authorities, strict control requirements for these sources. In 1979, EPA promulgated a revised New Source Performance Standard for new coal-fired power plants. This standard is significantly more stringent than applicable emission limits for most existing power plants. Existing power plants on average emit more than 80 pounds of sulphur dioxide for every ton of coal they burn. The new plants covered by the revised standard will produce on average only 12 pounds of sulphur dioxide for each ton of coal burned. Depending upon retirement schedules for existing plants, sulphur emissions will begin to decline after the year 2000 even with a high level of economic growth.

In the U.S. new large industrial boilers are also subject to New Source Performance Standards. These standards are in the process of being revised; this activity may result in the application of control requirements to smaller boilers as well. Automobiles, the major source of NO_x, are also subject to regulation under the U.S. Clean Air Act.

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Recent Canadian reviews of emission limits for existing major sources have recognized the significance of the long range transport of air pollutants, particularly its contribution to acid deposition. The National Energy Program announced by the Canadian Federal Government in November 1980 recognized the importance of making conversions of oil fired power plants to coal environmentally acceptable. Federal funding for each conversion has been made conditional on this principle.

In Ontario, the Provincial Government has invoked a regulation to control emissions from the INCO (International Nickel Co. Ltd.) facility at Sudbury, Ontario. The required reduction by 1983 to 1950 tons per day of sulphur dioxide represents a 70 per cent reduction in emissions over the levels produced in the late 1960's. A Canada/Ontario Task Force, with the cooperation of INCO, will report by September 1981 on options to reduce emissions to the lowest possible level.

The Provincial Government is also examining where further investment in abatement measures can best be retrofitted to existing power generating facilities of Ontario Hydro. Ontario Hydro currently uses washed coal (no specific gravity separation) in all its generating stations and employs low sulphur fuels in environmentally sensitive areas. The Ontario Government expects to announce specific proposals for Ontario Hydro early in 1981 on its emission control program, which will specify limitations and reducutions of both SO_2 and NO_x to be accomplished in 1990.

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C. Summary of Work Group Interim Reports

The following summary statements have been taken from the Work Group Interim Reports.

Impact Assessment Work Group (WG-1)

In this first phase of activities under the MOI, the Impact Assessment Work Group has concentrated its resources on identifying the key physical and biological impacts resulting from pollution associated with transboundary air movement. In the Interim Report the acid precipitation component has been emphasized but other important problems, such as oxidants, are identified where there is presently a well documented concern. Other aspects will be dealt with in the second phase.

Acid deposition is currently being observed in most of eastern North America. Within this half-continent are large areas in which the surface soil material and bedrock types have little buffering capacity for acid inputs and are identified as "potentially sensitive". These areas include some of the most unique, unspoiled and biologically productive environments in North America. The potential is high for environmental degradation from the deposition of acid and other pollutants.

During atmospheric transport of sulphur oxides (SO_x) and nitrogen oxides (NO_x) in large scale air mass movements, conversion to their acid components takes place. Measurements of the present level of chemical constituents in precipitation show that significant portions of Ontario and

Quebec and most north-central and north-eastern states receive annually about 40 times more acid than normal.

This excessive loading is deposited in precipitation as wet fallout and in dry fallout as dust particles and in gaseous forms. Like acid precipitation, ozone is a secondary pollutant, not being emitted directly, but formed in the atmosphere in the presence of sunlight after chemical transformations of nitrogen dioxide and reactive hydrocarbons.

Terrestrial Effects

Ozone damage to vegetation, including reductions in yield for many crop species, has been well documeted in the eastern U.S. and Ontario. These crops include tobacco, white beans, soybeans, corn, potatoes, grapes, onion, cucumber, celery, pumpkin, squash and radish. At ambient concentrations of .05 to .10 ppm during continuous or intermittent exposure periods, loss of plant tissue may approach 15-30% and yield losses of 5-10% may occur for the most susceptible crops. Direct effects of acid precipitation, especially on crops for which the foliage is valued, have also been established under experimental conditions. Other potential impacts include: (1) damage to protective surface structures such as cuticle; (2) interference with normal functions of guard cells; (3) poisoning of plant cells after diffusion of acidic substances through stomata or cuticle; (4) disturbance of normal metabolism or growth processes without necrosis of plant cells; (5) alteration of leaf and root-exudation processes; (6) interference with reproduction processes, and (7) synergistic interaction with other environmental stress factors.

An increase in soil acidity can be detrimental to the chemical availability of several essential macro-nutrients and over decades a net loss of cations, (Ca and Mg) important for plant growth, from poorly buffered sites can be expected. Areas with soils of low pH are characterized as having low base exchange conditions. In this situation, any further loss of cations is considered significant, however small that loss may be. Much of eastern Canada's forest industry is founded on these low pH soils. The general restriction of commercial forest production to "less productive" sites, coupled with new harvesting technology (where more of the tree is removed from the site, reducing the availability of nutrients for recycling) and the tradition of not applying lime may increase the vulnerability of long term forest growth to acid precipitation.

An increase in soil acidity can also lead to mobilization of other elements (Al, Mn, Fe) sometimes in quantities toxic to terrestrial plants and to aquatic ecosystems. In fact, some studies have indicated that mass mortalities of fish observed during transient episodes of acidification in the spring are most likely a result of elevated levels of inorganic aluminum mobilized from the soils by strong acids present in snowmelt water.

The terrestrial system's influence on the acid component of precipitation also has important implications for the aquatic ecosystem. The results presented in this report on the mobility of nitrate and ammonium ions, have shown that most of the nitrogen added to the watershed is retained by growing plants. However, following a period of sulphate saturation in soils, most of the sulphur passes through to the aquatic

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system. Thus, it appears that control of sulphate deposition would be more effective in reducing the rate of acidification of surface waters than control of nitrogen inputs.

Aquatic Effects

The impacts of acid deposition on water quality and the aquatic ecosystem is better quantified and understood than for terrestrial ecosystems. There are a number of examples where dramatic changes in water quality believed to be directly attributable to acid precipitation have occurred. In Nova Scotia comparisons of recent data with results from the mid 1950's

show decreases in pH and concurrent increases in excess sulphate loads. At present there are 9 rivers in this province with a pH of 4.7 which no longer support salmon or trout reproduction; 11 rivers are in the pH range 4.7-5.0 where some juvenile salmon mortality is probably occuring; and 7 rivers are in the pH range 5.1-5.3 which is considered borderline for Atlantic salmon. If current acid loadings continue, it appears probable that more of the inland and Atlantic salmon fisheries in Canada will be lost.

A similar 17-year trend toward acidification of some headwater streams has been observed in New Jersey. As well, high elevation lakes in the Adirondacks have shown a marked pH decline over a 40 year period. This is one of the most sensitive lake districts in the eastern United States. A recent inventory has indicated that at least 180 former brook trout ponds will no longer support trout because of acidification.

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A summary of several Canadian lake studies supports the conclusion that acidic precipitation has reduced the alkalinity of surface water in many lakes, thus increasing their vulnerability to continued acid deposition. Many of the affected lakes are not technically acidified (in the sense of depressed pH), but the long-term biological consequences of the altered water chemistry are unknown at this time. Although naturally acid lakes do occur, a significant number of seriously acidified lakes appear to be a recent response of low alkalinity systems to the continuing addition of hydrogen and sulfate ions.

Concurrent with negative impacts on the fishery, there have been changes in other components of the aquatic ecosystem. Acidification results in changes in the make up, size and metabolism of plankton communities. These alterations hold important implications for other organisms higher in the food chain.

Many species of frogs, toads and salamanders breed in temporary pools which are susceptible to pH depression due to the rapid flushing of accumulated acid during spring snowmelt. Field surveys in North America and Europe have documented the sensitivity of amphibians to depressed pH and the decreases in their number, especially, those inhabiting temporary pools. The danger that they may become locally extinct and their importance in the foodchain hold important implications for other wildlife.

Health Effects

Although available information gives little cause for concern over direct health affects from acid deposition, there are at least two indirect effects of concern; (1) contamination of edible fish by toxic materials,

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principally mercury and (2) leaching and corrosion of watersheds and water storage and distribution systems, leading to elevated levels of toxic elements in drinking water supplies.

Although the mechanisms are not fully understood, available data indicate that fish in poorly buffered lakes contain elevated mercury levels, some in excess of Canadian and United States action levels (0.5 mg/kg and 1.0 mg/kg respectively). Continued consumption of fish containing mercury in excess of these action levels can lead to brain damage and neurological disorders. No clear evidence exists, however, that such effects have resulted as a direct result of acidic precipitation.

A number of drinking water supplies have become contaminated with metals as a result of acidic deposition, but no clear evidence of health effects from drinking these contaminated waters was reported. The elements most frequently detected were lead, cadmium, copper, and zinc. In one Pennsylvania county 16 percent of cistern waters contained lead in excess of the United States and Canadian drinking water standards (50mg/l). Populations at high risk include those obtaining drinking water from poorly buffered lakes and streams (or eating fish from such areas) and those using acidified groundwater or cisterns as a source of drinking water.

Visibility Effects

Effects of transboundary air pollution on visibility are related to air quality, not to acidic deposition. Acid precursors that can significantly affect visibility are sulphuric acid and various ammonium sulphate aerosols. Available data do not suggest that nitrates (predominantly in the vapor phase) play a significant role, but visible brown plumes from NO_2 have been reported at a distance of 100 km from isolated point sources.

A substantial decline in regional summertime visibility in eastern North America between the mid 1950's and mid 1970's has been documented. This change may be associated with changes in the level and distribution of sulphur oxide emissions. As well, a reduction in visibility has been noted in the western U.S.; an area noted for its vistas.

Man Made Structures

Acid deposition, oxidants, gases and particulates contribute to the accelerated degradation of materials. Many metallic construction materials are adversely affected by acid deposition through increased dissolution of protective surface oxides or of the metal itself. Masonry materials containing carbonate, such as limestone or marble, are very susceptible to attack by acid deposition. Plastics, elastomers, and organic paints and coatings are degraded by oxidants and by acid-catalyzed polymer decomposition. Physical, chemical or bacterial actions resulting from available air pollutants can contribute to deterioration and corrosion of these different types of materials.

Possibly the most difficult aspect, when viewed from an international perspective, will be the separation of the effects attributable to local emissions from those associated with transboundary flow.

Loading/Effects Relationships

A number of different approaches have been examined to assist in the task of deriving relationships between parameters of acid loading and system response. These models are all under active development, and in the

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aquatic sector they have advanced to the point where a preliminary application is possible, although it is important to stress that full validation remains to be achieved.

One model, developed in Sweden, indicates that annual sulphate loadings of less than 15 to 17 kg/ha would be unlikely to degrade "moderately sensitive" lakes. The most sensitive lakes and streams are likely to be on the border line of potential effects at an annual sulphate loading rate greater than 9 to 12 kg/ha.

A second model, developed in Norway, shows that precipitation pH of 4.5 and lakewater sulphate concentrations of 60 μeq/l, are the maximum tolerable for lake waters with 50 μeq Ca/l or more. This in-lake concentration of sulphate converts to a precipitation sulphate concentration of about 40 μeq/l. The predicted reductions in precipitation sulphate concentrations to 40 μeq/l in heavily loaded areas is needed to improve the pH from about 4.2 to about 4.5 to protect moderately sensitive lakes. Highly sensitive lakes and streams may be protected at predicted precipitation levels of sulphate of 21 μeq/l which should result in a pH of about 4.8.

A third model, developed in the U.S., combines the acute physiological effects of hydrogen and aluminum ions on fish in their early life stages with data on pH during flushing events (snowmelt or heavy rain). These data show a pH depression (ΔpH) of 0.7 to 1.0 will cause to be a response of substantial physiological significance. Given this dose/response relationship, a loading threshold may be defined as the episodic sulphate loading which, when subjected to a defined flushing event, leads to the

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minimal biologically significant short-term hydrogen and aluminum ion exposure. This model suggests a sulphate loading of 5 to 7 kg/ha/yr produces a critical surface water response (Δ pH in the range of 0.7 to 1.0) for streams in sensitive areas; a loading threshold of 7 kg SO_4/ha/yr converts to about 21 µeq SO_4/l (assuming 70cm/yr precipitation).

None of the predictions of these models are yet viewed as acceptable targets. All three models would benefit from further refinement, and the Scandanavian models have not been validated using North America data. However, validation of these predictions is likely to produce numbers which fall within the range given by present information.

A number of approaches to mapping terrestrial sensitivity to acid precipitation have been undertaken in the U.S. and Canada. Recent discussions however, have indicated that the assessment of terrestrial sensitivity must consider and distinguish between those aspects of the terrestrial ecosystem which have an effect on forest and agricultural productivity on the one hand and aquatic sensitivity on the other. Further refinement and mapping of the different criteria will be undertaken in Phase II.

In the man-made structure area, several approaches to modelling dose/response relationships have been developed using materials of known composition. However, interpolation of results from test conditions are difficult, largely because of a lack of environmental and meteorological data at the test sites.

Atmospheric Modelling Work Group (WG-2)

The importance of the atmosphere as a pathway or delivery mechanism for acidic and acidifying substances to regions of sensitive receptors in North America is now well established. Sulphur and nitrogen oxides, the major precursors of acid deposition, are known to be emitted in large quantities in eastern North America, and to be transported through the atmosphere for distances of up to several hundreds or thousands of kilometers. The atmospheric lifetimes of these substances and their reaction products are sufficiently long that approximately two-thirds are deposited back to the North American continent, primarily in the east. The remainder are carried out over the Atlantic Ocean. Because the scale of the transport is so large, county, state, provincial and national boundaries are often transversed, posing problems for and among several jurisdictions.

Acidity is associated with, through atmospheric and ecosystem chemical transformations, both primary and secondary sulphur and nitrogen compounds. As a result, portions of eastern North America (as well as isolated western parts) are being subjected to depositions of sulphur and nitrogen oxides (sulphur dioxide, sulphuric acid, nitrogen dioxide, nitric acid, sulphate and nitrate compounds) and hydrogen ions (acidity) that are as great as those in other severely impacted areas of the world (e.g. southern Scandinavia). In addition to the well known deposition pathway of acid rain, acidic and acidifying substances are also known to be deposited as dry deposition, that is, by processes not involving precipitation. In the case of sulphur, dry and wet deposition are estimated to be approximately equivalent in eastern North America, with dry deposition being relatively more important closer to sources.

National precipitation chemistry monitoring networks in Canada (CANSAP) and the United States (NADP) are beginning to produce comprehensive, reliable data on a continent-wide basis, and long range transport models (LRT) have been able to estimate the order of magnitude of inter-regional transport and deposition for large areas. The next step required in the refinement of the above types of information is to provide improved spatial and temporal resolution, and to link pollution source regions and sensitive receptor areas in a quantitative fashion. Progress is being made in these areas through the improvement of monitoring network coverage and through the efforts being placed in model development and application.

This latter area is the one on which Work Group 2 placed much emphasis during their Phase I work. They were charged with describing the transport of air pollutants from their sources to final deposition, especially deposition in sensitive ecological areas. The main thrust was to describe the development of state-of-the-art, source-receptor relationships based on available model results and measured deposition values from monitoring networks. This exercise is in a preliminary stage, however, within the constraints of Phase I the best available information has been produced, assembled and reviewed to guide transboundary air pollution control strategies in both countries.

Several LRT models for sulphur oxides have been developed in both Canada and the U.S. which are being used for long-range transport studies.

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Only models that met certain criteria, e.g., fully operational, numerically practical, flexible enough to include new data and other such factors, were used. Features of the individual models were reviewed. The emphasis was strongly placed on the application of models applicable to the larger scales. Short and mid range models do exist and can be applied to specific cases of interest as they are identified in the Phase II work.

The LRT models selected for intercomparison had several important features. They used emission and meteorological data, and physical, chemical and empirical parameters to calculate the transport of a given pollutant to a sensitive area. To date the models have been limited to describing sulphur deposition on a monthly or annual basis. Hydrogen and nitrate ion deposition, two important factors in acid rain, have not yet been successfully incorporated in the models. Initial source-receptor relationships for sulphur have been determined using model calculations.

Because the models are to be used to develop and analyze control strategies, a quantitative relationship between pollution emissions and deposition in sensitive areas must be established. To do this, a transfer matrix approach was adopted. Theoretically, by using this method, a change in rate of emissions can be tied to a change in the deposition in a sensitive area. Preliminary transfer matrix results have been presented, but the detailed transfer coefficients within these matrices are subject to future changes, possibly significant, as modeling techniques are refined. Although preliminary in nature, the needed framework to produce more accurate transfer matrices during Phase II has been set up.

In order to check the accuracy of models, field measurements of deposition from the existing monitoring networks in both countries are required. At present, wet deposition/acid rain measurements are being made regularly in several monitoring networks in both countries. These have been used for evaluation of models selected by Work Group 2 during Plase I. However, dry deposition, an important factor in ecological effects, can not yet be measured on a routine basis. Existing deposition data will be used to evaluate more thoroughly the selected models throughout Phase II.

Knowledge of the atmospheric mechanisms by which SO_2 converts to SO_4 is incomplete. This can lead to uncertainty in the SO_4 deposition reductions that would be achieved as a result of possible SO_2 emission control efforts.

Although the currently available long-range transport models do have restrictions on their usefulness, they are indispensible for estimating source-receptor relationships. Their further development, evaluation and intercomparison will be a major activity of Work Group 2 in Phase II.

Emissions, Costs and Engineering Work Group (WG-3B)

Extensive efforts have been expended in both the United States and Canada to establish emission data bases for sources of sulphur and nitrogen oxides. Table 1 presents the current emissions of sulphur and nitrogen oxides for the major source categories for each country.

Two-thirds of all United States sulphur dioxide emissions come from electrical generating plants, while other fossil fuel burning installations and industrial processing account for nearly equal shares of remaining United States sulphur dioxide emissions. A large majority of these

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TABLE 1

CURRENT EMISSIONS IN THE U.S. AND CANADA (10^6 Tons)

	U.S.A. (1980 Estimated)		CANADA 1979*		TOTAL	
	NO_x	SO_x	NO_x	SO_x	NO_x	SO_x
Utilities	6.2	19.5	0.3	0.8	8.2	20.3
Industrial Boilers/ Process Heaters/ Residential/ Commercial	7.1	7.3	0.6	1.1	7.8	8.4
Non-Ferrous Smelters	0.0	2.0	0.0	2.2	0.0	4.2
Transportation	9.0	.9	1.1	0.1	11.4	1.0
Other	-	-	0.2	1.1	0.2	1.1
TOTAL	22.3	29.7	2.2	5.3	27.6	35.0

* Inco, Sudbury at 1980 emission rate.

emission sources are in the mid-west and northeast United States where they can affect potentially sensitive environmental receptors in the United States and Canada through atmospheric transport, and deposition of acidic compounds. The highest density of sulphur dioxide emissions is in the upper Ohio Valley (eastern Ohio, northern West Virginia and western Pennsylvania) where a number of large power plants burn high sulphur coal with little control of their sulphur emissions.

Total Canadian sulphur dioxide emissions are about one-fifth those of United States sources, and are concentrated in the non-ferrous smelting sector which accounts for forty-five percent of total sulphur emissions. Power plants account for little more than ten percent, while other combustion sources and other industrial processes nearly equally account for the remaining Canadian sulphur dioxide emissions. Almost half of Canadian emissions come from a small number of non-ferrous smelters. One of these smelters, located in central Ontario, is the largest single sulphur dioxide emission source in North America, and is responsible for fully twenty percent of Canada's sulphur dioxide emissions. Three quarters of the total Canadian emissions are east of the Manitoba-Saskatchewan border.

More than forty percent of the nitrogen oxide emissions in the United States come from the transportation sector. Electric utilities account for thirty percent and other combustion sources account for the remainder.

About sixty percent of Canadian nitrogen oxide emissions come from the transportation sector. Electric utilities account for ten percent and other combustion sources for twenty percent. Two-thirds of Canadian emissions are east of the Manitoba-Saskatchewan border.

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Natural NO_x emission rates in eastern North America are currently not well determined. However, indirect evidence can be used to assess the possible relevance of these emissions to acid deposition, as will be done in future Work Group activities.

Projected emissions of sulphur and nitrogen oxides in Canada are shown in Table 2.

Projected emissions of sulphur and nitrogen oxides in the U.S. are presented in Table 3. Projected emissions of sulphur oxides in the region that is believed to contribute most to acid deposition are expected to decline, assuming that strict compliance with current emission limits is attained.

Technology is available to significantly reduce SO_2 emissions from all major SO_2 emitting sectors. Because of their significance, the discussion in this summary is limited to thermal power and non-ferrous smelting.

Control of SO_2 emissions from thermal power plants has become a complex problem with several options available and many factors involved in making the choice among them.

Sulphur oxide emissions can be reduced by several methods:

1) use of naturally occurring low sulphur fuel
2) removal of the sulphur before combustion
3) reaction with an absorbent during combustion
4) flue gas desulphurization.

All are being used to some degree.

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TABLE 2

PROJECTED EMISSIONS OF SO_x AND NO_x IN CANADA (10^6 tons)

	YEAR 1980	1985	1990	1995	2000
NO_x TRENDS					
Utility Boiler	0.3	0.4	0.6	0.6	0.7
Industrial, Residential and Commercial Fuel Combustion	0.6	0.6	0.7	0.7	0.7
Non-Ferrous Smelters (Cu/Ni)	-	-	-	-	-
Transportation	1.1	1.3	1.5	1.6	1.8
Other	0.2	0.2	0.2	0.2	0.2
TOTAL	2.2	2.5	3.0	3.1	3.4
SO_x TRENDS					
Utility Boiler	0.8	1.1	1.2	1.3	1.4
Industrial, Residential and Commercial Fuel Combustion	1.1	1.1	1.2	1.2	1.2
Non-Ferrous Smelters (Cu/Ni)	2.2	2.0	2.0	2.0	2.0
Transportation	0.1	0.1	0.1	0.1	0.1
Other	1.1	1.1	1.1	1.1	1.1
TOTAL	5.3	5.4	5.6	5.7	5.8

Source: Data Analysis Division, Air Pollution Control Directorate, Environment Canada
Note: Based on a "status quo" scenario

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TABLE 3

PROJECTED EMISSIONS OF NO_x AND SO_2 IN THE U.S. (10^6 tons)

	YEAR 1980	1985	1990	1995	2000
NO_x TRENDS					
Utility Boiler	6.2	6.8	7.6	8.4	9.2
Industrial Boiler/ Process Heat	6.2	6.5	6.9	7.6	8.4
Non-Ferrous Smelters	0.0	0.0	0.0	0.0	0.0
Residential/Commercial	0.9	0.9	0.8	0.8	0.7
Transportation	9.0	8.3	8.6	9.4	10.2
TOTAL	22.3	22.5	23.9	26.2	28.5
SO_x TRENDS					
Utility Boiler	19.5	17.9	18.6	19.0	18.5
Industrial Boiler/ Process Heat	5.9	5.7	6.8	8.6	10.3
Non-Ferrous Smelters	2.0	0.77	0.60	0.56	0.52
Residential/Commercial	1.4	1.4	1.2	0.9	0.6
Transportation	0.9	0.9	0.9	0.9	0.9
TOTAL	29.7	26.7	28.7	30.0	30.8

Source: These emission estimates based on 1980 trends but projected with % change of models (utility-TRI, industrial ICF; RES/COM-SEAS; Transportation-Anne Arbor); NF Smelters come from an actual unit-by-unit survey.

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The listing in Table 4 is made for process choices at different required levels of emission reduction. It should be noted that these are only approximate and that site-specific conditions could well affect the pollution control option actually chosen.

Several approaches can be used for NO_x control. Low nitrogen fuel is one of these but is not as effective as low sulphur fuel is for SO_2 because more than half of the NO_x comes from the combustion air rather than the fuel. Combustion modification is the most cost effective method. Although it is widely used, it is limited in its effectiveness by practical engineering factors. If flue gas treatment is required, injection of ammonia to reduce, non catalytically, NO_x to nitrogen may be favored. Catalytic reduction with ammonia to reduce NO_x has potential, but is unproven on coal fired power plants. Various wet scrubbing methods have been considered but none seem very promising.

The selection of abatement method depends on the degree of control required, the cost of such control and the site specific characteristics for control. A listing of NO_x control options is contained in Table 5.

The non-ferrous smelting sector is a major source of SO_2 emissions. In eastern Canada, the major non-ferrous smelter sources emitted an estimated 2.2 million tons of SO_2 in 1980 (emissions at full capacity operations are estimated at 3 million tons). Virtually all of the major smelter emissions sources are in the copper-nickel sector. In the eastern United States there are no major non-ferrous smelter sources of SO_2. However, there are major non-ferrous sources of SO_2 in the Western United

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TABLE 4

Removal efficiency level, %	Process
Higher than 90%	1. Double alkali scrubbing 2. Limestone scrubbing with promoters 3. Coal gasification[a] 4. Regenerable scrubbing processes
90%	1. Limestone scrubbing with promoters 2. Limestone scrubbing 3. Double alkali scrubbing
50-90% (high-sulphur coal)	1. Limestone scrubbing 2. Fluidized bed combustion[a] 3. Chemical coal cleaning[a] 4. Low sulphur fuel substitution 5. Limestone Injection Multi-Staged Burner[a]
50-90% (low-sulphur coal)	1. Spray drier process 2. Limestone scrubbing
Below 50%	1. Physical coal cleaning (highly variable effectiveness due to coal properties) 2. Blending with low sulphur coal.

[a]If and when developed

States (copper sector). No studies have been attempted to determine if there are any conditions under which these western U.S. sources contribute to the acid rain problem in eastern North America.

The process technology in use varies from smelter to smelter. A majority of the smelters use the roaster - reverberatory furnace - converter process which is not amenable to a high degree of SO_2 control, at reasonable cost, due to the weak gas streams produced. Some copper-nickel smelters utilize more modern process technology, and SO_2 emissions are controlled to varying degrees.

The most applicable control technology in use is the production of sulphuric acid in a contact acid plant. Two constraints limit the use of this control technology:

1) weak SO_2 streams (under 4% SO_2) are not suitable for contact acid plants and a number of smelters do not have strong gas streams;
2) markets for sulphuric acid are limited, and it is possible that not all the acid produced could be marketed.

For any major SO_2 control program to succeed it would be necessary to:

1) improve or replace existing process technology (with weak SO_2 streams) with new process technology which produces higher strength SO_2 streams (suitable process technology is available in the majority of the cases);
2) find markets for the sulphuric acid.

Two other problem areas are identified:

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TABLE 5

Removal efficiency level, %	Process
90% or higher	1. Catalytic reduction with more than normal amount of catalyst, preceded by combustion modification (except for coal)
50-80%	1. As above, with a normal amount of catalyst 2. Combustion modification (all types) followed by non-catalytic reduction (ammonia injection without catalyst) 3. Combustion modification alone (for low part of range so as to minimize boiler problems) 4. Low-NO_x burners (under development)
Below 30%	1. Staged combustion[a] 2. Low-NO_x burners[a] 3. Gas recirculation (except for coal)[a]

[a]Used in combination with others if necessary to achieve the required reduction.

1) In many smelters, some weak gas streams will remain, even with new process technology, SO_2 emission control technology for weak gas streams in this sector is in the early development stages;
2) The choice of smelter processes to handle concentrates which contain high levels of impurities is limited. This in turn may reduce the level of SO_2 control achievable at smelters handling these concentrates.

These factors are being given careful consideration in analyses conducted by the Canadian Federal and Provincial Governments.

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III. PREPARATION OF STRATEGY PACKAGES

The purpose of this section is to provide the initial framework for developing control strategies that incorporate the guiding principles continued in the Joint Statement of July 26, 1979 on Transboundary Air Quality. The Joint Statement reviews the existing international rights, obligations, commitments and cooperative practices to which both countries subscribe. The complete text of the Joint Statement is incorporated in Section A of this chapter.

Section B discusses the development of baseline scenarios. These scenarios contain a number of assumptions which describe the future status of relevant economic, energy and environmental control factors. Control strategies under development will draw on the results of the Work Group efforts and will focus on emission control and mitigation measures beyond those anticipated under baseline conditions.

The final section of this chapter discusses important issues which require consideration of and coordination between Work Group 3A and 3B in the development of control strategies. These issues relate to: (1) finding acceptable allocations of emission reductions between the two countries, which are subject to bilateral discussions, and (2) balancing those factors pertaining to the allocation of emission reductions among different jurisdictions within a single country, which is subject to the sole consideration of that country. In conducting this work, it is recognized that although cost/benefit analysis can be a useful tool for examining environmental issues within the confines of a single country, this

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technique is not appropriate for application to the international situation.

A. Review of Existing International Principles and Practices

The approach of the two Governments to transboundary air pollution has been set out in the Joint Statement of July 26, 1979, and resulted in the Memorandum of Intent of August 5, 1980. The text of the Joint Statement is repeated here as a guide to developing strategies to control transboundary air pollution.

> Transboundary air quality has become a matter of increasing concern to people in both the United States and Canada. This issue has many dimensions, including the long range transport of air pollutants and the phenomenon of 'acid rain'. Both Governments have recognized the need for close and continuing cooperation to protect and enhance transboundary air quality.
>
> Discussions on transboundary air quality were initiated through an Exchange of Notes of November 16 and 17, 1978, in which the United States Department of State proposed that "representatives of the two Governments meet at an early date to discuss informally (a) the negotiation of a cooperative agreement on preserving and enhancing air quality, and (b) other steps which might be taken to reduce or eliminate the undesireable impacts on the two countries resulting from air pollution."
>
> In reply, the Canadian Government indicated that it shared United States concern about the growing problem of transboundary air pollution. In particular, it noted the potential environmental impact, and the transboundary significance, of the long range transport of air pollutants. It therefore welcomed the opening of 'informal discussions ... with a view to developing agreement on principles which recognize our shared responsibility not to cause transboundary environmental damage, and which might lead to cooperative measures to reduce or eliminate environmental damage caused by transboundary air pollution.

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Bilateral discussions of an informal nature took place on December 15, 1978, and June 20, 1979, and both Governments have exchanged discussion papers on principles which they believe have relevance to transboundary air pollution. As a result of these discussions it has become clear that Canada and the United States share a growing concern about the actual and potential effects of transboundary air pollution and are prepared to initiate cooperative efforts to address transboundary air pollution problems.

There is already a substantial basis of obligation, commitment and cooperative practice in existing environmental relations between Canada and the United States on which to address problems in this area. Both Governments are mutually obligated through the Boundary Waters Treaty of 1909 to ensure that

> "... boundary waters and waters flowing across the boundary shall not be polluted on either side to the injury of health or property ..." (Article IV)

Both Governments have also supported Principle 21 of the 1972 Stockholm Declaration on the Human Environment, which proclaims that

> "... States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental policies and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction ..."

A number of cooperative steps have been taken to deal with transboundary air pollution. In the 1978 Great Lakes Water Quality Agreement, both Governments committed themselves to develop and implement

> "Programs to identify pollutant sources and relative source contributions ... for those substances which may have significant adverse effects on environmental quality including indirect effects of impairment of tributary water quality through atmospheric deposition in drainage basins. In cases where significant contributions to Great Lakes pollution from atmospheric sources are identified, the Parties agree to consult on remedial measures."

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Both Governments have sought to implement the principles of notification and consultation on activities and projects with potential transboundary impact, and to promote exchanges of scientific and technical information. In 1978 the two Governments established a Bilateral Research Consultation Group on the Long Range Transport of Air Pollutants to coordinate research efforts in both countries. Both Governments have also engaged the International Joint Commission in some aspects of transboundary air pollution. This has been done through References under the Boundary Waters Treaty establishing the Michigan/Ontario Air Pollution Board and the International Air Pollution Advisory Board, and through the Great Lakes Water Quality Agreement of 1978

Having regard to these and other relevant principles and practices recognized by them, both Canada and the United States share a common determination to reduce or prevent transboundary air pollution which injures health and property on the other side of the boundary. Recognizing the importance and urgency of the problem, and believing that a basis exists for the development of a cooperative bilateral agreement on air quality, the Government of the United States and the Government of Canada therefore intend to move their discussions beyond the informal stage to develop such an agreement. Both sides agree that the following further principles and practices should be addressed in the development of a bilateral agreement on transboundary air quality:

1. Prevention and reduction of transboundary air pollution which results in deleterious effects of such a nature as to endanger human health, harm living resources and ecosystems, and impair or interfere with amenities and other legitimate uses of the environment.

2. Control strategies aimed at preventing and reducing transboundary air pollution including the limitation of emissions by the use of control technologies for new, substantially modified, and as appropriate, existing facilities.

3. Expanded notification and consultation on matters involving a risk or potential risk of transboundary air pollution.

4. Expanded exchanges of scientific information and increased cooperation in research and development

concerning transboundary air pollution processes, effects, and emission control technologies.

5. Expanded monitoring and evaluation efforts aimed at understanding the full scope of the transboundary air pollution phenomenon.

6. Cooperative assessment of long-term environmental trends and of the implications of these trends for transboundary air pollution problems.

7. Consideration of such matters as institutional arrangements, equal access, non-discrimination, and liability and compensation, as relevant to an agreement.

8. Consideration of measures to implement an agreement.

Since the Joint Statement was issued, both Governments have signed the UN Economic Commission for Europe Convention on Long Range Transboundary Air Pollution on November 13, 1979. This Convention reaffirms the commitment of both countries to develop effective international solutions to the problem.

Measures intended to deal specifically with transboundary air pollution between the United States and Canada are outlined in the Memorandum of Intent (MOI) signed by both Governments on August 5, 1980. The MOI notes the intention of both Governments to begin negotiation of a cooperative agreement on transboundary air pollution, and creates the Work Group structure to assist in preparations for negotiations. The MOI records the intention of both Governments to take interim actions available under current authority to combat transboundary air pollution pending conclusion of an agreement, including interim control action, advanced notification and consultation on activities potentially contributing to

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transboundary air pollution, and cooperation in scientific research and monitoring.

Domestic legislation in both countries recognizes the need to take action to control international air pollution. The United States Clean Air Act allows the U.S. Government to require emission reductions from States where there is reason to believe that pollution from U.S. sources endanger public health or welfare in a foreign country, so long as that country provides essentially the same rights to the U.S.

In December 1980, the Canada Clean Air Act was amended with a view to providing the United States with essentially the same rights as those provided to Canada under the U.S. Clean Air Act. In particular, the amendments now allow the Canadian Government to regulate emissions on both a regional and site specific basis to protect the environment and human health in the United States.

B. Assumptions for Baseline Scenarios

It is recognized that the anticipated costs of any proposed control strategy to reduce transboundary air pollution can be strongly dependent upon assumptions made about future economic and energy conditions (domestic and international) and future policies to manage local-scale air pollution. Yet, these future conditions and policies cannot be predicted with confidence, dependent as they are on trends in social values, productivity and resource availability.

Even though the validity of such forecasts can be questionned, policy analysis requires some estimate of baseline ("business-as-usual") conditions to be established, against which the effect of policy changes can be measured. This difficulty is most frequently overcome in one of two ways:

1) construct two or more markedly disparate baseline scenarios against which all proposed policy measures can be tested. Those policy measures which are invarient in their effects, independent of choice of baseline scenarios, can be considered to be more certain in their costs and effectiveness than those whose effects are dependent upon choice of baseline scenario.
2) construct one baseline scenario against which all proposed policy measures can be tested. For those policy measures which appear promising, execute widely varying changes in baseline assumptions to test the sensitivity of the policy measures to baseline assumptions.

In specific situations a choice is generally made between these two approaches based on several criteria: number of policy options to study, cost of analysis for each scenario, opportunity and ability to perform sensitivity analyses, etc.

Studies currently underway in both countries on possible control options have not coordinated their baseline assumptions, although such coordination is recognized to be highly desireable. Such coordination does not require the use of the same value for each scenario parameter in both countries, only that the choice of parameters is consistent for the two. For example, assumed U.S. energy imports from Canada should match assumed Canadian exports to the U.S., but the market price of energy in the two countries may be quite different due to varying domestic energy policies.

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Baseline scenario assumptions recently used in studies by the two countries are presented in Appendix D.

Efforts are underway to coordinate the development of a prototype baseline scenario that can be used by studies in both countries. Once such a scenario has been constructed and tested, a decision must be reached on whether 1) multiple baseline scenarios will be developed, or 2) extensive sensitivity analysis will be performed on one scenario.

Even with Work Group 3A providing a baseline scenario(s), Work Group 3B will still have to make further detailed assumptions concerning many engineering and economic parameters. Some of these will be unique to one country. For others, differing assumptions for each country or for different regions within a country will be appropriate. A partial list of these parameters include:

- Regional disaggregation of GNP
- Regional disaggregation of energy prices and energy consumption
- Conversion of oil-fired plants to coal
- Nuclear power plant construction schedules and capacity factors
- Detailed pollution control costs
- Detailed coal supply linkages

It is the responsibility of Work Group 3B to project, to the extent practical, a reasonable range and mean value for these parameters. Work Group 3B must also determine the sensitivity of their analyses results to changes of these parameters within their projected range.

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C. Guidance for Preparing Control Strategy Packages

During Phase II, Work Group 1 will identify reductions in sulphur deposition rates necessary to protect sensitive areas from acidification. Work Group 3B will utilize the atmospheric transfer matrices developed by Work Group 2 to determine the amount of emission reductions from specific source areas to achieve the deposition reduction objectives. Further, Work Group 3B will analyze the costs associated with these emission reductions. During this period, Work Group 3B will need guidance regarding appropriate factors to be considered in allocating required emission reductions among contributing source areas. Any set of deposition reductions proposed for a sensitive area or group of sensitive areas will not have a mathematically unique solution in terms of an individually specified reduction for each contributing source area. This introduces the need for some guidance to Work Group 3B in allocating reductions among contributing source areas.

In preparing control strategy packages, Work Group 3B in consultation with Work Group 3A, will be guided by existing international rights, obligations, commitments and cooperative practices as articulated in Section A of this Chapter. Since there remains room for interpretation in applying these rights, obligations, etc for specific situations, the Work Groups will need to provide the Coordinating Committee with sufficient technical information on implications of alternative approaches to enable interpretation of international transboundary air pollution responsibilities.

A second area for which guidance to Work Group 3B is required is in allocating emission reductions to source regions within the boundaries of a single country. Both Chairmen of Work Group 3A have communicated

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separately to their respective Work Group 3B Chairman as to how to address domestic issues associated with within-country reductions. These are included in Appendices B and C of this report. It is anticipated that further consultation among members of Work Group 3A and 3B from each country will continue separately as required.

During Phase II a separate series of control strategies will be prepared for each major source region in Canada and the United States. For each source region, the strategies will focus on emission reductions ranging from business as usual to the application of best available control technology (maximum reductions technically possible). The strategies will include appropriate intermediate steps depending on the nature of the sources within the region and the control technology or actions which could be applied. For each intermediate step, the implications of taking that step for moving to the next step will be addressed (i.e., does the application of particular technology to achieve a specific emission reduction in a region significantly influence or preclude moving to more stringent action?). Strategies of varying stringency for each source region will be studied, through the use of the transfer matrices developed by Work Group 2, in order to determine their probable effect in reducing sulphur deposition in identified sensitive areas.

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IV. COORDINATION

A. Inter-Work Group Coordination

Efforts to coordinate the flow of information between Work Groups have been initiated during Phase I. Such information flow must be structured such that (1) each variable used by more than one Work Group is described in the same measurement units by each Work Group, and (2) each piece of information required by one Work Group from another Work Group is available from the latter Group by the time required by the former Group. These coordination efforts must be ongoing throughout the Work Group activities.

B. Coordination of Research and Monitoring Activities

Since acid deposition does not recognize the U.S./Canadian border, it is important that acid deposition monitoring be conducted both in the United States and in Canada and that the results of monitoring be comparable. Coordination of routine monitoring efforts for aerosols and particulates in both countries may also be desirable. Efforts to harmonize U.S. and Canadian acid deposition monitoring efforts are currently in progress. A large state/federal air quality monitoring program and data base has been established in the United States to support current Clean Air Act regulatory activities. Environment Canada maintains a national air quality monitoring network in addition to an air quality research network.

Precipitation monitoring is currently characterized by a good deal of heterogeneity. At present, several major networks in the United States and Canada collect data on precipitation chemistry. These networks include CANSAP, APOS, APN in Canada and USGS, EPA-NOAA-WMO, NADP, TVA, EPA Region

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V, EPA-DOE-MAP3S, and EPRI in the U.S. The APN, MAP3S and EPRI are research networks conducting event sampling. In addition, there are several other state and provincial networks or university research networks in both countries. All networks collect samples of wet precipitation and some collect bulk (combined wet and dry) samples. Since the networks were initiated for different reasons, frequently operational and analytical procedures are different. All the existing networks, at a minimum, analyze for major cations and anions.

To obtain more comparable data, several activities have been undertaken. The more important of these are:

- Establishing a common acid precipitation chemistry data system. This system has been established by the Environmental Protection Agency's Environmental Monitoring and Systems Laboratory, Research Triangle Park, North Carolina. This system is currently operational and is archiving data from participating U.S. and Canadian networks including quality control information. The existence of the common system should encourage adoption of more comparable monitoring procedures in the future.
- U.S./Canadian monitoring networks and protocols for operating the networks are becoming more integrated. Current efforts include the operation of monitoring devices from both countries at selected sites in each country.
- The U.S. Federal Acid Precipitation Assessment Plan will determine objectives for a national deposition monitoring network to establish long-term trends.

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- Extensive sample intercomparison and sample exchange are contemplated.
- The Bilateral Research Consultation Group fosters coordination in the study of long-range transport of air pollution (LRTAP) in North America. The Group, which was established in 1978, consults on research efforts in Canada and the United States and facilitates technical information exchange by ensuring intercomparability of data. The Group has published annual reports in 1979 and 1980 on the status of current information about LRTAP in North America.

C. Identification of On-going Research Programs

Acid deposition research is being conducted by governments, universities and industries in both the U.S. and Canada. In the United States, the largest support is provided by the Federal agencies and the Electric Power Research Institute. In Canada, support is provided by both the Federal and Provincial governments. A summary of these programs is contained in Appendix E.

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V. PHASE II WORK GROUP ACTIVITIES

As is stated in Chapter I, the principal objective for Phase II Work Group activities is to provide the Coordinating Committee, before bilateral negotiations commence, the best available information on the sources of, atmospheric transport relationships for, and likely long-term effects of transboundary acid deposition. To achieve this objective Work Group 3A will guide and coordinate Work Group activities so as to provide integrated analyses of the effectiveness, costs, and other implications of varying degrees of protective measures for identifed sensitive areas.

Additionally, Work Groups will be improving and expanding the usefulness of their technical analysis tools. They will be broadening the coverage of acid deposition related issues considered, thereby bridging, where possible, recognized information gaps. They will be obtaining peer review of analysis tools and results, where the need for review is indicated. They will be identifying other candidate transboundary air pollution issues for consideration in Phase III, and they will be preparing their Phase III work plans.

A. Analysis Activities in Phase II

The reports produced by the Work Groups by the end of Phase II will differ from the Phase I reports in several respects. Although each Work Group has assembled in its Phase I activities the most currently available information on acid deposition, and reviewed and adopted for analysis purposes state-of-the-art scientific methodologies and computerized analytical models, additional efforts are required by each Work Group to extend its analytical capabilities.

In some cases, Work Groups have utilized the limited time and support resources available in Phase I to focus on the most important aspects of the acid deposition problem at the expense of evaluating less fully other secondary aspects, even though these aspects may be important in isolated situations. In other cases, efforts which commenced in Phase I to develop data bases and analytical tools will not be completed until some time in Phase II or even Phase III. Analysis efforts affected by either of these situations will be considered incomplete and therefore, tentative, until the full, planned analyses are completed, including subjecting them to necessary peer review. Such efforts will be an extension of those work efforts commenced in Phase I.

A major objective in Phase II will be to integrate within the Work Group activities the application of appropriate analysis tools to the transboundary acid deposition problem. By coordinating their efforts, the Work Groups will identify and analyze alternative steps to reduce the adverse effects of acid deposition on identified sensitive areas. These analyses will require close, inter-disciplinary coordination under an ambitious time schedule in order to provide the Coordinating Committee with necessary technical information.

Such integrated analyses will proceed by successive iterations. A single iterative cycle begins with Work Group 1 producing target deposition thresholds which it believes are necessary in order to provide identified sensitive areas with a selected degree of protection. Work Group 3B, as

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guided by Work Group 3A, will use the transfer matrices developed by Work Group 2 to develop alternative ways to reduce the deposition in all identified sensitive areas to values at or below the thresholds specified by Work Group 1. Work Group 3A will coordinate an examination of the economic and other consequences of achieving the indicated emission reductions for each alternative, along with the extent and nature of protection that would be provided to the identified sensitive areas. Work Group 3A will evaluate the findings from these analyses, including the uncertainties associated with each analysis result and its importance to what ever conclusions are reached. Work Group 3A will then recommend new protective criteria to Work Group 1 to be used in the next iterative cycle.

B. Recommendations for Additional Study by Work Groups

It has been recommended that the Work Groups consider undertaking the following tasks as early as possible in Phase II. While some of these issues may have been examined in Phase I, more effort will be required in Phase II. After consideration of these tasks, the Work Group Chairmen have been requested to consult with Work Group 3A to determine how, when, and to what extent they will be addressed.

Work Group 1

1. Analyze the methodologies available for quantifying effects in economic terms. This analysis should be sufficiently detailed to identify the critical steps and to identify resource requirements in undertaking this activity in Phase III, if it is decided to proceed.

2. Determine the capability of retrospectively modelling historic adverse effects of acidic deposition taking into account the inherent uncertainties associated with such estimates and the availability of historic data.

Work Group 2

1. Provide a means to estimate short range and mesoscale transport for sulphur compounds relative to long range transport for identified sensitive areas. Provide a means for evaluating such transport, if significant.
2. Assess the relative contribution to acid deposition on identified sensitive areas of primary sulphate emissions from oil-fired and coal-fired combustion sources in comparison with secondarily formed sulphate from these sources. Compare the primary sulphate deposition in identified sensitive areas from oil-fired sources with the total sulphur deposition from all other sources.

Work Group 3B

1. Explore the effects of substantial extensions to the useful economic lives of existing SO_2 emitting facilities.
2. Respond to the guidance on domestic issues contained respectively in the Appendicies B and C.

Work Group 4

1. Work Group 3A attaches importance to the activities of Work Group 4 in evaluating various mechanisms for implementing the notification and consultation elements of an agreement. The mechanism should be capable of providing notification of legislative or regulatory changes that may

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be required by an agreement as well as activities and practices potentially affecting pollutant levels.

2. Work Group 3A also attaches importance to the Work Group 4 mandate to develop proposals for institutional arrangements needed to give effect to the control aspects of an agreement. One option would be to request the International Joint Commission to assist in implementing an agreement. A variation of this option would be to create a new bilateral body for this purpose. Presentation of this information to the Coordinating Committee at an early date, no later than the end of Phase II, will allow the Committee to determine which options it wishes to explore further, whether it desires other mechanisms explored and whether it needs further information on existing structures and practices.

3. In order to assist the Coordinating Committee and Work Group 3A in assessing actions each Government would need to take in implementing various control strategies, Work Group 4 is requested to develop a brief overview of applicable laws, regulations and practices. Specifically, the Group should identify the legislative and regulatory mechanisms, and governmental practices currently available at the federal, state/provincial and local levels to address this problem.

C. <u>Preparation of Phase III Work Plans</u>

The principal Phase III analysis objective is to provide the Coordinating Committee with requested information on all transboundary air pollution issues of interest to the two Governments. Thus, in addition completing the acid deposition analyses initiated in Phase I, Phase III

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work programs will analyze other important transboundary air pollution issues. Consequently, it is important that these additional issues be identified and adequately defined during Phase II so that the Phase III work plans will cover the indicated technical analyses.

Among those issues of a regional nature which are recognized to have an important transboundary component are:

1) Regional Scale Formation and Transport of Photochemical Oxidants

The advection of large air masses containing elevated ozone concentrations has been reported by several investigators to occur between the eastern United States and Canada during summertime oxidant episodes. The relative contribution of precursor emissions from sources which are a long distance upwind from areas of elevated oxidant concentrations is still unknown.

Elevated oxidant levels can produce adverse effects on forestry, agriculture and human health over large areas. Ozone and related oxidants weaken many crop and forest species, as well as increase their sensitivity to insect infestation and pathogens. Frequently, these episodes of elevated oxidant concentrations occur simultaneously with those of elevated sulphate concentrations.

2) Other Effects of Sulphates

Visibility deteriorated during the summer months in large areas of eastern North America from the mid 1950's through the early 1970's. Decreased visibility trends in these regions

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correlate strongly with trends of increasing regional sulphate concentrations during the summer months.

Sulphate effects on health are subject to much uncertainty--yet reduction in exposure of human populations to sulphates is considered by some to be of high public benefit. Estimates of mortality and morbidity due to sulphates can be made but the uncertainty associated with these estimates make them of dubious value in the opinion of other investigators.

3) Deposition of Toxic Materials, Trace Metals and Organics

There is a concern for the contamination of remote aquatic regimes by trace metals and synthetic organics by deposition from the atmosphere. Dry vapor deposition has been measured as the most important contribution of mercury into two Canadian lakes which have been studied. Direct measurement of PCB's and other synthetic organic contamination in the Great Lakes has been made and may account for a large portion of the total lake load of these pollutants.

Other transboundary issues will be identified by a sub-group of Work Group 3A with the full Work Group reviewing the sub-group report and recommending to the Coordinating Committee which issues should be included in Phase III work plans. These additional issues are likely to be local in nature or associated with specific emitting facilities.

To a major extent, the technical base for analyzing many of the additional transboundary issues will have been established in developing

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required acid deposition analysis capabilities. Common data bases and analytical tools developed during the first two Phases of Work Group activities will be useful, even though these will require some changes for application to other transboundary air pollution issues. Development and application of other methodologies will also be required during Phase III, depending upon the specific additional transboundary issues selected.

VI CONCLUSIONS

The following general conclusions can be drawn from the results of work carried out thus far by Work Groups 1, 2, 3B and 3A, pursuant to the August 5, 1980 Memorandum of Intent (MOI).

1. The Work Groups have made good progress in meeting the requirements of the MOI for a January 15, 1981 interim report. With continued effort by Work Group members, and the support and provision of resources by Government agencies they can be expected to provide the Coordinating Committee with refined reports, which will facilitate the negotiations scheduled to commence by June 1, 1981.

2. The findings of the Work Groups in these interim reports give further precision to the problem of transboundary air pollution, which motivated the Governments to sign the MOI. They also indicate that a variety of technologies are available to reduce emissions from major emitting sectors. Further work will focus on the identification of Canada/U.S. control strategies for consideration.

3. As envisaged in the MOI, the interim reports are a first step in the preparation of technical and scientific groundwork for negotiation of a cooperative agreement on transboundary air pollution. In view of the importance and urgency of this problem however, they may also assist in formulating the interim actions by both countries called for in the MOI to deal with the problem, pending conclusion of an agreement.

APPENDIX A

ANNEX TO THE AUGUST 5, 1980 MEMORANDUM OF INTENT

I. PURPOSE

To establish technical and scientific work groups to assist in preparations for and the conduct of negotations on a bilateral transboundary air pollution agreement. These groups shall include:

1. Impact Assessment Work Group
2. Atmospheric Modeling Work Group
3A. Strategies Development and Implementation Work Group
3B. Emissions, Costs and Engineering Assessment Subgroup
4. Legal, Institutional Arrangements and Drafting Work Group

II. TERMS OF REFERENCE

A. General

1. The Work Groups shall function under the general direction and policy guidance of a United States/Canada Coordinating Committee co-chaired by the Department of External Affairs and the Department of State.

2. The Work Groups shall provide reports assembling and analyzing information and identifying measures as outlined in Part B below, which will provide the basis of proposals for

inclusion in a transboundary air pollution agreement. These reports shall be provided by January 1982 and shall be based on available information.

3. Within one month of the establishment of the Work Groups, they shall submit to the United States/Canada Coordinating Committee a work plan to accomplish the specific tasks outlined in Part B, below. Additionally, each Work Group shall submit an interim report by January 15, 1981.

4. During the course of negotiations and under the general direction and policy guidance of the Coordinating Committee, the Work Groups shall assist the Coordinating Committee as required.

5. Nothing in the foregoing shall preclude subsequent alteration of the tasks of the Work Groups or the establishment of additional Work Groups as may be agreed upon by the Governments.

B. Specific

The specific tasks of the Work Groups are set forth below.

1. Impact Assessment Work Group

The Group will provide information on the current and projected impact of air pollutants on sensitive receptor areas, and prepare proposals for the "Research, Modeling and Monitoring" element of an agreement.

In carrying out this work, the Group will:

- identify and assess physical and biological consequences possibly related to transboundary air pollution;
- determine the present status of physical and biological indicators which characterize the ecological stability of each sensitive area identified;
- review available data bases to establish more accurately historic adverse environmental impacts;
- determine the current adverse environmental impact within identified sensitive areas--annual, seasonal and episodic;
- determine the release of residues potentially related to transboundary air pollution, including possible episodic release from snowpack melt in sensitive areas;
- assess the years remaining before significant ecological changes are sustained within identified sensitive areas;
- propose reductions in the air pollution deposition rates--annual, seasonal and episodic--which would be necessary to protect identified sensitive areas; and
- prepare proposals for the "Research, Modeling and Monitoring" element of an agreement.

2. <u>Atmospheric Modeling Work Group</u>

The Group will provide information based on cooperative atmospheric modeling activities leading to an understanding of the transport of air pollutants between source regions and sensitive areas, and prepare proposals for the "Research, Modeling and Monitoring" element of an agreement. As a first priority the group will by October 1, 1980, provide initial guidance on suitable atmospheric transport models to be used in preliminary assessment activities.

In carrying out its work, the Group will:

- identify source regions and applicable emission data bases;
- evaluate and select atmospheric transport models and data bases to be used;
- relate emissions from the source regions to loadings in each identified sensitive area;
- calculate emission reductions required from source regions to achieve proposed reductions in air pollutant concentration and deposition rates which would be necessary in order to protect sensitive areas;
- assess historic trends of emissions, ambient concentrations and atmospheric deposition trends to gain further insights into source receptor relationships for air quality, including deposition; and

- prepare proposals for the "Research, Modeling and Monitoring" element of an agreement.

3A. <u>Strategies Development and Implementation Work Group</u>

The Group will identify, assess and propose options for the "Control" element of an agreement. Subject to the overall direction of the Coordinating Committee, it will be responsible also for coordination of the activities of Work Groups I and II. It will have one subgroup.

In carrying out its work, the Group will:

- prepare various strategy packages for the Coordinating Committee designed to achieve proposed emission reductions;
- coordinate with other Work Groups to increase the effectiveness of these packages;
- identify monitoring requirements for the implementation of any tentatively agreed-upon emission-reduction strategy for each country;
- propose additional means to further coordinate the air quality programs of the two countries; and
- prepare proposals relating to the actions each Government would need to take to implement the various strategy options.

3B. Emissions, Costs and Engineering Assessment Subgroup

This Subgroup will provide support to the development of the "Control" element of an agreement. It will also prepare proposals for the "Applied Research and Development" element of an agreement.

In carrying out its work, the Subgroup will:

- identify control technologies, which are available presently or in the near future, and their associated costs;
- review available data bases in order to establish improved historical emission trends for defined source regions;
- determine current emission rates from defined source regions;
- project future emission rates from defined source regions for most probable economic growth and pollution control conditions;
- project future emission rates resulting from the implementation of proposed strategy packages, and associated costs of implementing the proposed strategy packages; and
- prepare proposals for the "Applied Research and Development" element of an agreement.

4. Legal, Institutional and Drafting Work Group

The Group will:

- develop the legal elements of an agreement such as notification and consultation, equal access, non-discrimination, liability and compensation;
- propose institutional arrangements needed to give effect to an agreement and monitor its implementation; and
- review proposals of the Work Groups and refine language of draft provisions of an agreement.

APPENDIX B

RECOMMENDATIONS TO THE U.S. CHAIRMAN OF WORK GROUP 3B

The following recommendations from the United States Chairman of Work Group 3A to the United States Chairman of Work Group 3B concern issues which are closely tied to questions of domestic policy. There are none-the-less relevant to the development of bilateral control strategies for transboundary air pollution. Consequently, Work Group 3A has decided to issue separate recommendations from each national 3A Chairman to the corresponding national Chairman of Work Group 3B to address those issues which are believed to be domestic in nature. Work Group 3B should respond to these recommendations during Phase II.

Energy Recommendations

1) Work Group 3B should indicate how each control scenario will affect the domestic fuel mix of oil, coal, natural gas and nuclear.

Socio-Economic Issues

1) Work Group 3B should indicate the extent to which each control scenario would disrupt the current coal marketing patterns and what the shifts between and within emitter regions would be for each scenario.
2) Work Group 3B should indicate the employment dislocation associated with shifts in coal mining patterns per emitter region for each control scenario.

Solid Waste Issue

Work Group 3B should indicate the volume of solid waste that would be generated by each control scenario and whether this would represent a constraint in terms of water quality impacts or availability of land for waste disposal. Work Group 3B should identify available techniques for reducing the generation of waste and the relative costs of these waste reduction techniques.

APPENDIX C

CANADIAN WORK GROUP 3A GUIDANCE TO CANADIAN WORK GROUP 3B

The Canadian LRTAP Control Strategies Program is designed to identify, develop, and evaluate alternative abatement options for Canada and to assess the impact of various U.S. emission scenarios in Canada.

The control strategies program consists of four basic components:

1) An assessment of emission sources and the reduction which could accrue from the application of specific abatement technologies and/or process changes.

2) Determination of the social and economic consequences of applying various levels of emission reduction to emitting sources and to the other sectors of society.

3) Macroscale assessment of physical and economic benefits that would result from reduced environmental insult.

4) Development and analysis of abatement options.

In the first component background studies of the industries should assess the size and composition of the emitting industry sectors, the processes used, and air pollution control technology and emissions. Particular emphasis should be placed on putting the Canadian industry in a world-wide context. Site specific assessments should be made of potential reductions in emissions which would accrue to the application of selected technologies. The control technology studies should review existing, emerging, and future methods available to reduce emissions of acid causing pollutants.

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In the second component, commodity studies should be used to provide information on supply/demand forecasts, general pricing trends, international trends and alternative competitive markets. The by-product feasibility studies should determine the potential markets, domestic and international, for abatement by-products such as sulphuric acid. Also included in these studies should be assessments of implications of by-product disposal such as transportation problems and the generation of new industry. The costs, both capital and operating, of various reductions in emissions, should be determined on a site specific basis, as well as on an aggregrated basis. Assessments of these and other costs should be made using various financial indicators such as profitability, cash flow, investment, competitiveness, debt/equity relationships. Assessments of the impact of control actions on the upstream and downstream sectors should also be undertaken. As assessment of the ability of the pollution control industry to provide the necessary equipment, etc. in a timely fashion should be an integral component of this phase of the program.

The third component of the program should be designed to identify current and potential physical and, to the degree possible, economic impacts of the acid rain phenomenon on various sectors of society. Information should be compiled to identify the economic and social value of the impacted sectors including tourism, sportfishing, agriculture, and forestry. This information should then be combined with effects information available from the scientific investigations and other appropriate sources to estimate the social and economic significance of the acid rain problem on various sectors of society.

In the fourth component data sets and information gathered in the first three components of the program should be analyzed and integrated to develop and evaluate alternate abatement options. Studies to be carried out in this component should include:

- analysis of the range of policy options (e.g. tax policy, regulation, etc.) available to implement control requirements and the probable consequences of each option (e.g. equitability, incentive to companies to implement, etc.);
- analysis of uncertainties in engineering, scientific, social and economic data and their impact on decision-making.
- analysis of the socio-political feasibility of proposed solutions in both the Federal/Provincial and Canada/U.S. contexts.

APPENDIX D

REPRESENTATIVE BASELINE SCENARIO ASSUMPTIONS

Scenario Parameter	United States	Canada
Gross National Product growth rate (annual)	2.7%	
Scenario Parameter		
Primary energy consumption		
petroleum	-	
natural gas	-	
coal	-	
biomass	-	
hydro, nuclear, etc	-	
Primary energy prices (1980 $'s)		
petroleum	$38.00/bl (1985) 43.00/bl (1990) 51.50/bl (1995) 60.00/bl (2000)	
natural gas	-	
coal	specified by supply region	
Electricity demand growth rate (annual)	3.4% (1981-1990) 2.5% (1991-1995) 2.0% (1996-2000)	
Electricity imports/exports	no change from 1976 values	
Capacity growth in non-utility emission sectors		
industrial combustion	-	
petroleum refining	-	
non-ferrous smelting	-	
other industrial processes	-	
transportation	-	
residential/commercial	-	
Pollution control		
existing sources	meet existing SIP requirements by 1985	
new sources	utility sources meet new NSPS; industrial sources meet SIP's and old NSPS's; other sources meet 1980 NSPS	

APPENDIX E

NORTH AMERICAN ACID DEPOSITION RESEARCH PROGRAMS

In FY 1980, the various U.S. Federal agencies spent or obligated about $10 million on programs related to acid deposition. It is estimated that about $11 million will be spent by the Federal agencies in FY 81. In Canada, the Federal Government spent about $5.5 million in FY 1980, and the Province of Ontario spent about $1.3 million. Alberta, Quebec, New Brunswick, and Nova Scotia have programs totaling over $0.5 million dollars. Similar levels of expenditure will continue in the next few years.

The purposes of the Canadian and U.S. programs are very similar; that is, to identify the sources, causes and processes involved in acid deposition and to evaluate the environmental, social, and economic effects. Both wet and dry deposition of acidic substances are being investigated. These programs of policy-oriented research will issue reports that may include: assessments of the status of existing knowledge about acid deposition and its effects; recommendations about what policies and actions may be effective for managing acid deposition; and suggested strategies for ameliorating the harmful effects associated with acid precipitation.

The U.S. Federal effort is coordinated by lead agencies and is focused on the following research areas:

Aquatic Effects	EPA
Terrestrial Effects	DOA
Effects on Material	DOI
Natural Sources	NOAA
Man-made Sources	DOE
Atmospheric Processes	NOAA
Deposition Monitoring	DOI
Control Technology	EPA
Assessments and Policy Analysis	EPA

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Lead agencies coordinate planning and implementation of research in their assigned areas and are responsible for overseeing the development of budgeting and program information. The broad strategy of the U.S. Interagency program includes:

- Using existing scientific knowledge for timely assessments and, when appropriate, policy guidance. Currently, available data and information from the U.S. and other nations will be analyzed and applied to the extent possible.
- Initiating long-term research to develop more knowledge. The emphasis will be on activities that contribute to establishing a firm scientific basis for decision making.
- Establising a long-term National Trends Network (NTN) for monitoring wet and dry deposition.
- Continuously evaluating information on acid deposition and its effects.

The specific activities of each agency are identified in the U.S. National Acid Precipitation Assessment Plan. Detailed project inventories are available from contributing agencies including the U.S. EPA and Department of Interior. The first set of milestone reports planned for the 1981 to 1985 period are as follows:

ACID RAIN MILESTONE REPORTS

(1981 to 1985)

		Lead Agency
1981	Critical Assessment of Current Scientific Knowledge	EPA
1981	Monitoring Strategy and Plan	DOI
1982	Special Assessment of Projected Deposition Patterns	NOAA
1982	Special Assessment of Aquatic Effects	EPA

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1983	Special Assessment of Terrestrial Impacts	DOA
1983	Special Assessment of Natural Sources	NOAA
1983	Special Assessment of Materials Damage	DOI
1983	State of the Art Report on Control Technologies	EPA
1984	Special Assessment of Global Trends	NOAA

Contributions from U.S. and local governments, academic institutions, private industry and individuals will be sought during the implementation of the U.S. Program.

Canadian Federal Government expenditures in research will exceed $10 million in 1981-82. Provincial research expenditures are also increasing. The Federal program is coordinated by an Interdepartmental Committee chaired by Environment Canada and involves many components of that department as well as the Departments of: Fisheries and Oceans; Agriculture; Energy, Mines and Resources; National Health and Welfare and the National Research Council.

In Canada, the programs of the Federal Government and the Provinces are complementary, and are coordinated by several Federal/Provincial management and technical groups. Key committees, and their responsibilities, include:

- The Federal/Provincial LRTAP Management Board: coordinates programs, discusses policy issues
- The Federal/Provincial LRTAP Science Committee: coordinates research and monitoring, and brings upcoming technical issues to the attention of the Management Board
- The Federal/Provincial LRTAP Control Strategies Committee: discusses issues of control related to various industrial sectors in Canada, especially the power generation and smelting groups. Makes recommendations to the Management Board.

Various areas of research and assessment are carried out by each government and coordinated via these committees.

APPENDIX F

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