NATIONAL WATER RESEARCH INSTITUTE

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# EXPRES: AN EXPERT SYSTEM FOR ASSESSING THE FATE OF PESTICIDES IN THE SUBSURFACE PHASE THREE REPORT: COMPILATION OF A DATA BASE FOR TESTING EXPRES

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NWRI CONTRIBUTION 90-91

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by

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## MANAGEMENT PERSPECTIVE

The Pesticide Division of the Commercial Chemicals Branch, Environment Canada, is required to assess the environmental hazards associated with a pesticide and its transformation products before it is approved for public use. One specific concern of the Pesticide Division is the potential for a pesticide to contaminate shallow groundwater resources. Although a number of models currently exist that can predict the transport and transformation of pesticides in the subsurface, generally, regulatory personnel do not have the expertise required to accurately utilize these models. The Groundwater Contamination Project, NWRI, was approached by the Pesticide Division to develop an expert system that can be used to aid in the assessment of the potential for groundwater contamination by pesticides. In addition, this expert system can be used for the identification of agricultural development which may or may not be sustainable. This report discusses work completed in Phase 3 of a two year program currently being undertaken by the Groundwater Contamination Project to develop the expert system. Specifically, the report describes the compilation of a data set to be used to test and validate the expert system. The data set consists of all parameters required by the expert system for one pesticide (aldicarb) and for one agricultural setting (a potato field on Prince Edward Island).

## PERSPECTIVE-GESTION

La Division des pesticides de la Direction des produits chimiques commerciaux d'Environnement Canada doit évaluer les risques environnementaux que constituent un pesticide et ses produits de transformation, avant d'approuver son utilisation par le grand public. Le risque de contamination des eaux souterraines peu profondes est un point auquel s'intéresse particulièrement la Division des pesticides. Il existe actuellement un certain nombre de modèles permettant de simuler le transport et la transformation des pesticides dans le sous-sol, mais les personnes chargées de la réglementation ne possèdent pas, en général, les compétences nécessaires pour utiliser ces modèles avec précision. La Division des pesticides a communiqué avec les responsables du Projet d'étude de la contamination des eaux souterraines, à l'INRE, en vue d'élaborer un système expert qui facilitera l'évaluation du risque de contamination des eaux souterraines par les pesticides. De plus, ce système expert peut être utilisé pour identifier les cas où le développement agricole peut être ou non soutenable. Dans ce rapport, on examine les travaux effectués au cours de la troisième phase d'un programme de deux ans auquel travaille actuellement le personnel du Projet d'étude de la contamination des eaux souterraines, en vue d'élaborer le système expert. Plus précisément, on décrit dans le rapport la compilation d'un ensemble de données destiné à être utilisé pour vérifier et valider le système expert. Cet ensemble de données comprend tous les paramètres qu'il faut introduire dans le système expert pour un pesticide (aldicarbe) et un cadre agricole (un champ de pommes de terre à l'Île-du-Prince-Édouard).

## ABSTRACT

The expert system being developed is designed to aid regulatory personnel in their assessment of the potential for pesticides to contaminate the soil and shallow groundwater environment. The expert system, known as EXPRES (EXpert system for Pesticide Regulatory Evaluation Simulations), consists of two existing numerical models that are used to simulate the transport and transformation of pesticides in the unsaturated zone, coupled with a knowledge-based system that guides the user through the choice of all the necessary information for characterizing the geological, physical, climatic, hydrogeological, pedological and agricultural setting of typical agricultural regions across Canada, as required by the pesticide models.

This report describes with the development of a data set to be used to test and validate the expert system. All the parameters required by the two pesticide models for a single pesticide (aldicarb) and for a single agricultural zone (a potato field on Prince Edward Island) have been compiled. The data set consists of information from four general areas. They are: (1) the physical and chemical properties of the pesticide; (2) the pedological and hydrogeological characteristics of the site; (3) the farm management (crop, irrigation, pesticide application) practices, and; (4) meteorological data for the agricultural setting.

Aldicarb has been chosen for the initial data base because evidence indicates that it is capable of contaminating shallow groundwater supplies even when recommended application procedures are followed and because several studies (field, laboratory, and modelling) have been conducted to investigate the fate of aldicarb in the subsurface. A potato field on Prince Edward Island was chosen as the initial agricultural setting because one of the aldicarb studies that has been performed was conducted on Prince Edward Island.

# RÉSUMÉ

Le système expert appelé EXPRES (sigle correspondant à EXpert system for Pesticide Regulatory Evaluation and Simulation), actuellement en cours d'élaboration, a été conçu en vue d'aider le personnel chargé de la réglementation à évaluer le risque de contamination du sol et des eaux souterraines peu profondes par les pesticides. Ce système expert est constitué de deux modèles numériques existants permettant de simuler le transport et la transformation des pesticides dans la zone d'aération, et d'un système basé sur les connaissances qui guide l'utilisateur dans le choix de toutes les informations qu'il doit introduire dans les modèles simulant le comportement des pesticides pour caractériser le cadre géologique, physique, climatique, hydrogéologique, pédologique et agricole de régions agricoles caractéristiques à travers le Canada.

On décrit dans le présent rapport l'élaboration d'un ensemble de données destiné à être utilisé pour vérifier et valider le système expert. Tous les paramètres qu'il faut introduire dans les deux modèles simulant le comportement des pesticides ont été compilés pour un seul pesticide (aldicarbe) et pour une seule zone agricole (champ de pommes de terre à l'Île-du-Prince-Édouard). L'ensemble de données comprend des informations dans quatre grands domaines: (1) les propriétés physiques et chimiques du pesticide; (2) les caractéristiques pédologiques et hydrogéologiques du site; (3) les pratiques culturales (culture, irrigation, application de pesticides); et (4) les données météorologiques destinées au cadre agricole.

On a choisi l'aldicarbe pour la base de données initiale, car les résultats obtenus indiquent que ce produit peut contaminer les eaux

souterraines peu profondes, même lorsque les méthodes d'application recommandées sont observées, et parce plusieurs études (in situ, en laboratoire et par modélisation) ont été effectuées sur le devenir de l'aldicarbe dans le sous-sol. On a choisi un champ de pommes de terre dans l'Île-du-Prince-Édouard comme cadre agricole initial, parce qu'une des études qui portaient sur l'aldicarbe a été effectuée dans Île-du-Prince-Édouard.

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# 1.0 INTRODUCTION

With evidence indicating that pesticides have the potential to cause serious groundwater contamination even when recommended application procedures are followed (Jones, 1985; Harkin et al., 1986; Priddle et al., 1987;1988;1989; and Mutch, 1989), it was recognized that techniques must be developed to better assess the fate of pesticides in the environment before these pesticides are registered for commercial use. Existing pesticide models, capable of simulating the fate of pesticides in the unsaturated zone, would allow regulatory personnel to improve their assessment of new pesticides. However, the application of these models in the registration process has been limited because regulatory personnel do not typically have the training in the physical, chemical and biological processes that control the fate of a pesticide in the environment, or the experience in the use of these complex numerical codes that simulate the fate of the pesticides. As a result, an expert system is being developed to bridge the gap between regulatory personnel and the simulation models.

The expert system (**EXPRES** - **EX**pert system for **P**esticide **R**egulatory **E**valuation **S**imulations) will guide the user through the necessary steps required to undertake a simulation with the pesticide models and to evaluate the results. The expert system will prompt the user for the required data and choice of simulation options, and will assist the user by providing explanations of the data requested, and assistance in the selection of appropriate values for the model parameters. The assistance may take the form of the retrieval of typical values from its data bases, or it may provide the user with empirical techniques that may be used to estimate an appropriate value for the model parameters.

The development of EXPRES is currently at the end of Phase 3 (Compilation of a Data Base for Testing EXPRES) and this report will deal with the design and development of the initial data bases for the testing and validation of the expert system. Readers are referred to two earlier reports: (1) *Phase One Report: A Review and*

*Analysis of Existing Pesticide Transport and Transformation Models* (Mutch and Crowe, 1989), and (2) *Phase Two Report: Development of the Basic Expert System* (Mutch and Crowe, 1990), for a more detailed description of the pesticide models and the expert system.

The specific objectives of Phase 3 are:

1. to construct a data base containing the physical, chemical and biological parameters which characterize the soil, groundwater, crops and climate in a typical agricultural zone in Canada;
2. to construct a data base of the chemical properties of a pesticide;
3. to construct the data bases in a manner which will allow them to be easily expanded to include other agricultural zones, and to be updated as new data becomes available.

## 2.0 DATA BASES REQUIRED BY EXPRES

EXPRES will require three separate data bases for its operation. The three are: (1) the Facts Base, (2) the Knowledge Base, and (3) the Explanation Base. The Knowledge Base contains the encoded expertise or knowledge (production rules) required to guide the user through the choice of parameters and model options required for a particular pesticide transport and transformation simulation. The Explanation Base will contain definitions, explanations and information (i.e. typical values, a range of plausible values, empirical formulas, etc.) to assist the user in the selection of appropriate values for the model parameters. The development of the both the production rules required for the Knowledge Base, and the information for the Explanation Base, is an ongoing process and has been touched upon in the Phase Two Report (Mutch and Crowe, 1990). It will therefore, not be discussed further in this report. The remainder of this report will concentrate on the development of the initial Facts Base for the validation of EXPRES.

### 2.1 THE FACTS DATA BASE

The Facts Base employed in EXPRES will be comprised of detailed information regarding the physical, climatic, hydrogeological and farm management practices of typical agricultural zones across Canada. EXPRES will eventually contain information for a number of agricultural zones across Canada. A tentative list of the agricultural zones to be included in EXPRES is given in Table 1. However, because the intent of the data base is for the testing and validation of the expert system, the data base developed in Phase 3 of the project contains the information describing only one typical agricultural zone.

The intent of the EXPRES expert system is to evaluate the fate of new pesticides seeking registration, and therefore, in the final version of EXPRES the user will be expected to provide all the information describing the particular pesticide of interest since

Table 1. Typical agricultural zones across Canada to be incorporated into EXPRES. (A tentative list).

| TYPICAL AGRICULTURAL ZONES ACROSS CANADA |
|---|
| 1. AN ORCHARD IN CENTRAL BRITISH COLUMBIA |
| 2. A BERRY FIELD IN THE FRASER RIVER DELTA, B.C. |
| 3. A GRAIN FIELD IN THE PEACE RIVER DISTRICT OF ALBERTA |
| 4. A SUGAR BEET FIELD IN SOUTHERN ALBERTA |
| 5. A WHEAT FIELD IN SASKATCHEWAN |
| 6. A GRAPE VINEYARD IN THE NIAGARA REGION OF ONTARIO |
| 7. A CORN FIELD IN ONTARIO |
| 8. A POTATO FIELD IN QUEBEC |
| 9. A POTATO FIELD IN PRINCE EDWARD ISLAND |
| 10. A FOREST ZONE IN NEW BRUNSWICK |
| 11. AN ORCHARD IN NOVA SCOTIA |

this information must be obtained from the manufacturer of the pesticide and will not be available during the compilation of the data bases for EXPRES. However, because the objective of Phase 3 is to develop a data base that will be used by personnel of the Pesticide Division in their initial evaluation of EXPRES, the data base will also contain a complete set of physical and chemical data required by EXPRES for a single pesticide. This will aid in the evaluation of the expert system for regulatory personnel on their initial introduction to the system.

# 3.0 SELECTION OF THE PESTICIDE AND AGRICULTURAL ZONE

## 3.1 THE SELECTION OF THE PESTICIDE ALDICARB

As stated previously, there is evidence that the use of some pesticides may lead the contamination of shallow groundwater supplies even when the recommended application procedures are followed. Aldicarb is one such pesticide, and as such, has been chosen for the testing of EXPRES. This pesticide is known to have contaminated aquifers in a number of areas in both the United States and in Canada, and a number of detailed studies investigating the fate of aldicarb in soils and groundwater have been performed (Dierberg and Given, 1986; Harkin et al., 1986; Jones et al., 1986; Pacenka et al., 1987; Lightfoot et al., 1987; Matheson et al.,1987; Lemley, et al., 1988; Moye and Miles, 1988; Priddle et al., 1987; 1988; 1989; and Mutch et al., 1990). Aldicarb has also been chosen because the fate of the pesticide has been modelled with the PRZM and LEACHM codes on several occasions (Carsel et al., 1985; Jones, 1986; Jones et al., 1986; Wagenet and Hutson, 1986; Carsel et al., 1988; Hegg et al., 1988; Pennell et al., 1989; and Mutch, 1989).

### 3.1.1 A GENERAL DESCRIPTION OF ALDICARB

A pesticide must possess three characteristics before it is considered to be a serious threat to groundwater supplies; these being, the pesticide must be highly toxic, mobile, and persistent. Aldicarb possesses all three of these characteristics.

Aldicarb is the active ingredient in the systemic pesticide, Temik, developed and manufactured by Union Carbide Agricultural Products Company, Inc. (now Rhone Poulenc). Temik belongs to the oxime carbamate insecticide family and is one of the most toxic pesticides registered for agricultural use today (Dierberg and Given, 1986; Matheson et al., 1987). The oral $LD_{50}$ (rats) for aldicarb is only 0.9 mg/kg (Ware, 1978).

Aldicarb also has a high dermal toxicity ($LD_{50}$ = 5 mg/kg for rabbits (Ware, 1978)) and is formulated as a granular pesticide to

reduce the risk of exposure during application. The granules are incorporated into the soil where they dissolve in the soil moisture, mobilizing the active ingredient (aldicarb) in the soil water. Aldicarb is taken up by the plant through its root system and is distributed throughout the portion of the plant above ground surface and pests are killed as they begin to ingest the plant. Systemic pesticides must possess high water solubilities, which gives them mobility, to function effectively; aldicarb has a solubility of 6000 mg/L at 25°C (Carsel et al., 1985).

Upon dissolution, the degradation of aldicarb may follow two possible pathways: oxidation and hydrolysis. The parent pesticide (aldicarb) is oxidized to aldicarb sulfoxide. This oxidation reaction generally occurs quickly and the parent pesticide is rarely found in sampling programs. Aldicarb sulfoxide, may then be oxidized to aldicarb sulfone (Figure 1). Aldicarb sulfone is also known by the name aldoxycarb. These two transformation products (daughter products) are also highly mobile, toxic, and persistent in the environment and therefore must be considered in any study of aldicarb. The solubilities and oral $LD_{50}$ (rats) values for aldicarb sulfoxide and aldicarb sulfone are 28000 and 7800 mg/L (Carsel et al., 1985) and 0.9 and 24 mg/kg, respectively (Jones, 1986).

The second degradation pathway for aldicarb is via hydrolysis of these three products (parent pesticide and two daughter products) to their respective oxime and nitrile species. During the hydrolysis reaction, the three aldicarb species lose a significant portion of their toxicities (see Figure 1) and are no longer a major environmental concern.

The rate of the detoxifying hydrolysis reaction is dependent on a number of physical and chemical conditions and will be highly variable from one location to another, and also from one time to another, at a given site (Jones, 1986; Moye and Miles, 1988). Lightfoot et al. (1987) found that aldicarb was most persistent in acidic soils (pH = 5 - 6) with low soil temperatures. Jones (1986), in summarizing the work conducted on aldicarb degradation

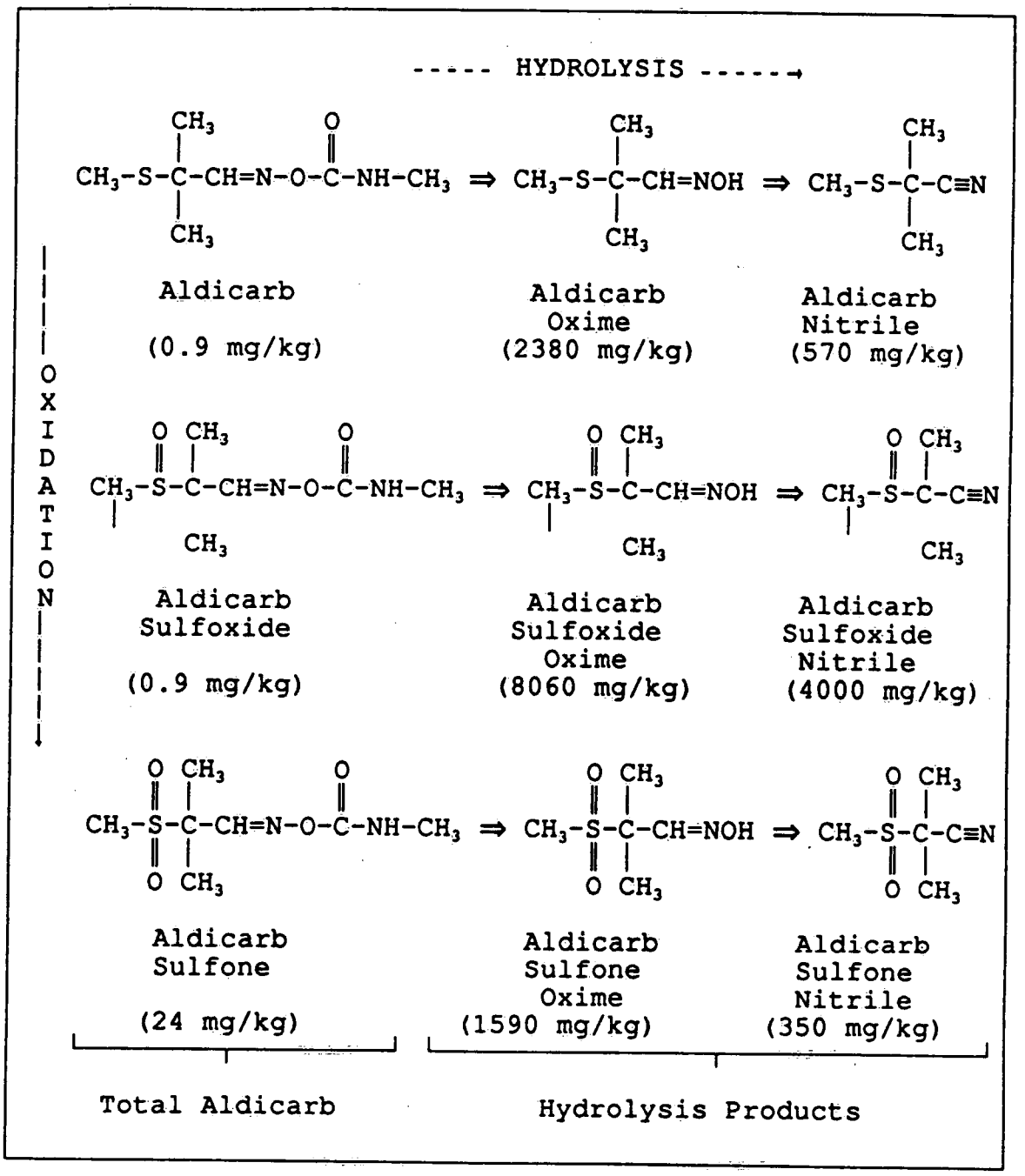


Figure 1. Degradation pathways of aldicarb. (X mg/kg) - acute oral $LD_{50}$ (rats). (After Jones, 1986.)

in both the saturated and unsaturated zones, reported hydrolysis half-lives ranging from less than two weeks to more than two years.

Aldicarb, as Temik, was first registered for use in the United States in 1970. Primary target pests included nematodes, mites, and aphids, and application rates ranged from approximately 2 to 11 kilograms of active ingredient (a.i.) per hectare (Moye and Miles, 1988). The application of aldicarb is presently restricted to emergence applications in the United States.

In Canada, aldicarb is registered for application at planting only, and a minimum 90-day application-to-harvest interval must be observed. A number of U.S. states and Canadian provinces have enacted additional legislation to govern the application of aldicarb. This legislation often requires that applicators of the pesticide be registered with a government agency. It may also restrict the amount of aldicarb that can be applied, the timing of the application, the distance from the nearest domestic well for which it can be applied, and the timing between successive applications of the pesticide.

### 3.1.2 ALDICARB CONTAMINATION OF GROUNDWATER

Aldicarb was first detected in domestic water wells on Long Island, New York in 1979. A sampling program conducted in 1979 found that 23 percent of the 330 wells tested in the survey contained aldicarb levels in excess of the 7 ppb total toxic residue (TTR : concentration of aldicarb + aldicarb sulfoxide + aldicarb sulfone) drinking water guideline recommended for aldicarb and established by the National Academy of Sciences for the State of New York (Moye and Miles, 1988). The recommended drinking water guideline of 10 ppb, set by the Environmental Protection Agency (EPA) Health Advisory, has been accepted by all other U.S. States. A larger sampling program on Long Island found that 1121 (13.5 %) of the 8404 wells tested were in excess of the 7 ppb recommended guideline level, with the highest detected concentration being 515 ppb (Moye and Miles, 1988). The results of the sampling programs led the manufacturer, Union Carbide, to withdraw the pesticide from

the Long Island market in February 1980 (Wartenberg, 1988).

Several factors may have contributed to the leaching of aldicarb to the water table on Long Island. Aldicarb was applied at high rates (5.6 - 7.8 kg/ha a.i.), on successive years, to sandy soils with low organic matter contents and shallow water table depths. Applications occurred at planting (and also at emergence), which coincided with heavy spring rainfall, suggesting high mobility with little attenuation of the pesticide. In addition, soil temperatures, pH, and microbial activity levels were low, leading to slow degradation rates and greater persistence in the soil environment (Harkin et al., 1986).

Aldicarb contamination of groundwater has also been a problem in the Central Sands area of Wisconsin. Nineteen percent of the 363 wells tested in a survey of Wisconsin well water contained detectable levels of aldicarb, with 5 percent in excess of the 10 ppb guideline. The maximum concentration detected was 111 ppb (Moye and Miles, 1988).

Conditions similar to those found on Long Island also exist in Wisconsin. However, the average annual precipitation is much lower in Wisconsin, and the soil and groundwater tend to be more alkaline. The higher pH of the soil and groundwater favours faster degradation of aldicarb and its metabolites, and as a result, the contamination in Wisconsin has generally been confined to shallow aquifers in areas where the pH remains low (Harkin et al., 1986).

On a larger scale, a review of sampling programs in 34 U.S. States, involving over 28000 different potable wells, found aldicarb TTR levels above the EPA recommended concentration of 10 ppb in 2735 wells in eight of the 34 States (Moye and Miles, 1988).

Detection of aldicarb residues in domestic wells has also been reported in a number of Canadian Provinces, including Prince Edward Island. Aldicarb was first used on PEI in 1978, and by 1983, it was estimated that between 5000 and 10000 kg of active ingredient was applied to 3000 hectares of potatoes annually (Matheson et al., 1987). On Prince Edward Island, aldicarb is applied to potato crops to control aphids, flea beetles, and the Colorado Potato

Beetle. Application rates are low (1.8 - 2.3 kg/ha a.i.) compared to application rates in other areas. The pesticide is applied to the soil in bands along with the seed potato at planting, and is incorporated to a depth of approximately 10 cm.

The Environmental Protection Service (EPS) of Environment Canada and the PEI Department of Community and Cultural Affairs conducted a joint study to assess the presence of aldicarb in the groundwater of Prince Edward Island (Matheson et al., 1987). The study conducted between June, 1983 and November, 1984 consisted of the analysis of water from 103 domestic wells, and aldicarb residues were found in 20 of the 103 (19.4 %) wells tested. All levels, however, were found to be below the Canadian maximum acceptable concentration (mac) of 9 ppb (Health and Welfare Canada, 1988). The maximum concentration detected was 5.4 ppb and most measured values were in the range of 1.3 to 2.2 ppb. Many of the factors contributing to the leaching of aldicarb on Long Island and Wisconsin also apply to the situation on PEI. Although application rates were much lower than those on Long Island, the pesticide was applied at planting to soils of low pH, temperature, and organic matter content (Matheson et al., 1987).

## 3.2 SELECTION OF A TYPICAL AGRICULTURAL ZONE

Several references are available that describe a study of the fate of aldicarb applied to a potato crop on Prince Edward Island (Matheson et al.,1987; Priddle et al., 1987; 1988; 1989; Mutch, 1989; and Mutch et al., 1990), and for this reason, a potato field on Prince Edward Island has been chosen as the initial agricultural zone for the testing of EXPRES (Figure 2).

The climate on Prince Edward Island is cool and humid, with the surrounding water bodies regulating the temperature, producing long, relatively mild winters, with short, moderately warm summers, and gradual transition periods between the two. The average total precipitation for the 30-year period (1941-1970) is 1059.2 mm with an estimated water equivalent snowfall accounting for approximately one quarter of the precipitation. Mean monthly temperatures range

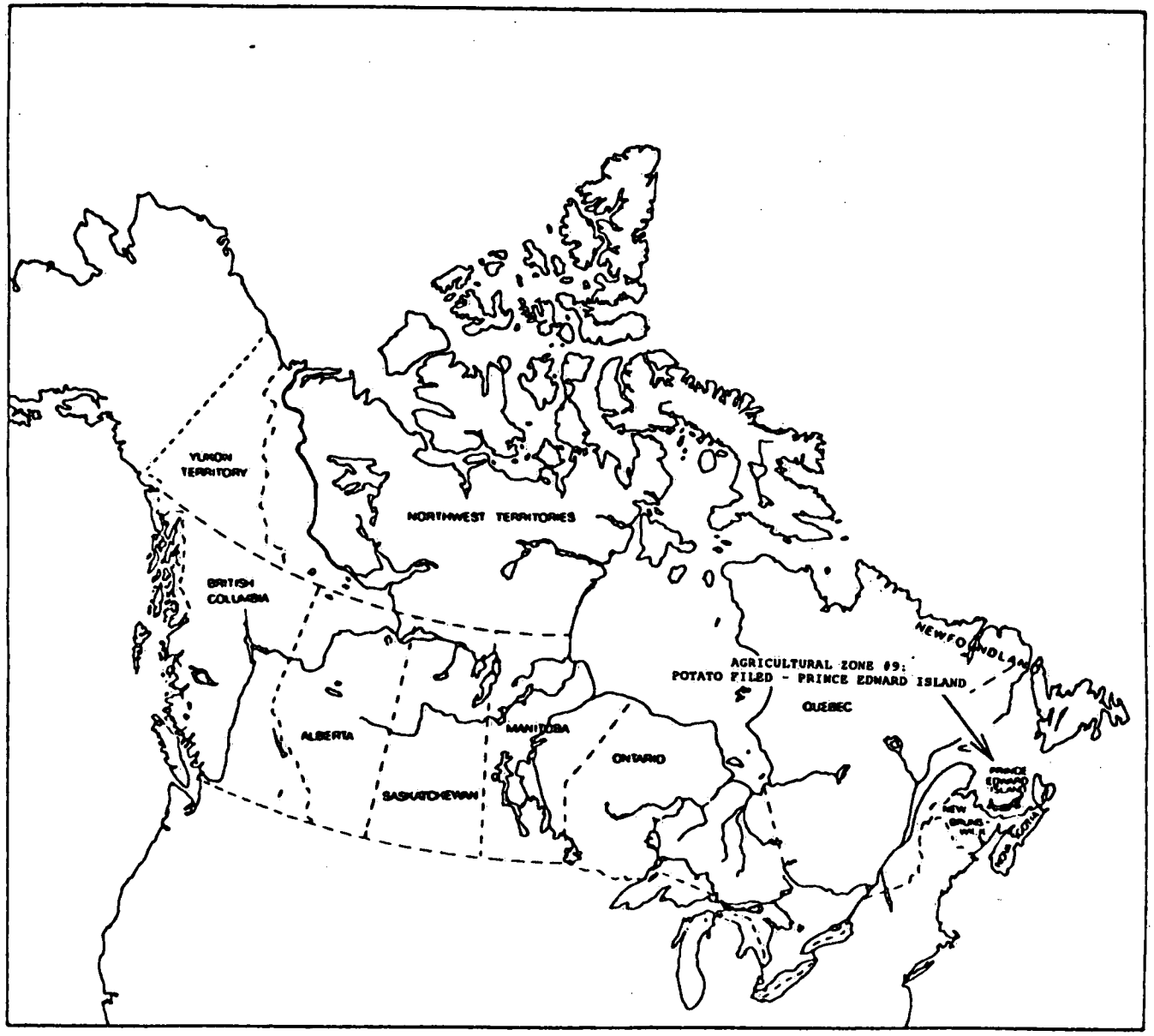


Figure 2. Agricultural zone #9 - A potato field on Prince Edward Island.

from -6.8°C in February to 19.1°C in July (MacDougall et al., 1981).

Sandstone is the dominant rock type underlying most of the Island, with a texture ranging from very fine to very coarse. The surface relief of the Island is gently undulating with a maximum amplitude of less than 60 metres (MacDougall et al., 1981), and the bedrock is covered by a relatively thin till layer (1 to 5 metres). The till is characteristically reddish brown in colour, strongly acidic, and usually compact and dense. The texture is dominantly a sandy loam but also includes loamy sands, loams, and clay loams (MacDougall et al., 1981). The Charlottetown Series soil covers the largest area of any soil in the province and most areas are cleared and cultivated and are highly valued as they are well suited to climatically adapted crops (MacDougall et al., 1981). The Charlottetown Series soil is an Orthic Humo-Ferric Podzol derived from a reddish brown, medium to strongly acid, fine sandy loam. The surface soil is well drained, while drainage in the subsoil varies from moderately, to poorly drained. The root depth for the soil varies from 50 to 75 cm, and organic matter contents are low to medium (MacDougall et al., 1981).

## 4.0 COMPILATION OF DATA BASES FOR EXPRES

The information required by the two pesticide models in EXPRES is subdivided into 4 major groups of information:

(1) chemical and physical properties of the pesticide (aldicarb);

(2) pedological and hydrogeological characteristics of the site;

(3) farm management (crop, irrigation, pesticide application) practices;

(4) meteorological data.

These data have been compiled and are presented in Tables 2 through 5 and in Appendix A. The ASCII data files and choice of model parameters used by EXPRES are transparent to the user and are therefore, not presented in this report. The tables that are presented contain the values compiled for the model parameters, as well as, the references from which they were derived.

The simulation models in EXPRES (PRZM - a management model, and LEACHM - a research model) describe the physical, chemical and biological processes controlling the fate of pesticides in the subsurface in differing amounts of detail, and thus, require different amounts of input characterization data. LEACHM is a research model, and as such, requires more input data. Several of the EXPRES data entry screens are specific to the LEACHM model only. For example, LEACHM has a more representative description of water flow (based on Richards equation) and will require model parameters characterizing the air entry value and the saturated hydraulic conductivity of the soil, in addition to the field capacity and wilting point parameters required by PRZM. LEACHM is also capable of simulating the fate of daughter products generated from the transformation of the parent pesticide. LEACHM, therefore, requires individual degradation and transformation rate constants for each of the degradation and transformation reactions of the pesticide species, where as PRZM requires only a single averaged or lump rate constant to describe the overall

disappearance of the pesticide.

The physical and chemical parameters that have been compiled for the pesticide, aldicarb, were derived from a number of studies conducted with the pesticide and are presented in Table 2.

Soil parameters required by EXPRES are presented in Table 3 and were taken primarily from a report describing a soil survey conducted on Prince Edward Island (MacDougall et al., 1981). Crop details and information on typical farm management practices required by EXPRES were obtained through conversations with farm managers located in the main potato growing region of Prince Edward Island (Table 4).

Meteorological data were obtained from the Atmospheric Environment Services for the weather station in Charlottetown, PEI. Daily precipitation and temperature values were obtained for the period January 1, 1970 to July 31, 1989, and daily pan evaporation values were obtained for the period June 1, 1977 to September 30, 1989. These data have been reformatted for use by EXPRES and 20-year mean (precipitation) and median (temperature and pan evaporation) values have been determined for use with EXPRES. Because of the length of these data, a hard copy format of these data is presented in Appendix A. Other meteorological parameters required by EXPRES are presented in Table 5, and the references for all the values compiled are presented in Table 6.

A request was made by the Pesticide Division to include a set of averaged meteorological data that would be representative of typical conditions that exist in the selected agricultural zone. This has been incorporated into EXPRES by including the mean precipitation values with the median temperature and pan evaporation values for the 20 period running from 1970 to 1989. A problem arises, however, when trying to obtain values of precipitation that are representative of conditions that are typical for an agricultural region since the precipitation values are statistically weighted towards a value of zero.

The mean or average daily precipitation over a 20 year period is not truly representative of the typical precipitation values of

Table 2. Pesticide parameters required by EXPRES.

| PESTICIDE PARAMETERS | VALUE | REFERENCE |
|---|---|---|
| PESTICIDE NAMES: | ALDICARB | - |
| | ALD. SULFOXIDE | - |
| | ALD. SULFONE | - |
| SOLUBILITY: ALDICARB | 6000 mg/L | 2 |
| ALDICARB SULFOXIDE | 28000 mg/L | 2 |
| ALDICARB SULFONE | 7800 mg/L | 2 |
| ORGANIC CARBON PARTITION COEFF.: | | |
| ALDICARB | 5.0 L/kg | 10,14 |
| ALDICARB SULFOXIDE | 1.0 L/kg | 10,14 |
| ALDICARB SULFONE | 2.0 L/kg | 10,14 |
| PARENT/DAUGHTER: | | |
| ALDICARB | PARENT | 6 |
| ALDICARB SULFOXIDE | DAUGHTER | 6 |
| ALDICARB SULFONE | DAUGHTER | 6 |
| APPLICATION DATE: | 200583 | 9,12 |
| APPLICATION RATE: | 2.0 kg a.i./ha | 9,12 |
| DEPTH OF INCORPORATION: | 10.0 cm | 9,12 |
| PESTICIDE APPLICATION METHOD: | SOIL APPLIC. | 9,12 |
| PESTICIDE DECAY RATE ON FOLIAGE: | 0.0693 1/day | 11 |
| FOLIAR EXTRACTION COEFFICIENT: | 0.10 | 1 |
| FOLIAR FILTRATION PARAMETER: | 2.80 | 1 |
| PESTICIDE DEGRADATION RATE/SOIL: | | |
| PRZM (0 - 40 cm) | 0.00693 1/day | 11 |
| PRZM (40 - 500 cm) | 0.00138 1/day | 11 |
| LEACHM ALDICARB | 0.0481 1/day | 5,6,11 |
| (0-40 cm) ALDICARB SULFOXIDE | 0.00374 1/day | 5,6,11 |
| ALDICARB SULFONE | 0.00962 1/day | 5,6,11 |
| LEACHM ALDICARB | 0.00962 1/day | 5,6,11 |
| (40-500 cm) ALDICARB SULFOXIDE | 0.00075 1/day | 5,6,11 |
| ALDICARB SULFONE | 0.00192 1/day | 5,6,11 |
| PEST. TRANSFORMATION RATE/SOIL: | | |
| LEACHM ALDICARB | 0.0908 1/day | 5,6,11 |
| (0-40 cm) ALDICARB SULFOXIDE | 0.0113 1/day | 5,6,11 |
| LEACHM ALDICARB | 0.0182 1/day | 5,6,11 |
| (40-500 cm) ALDICARB SULFOXIDE | 0.00225 1/day | 5,6,11 |
| MOLECULAR DIFFUSION COEFFICIENT: | 120 $mm^2$/day | 4,13 |
| MOLECULAR DIFFUSION CONSTANTS: | 0.001, 10.0 | 4,13 |
| DISPERSIVITY: | 100 mm | 11 |
| DIFFUSION COEFFICIENT IN AIR: | 4.3E+5 $mm^2$/DAY | 4,13 |
| INITIAL PESTICIDE CONCENTRATION: | 0.00 | - |
| VAPOUR DENSITIES: | | |
| ALDICARB | 3.6E-5 mg/$dm^3$ | 3 |
| ALDICARB SULFOXIDE | 3.6E-5 mg/$dm^3$ | 3 |
| ALDICARB SULFONE | 3.6E-5 mg/$dm^3$ | 3 |

SEE TABLE 6 FOR REFERENCES

Table 3. Pedological and hydrogeological parameters required by PRZM and LEACHM for a potato field on Prince Edward Island.

| SOIL HORIZON PARAMETERS | VALUE | REFERENCE |
|---|---|---|
| NO. SOIL HORIZONS: | 6 | 15 |
| WATER TABLE DEPTH: | 5.0 m | 19 |
| TOT. PROFILE DEPTH: | 5.0 m | 19 |
| MUSLE PARAMETERS: | | |
| USLEK | 0.25 | 1 |
| USLEP | 0.50 | 1 |
| USLELS | 1.20 | 1 |
| BULK DENSITIES: | | |
| SAND | 2.65 | 30 |
| CLAY | 2.65 | 30 |
| ORGANIC MATTER | 1.10 | 30 |
| DRAINAGE PARAMETER: | 0.0 | 1 |
| AREA OF FIELD: | 20 ha | 16,28 |

| SOIL HORIZON PARAMETERS | SOIL HORIZON | | | | | | REF. |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | |
| HORIZON THICK.:(cm) | 10.0 | 10.0 | 20.0 | 20.0 | 30.0 | 410.0 | 15 |
| S/R/B: | S | R | R | R | B | B | - |
| BULK DENSITY:(g/cm$^3$) | 1.32 | 1.05 | 1.33 | 1.33 | 1.62 | 1.86 | 15 |
| ORGANIC CARBON: (%) | 0.40 | 2.55 | 0.70 | 0.10 | 0.01 | 0.01 | 15 |
| FIELD CAPACITY: | 0.34 | 0.39 | 0.36 | 0.36 | 0.28 | 0.17 | 1,15 |
| WILTING POINT: | 0.03 | 0.14 | 0.12 | 0.12 | 0.19 | 0.9 | 1,15 |
| PERCENT SILT: | 37 | 38 | 37 | 37 | 34 | 34 | 15 |
| PERCENT CLAY: | 5 | 9 | 9 | 11 | 13 | 13 | 15 |
| STARTING THETA: | 0.18 | 0.26 | 0.26 | 0.24 | 0.23 | 0.13 | - |
| AIR ENTRY VALUE:(mm) | -57.8 | -85.4 | -60.6 | -62.8 | -123 | -123 | 30 |
| CAMPBELL'S CONSTANT: | 3.87 | 4.56 | 4.51 | 5.42 | 5.82 | 5.82 | 30 |
| SAT. HYDRAULIC: COND. (mm/day) | 779 | 2780 | 170 | 97 | 96 | 96 | 15 |
| ROOT FRACTION: | 0.25 | 0.30 | 0.30 | 0.15 | 0.0 | 0.0 | 16,28 |
| SOIL TEMP.: (°C) | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 15 |

SEE TABLE 6 FOR REFERENCES

Table 4. Farm management parameters required by PRZM and LEACHM for a potato field on Prince Edward Island.

| FARM MANAGEMENT AND CROP PARAMETERS | VALUE | REFERENCE |
|---|---|---|
| NUMBER OF CROPS: | 3 | 16,28 |
| NUMBER OF CROPPING PERIODS: | 3 | 16,28 |
| ROOT LENGTH: (m) | 500 | 8,30 |
| MIN. ROOT WATER POT'L: (kPa) | -3000 | 8,30 |
| MAX. ROOT WATER POT'L: (kPa) | 0.000 | 8,30 |
| ROOT FLOW RESISTANCE TERM: | 1.05 | 8,30 |
| MAXIMUM ACTUAL TRANSPIRATION: | 1.10 | 8,30 |

| FARM MANAGEMENT AND CROP PARAMETERS | CROP | | | REFER-ENCE |
|---|---|---|---|---|
| | POTATO | BARLEY | HAY | |
| MAX. INTERCEP. STORAGE: (cm) | 10.0 | 10.0 | 10.0 | 1 |
| MAXIMUM ROOT DEPTH: (cm) | 45.0 | 20.0 | 20.0 | 16,28 |
| CROP COVER FRACTION: | 0.80 | 0.60 | 0.60 | 16,28 |
| PESTICIDE UPTAKE EFFICIENCY: | 0.00 | 0.00 | 0.00 | 8 |
| PLANT DENSITY: (PLANTS/$m^2$) | 2.0 | 2.0 | 2.0 | 8 |
| MAX. DRY FOLIAGE WT.: (kg/$m^2$) | 0.90 | 0.56 | 0.78 | 1 |
| CROP CONDITION AFTER HARVEST: | RES. | RES. | RES. | 16,28 |
| CURVE NUMBER: | 86/75/80 | 86/73/79 | 86/69/77 | 1 |
| USLEC: | .50 | 0.45 | 0.45 | 1 |
| PLANTING DATE: | 200583 | 240584 | 100585 | 16,28 |
| EMERGENCE DATE: | 100683 | 080684 | 150585 | 16,28 |
| ROOT MATURITY DATE: | 200983 | 100984 | 100885 | 16,28 |
| PLANT MATURITY DATE: | 300983 | 100984 | 200885 | 16,28 |
| HARVEST DATE: | 111083 | 200984 | 200885 | 16,28 |

SEE TABLE 6 FOR REFERENCES

Table 5. Meteorological parameters required by PRZM and LEACHM for a potato field on Prince Edward Island.

| INPUT PARAMETERS REQUIRED BY EXPRES | | |
|---|---|---|
| **METEOROLOGICAL PARAMETERS** | **VALUE** | **REFERENCE** |
| NAME OF METEROLOGICAL STATION: | CH'TOWN CDA | - |
| MINIMUM DEPTH OF EVAPORATION: (cm) | 10.0 | 1 |
| PAN EVAPORATION COEFFICIENT: | 0.70 | 14 |
| SNOW MELT COEFFICIENT: (cm/day/°C) | 0.46 | 1 |
| AVERAGE DAYLIGHT HOURS: JAN. | 8.9 | 1 |
| FEB. | 10.2 | 1 |
| MAR. | 11.0 | 1 |
| APR. | 13.3 | 1 |
| MAY | 14.7 | 1 |
| JUN. | 15.4 | 1 |
| JUL. | 15.0 | 1 |
| AUG. | 14.3 | 1 |
| SEP. | 12.3 | 1 |
| OCT. | 10.7 | 1 |
| NOV. | 9.3 | 1 |
| DEC. | 8.5 | 1 |
| EROSIVE STORM DURATION: (hrs) | 2.3 | 1 |
| BAROMETRIC ENHANCEMENT FACTOR: | 0.0 | 8,30 |

Table 6. References for input parameter values compiled for EXPRES.

| REFERENCES FOR INPUT PARAMETERS COMPILED FOR EXPRES | |
|---|---|
| (1) Carsel et al., 1984 | (8) MacDougall et al., 1981 |
| (2) Carsel et al., 1985 | (9) MacPherson, 1988 |
| (3) Dierberg and Given, 1986 | (10) Moye and Miles, 1988 |
| (4) Hutson, 1988 | (11) Mutch, 1989 |
| (5) Lemley et al., 1988 | (12) Robinson, 1988 |
| (6) Lightfoot et al., 1987 | (13) Wagenet and Hutson, 1987 |
| (7) Linsley et al., 1982 | (14) Zhong et al., 1986 |

a region since it generally indicates that there would be a small amount of precipitation occurring on each day, where typically, there may be large amounts of precipitation on certain days followed by long periods with no precipitation. This point can be demonstrated by comparing the precipitation, temperature and pan evaporation data of a year selected at random (1980), with the mean (precipitation) and median values (temperature and pan evaporation) for the 20-year period (Figures 3 and 4, respectively). The constant addition of small amounts of precipitation may not produce the same leaching patterns as large applications of precipitation followed by periods with no precipitation. As well, with the use of median temperature values, there are no periods of snow melt during the winter months, where typical, one or two thaws may be expected during these months.

Using the median value for precipitation may not be more accurate because, for a given calendar date, there must be precipitation on that calendar day for more than 50 percent of the years in the data base for the median to be a non-zero value. In a large number of the cases, the median precipitation will be zero. The sum of the median precipitation values for an entire year will be significantly less than the average yearly precipitation for the agricultural region, and therefore, averaged or mean precipitation values are probably more representative of typical conditions, since the yearly sum of the averaged daily precipitation values equals the average yearly precipitation value for the 20-year period. However, since neither the mean nor the median is truly representative of typical conditions, it is recommended that the simulations performed by the Pesticide Division should be performed using the actual meteorological data whenever possible.

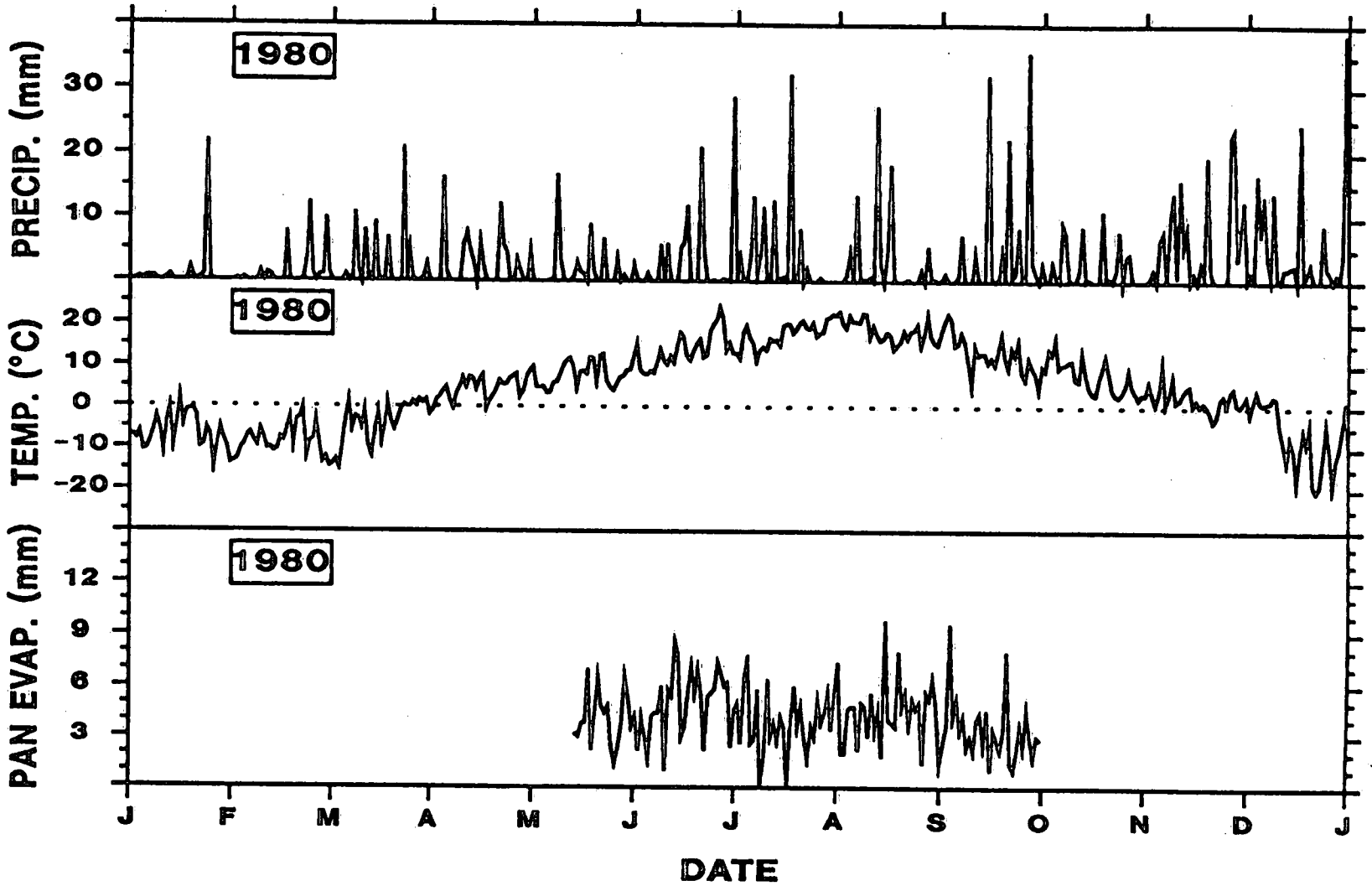


Figure 3. Meteorological data from the CDA weather station in Charlottetown, Prince Edward Island for the year 1980.

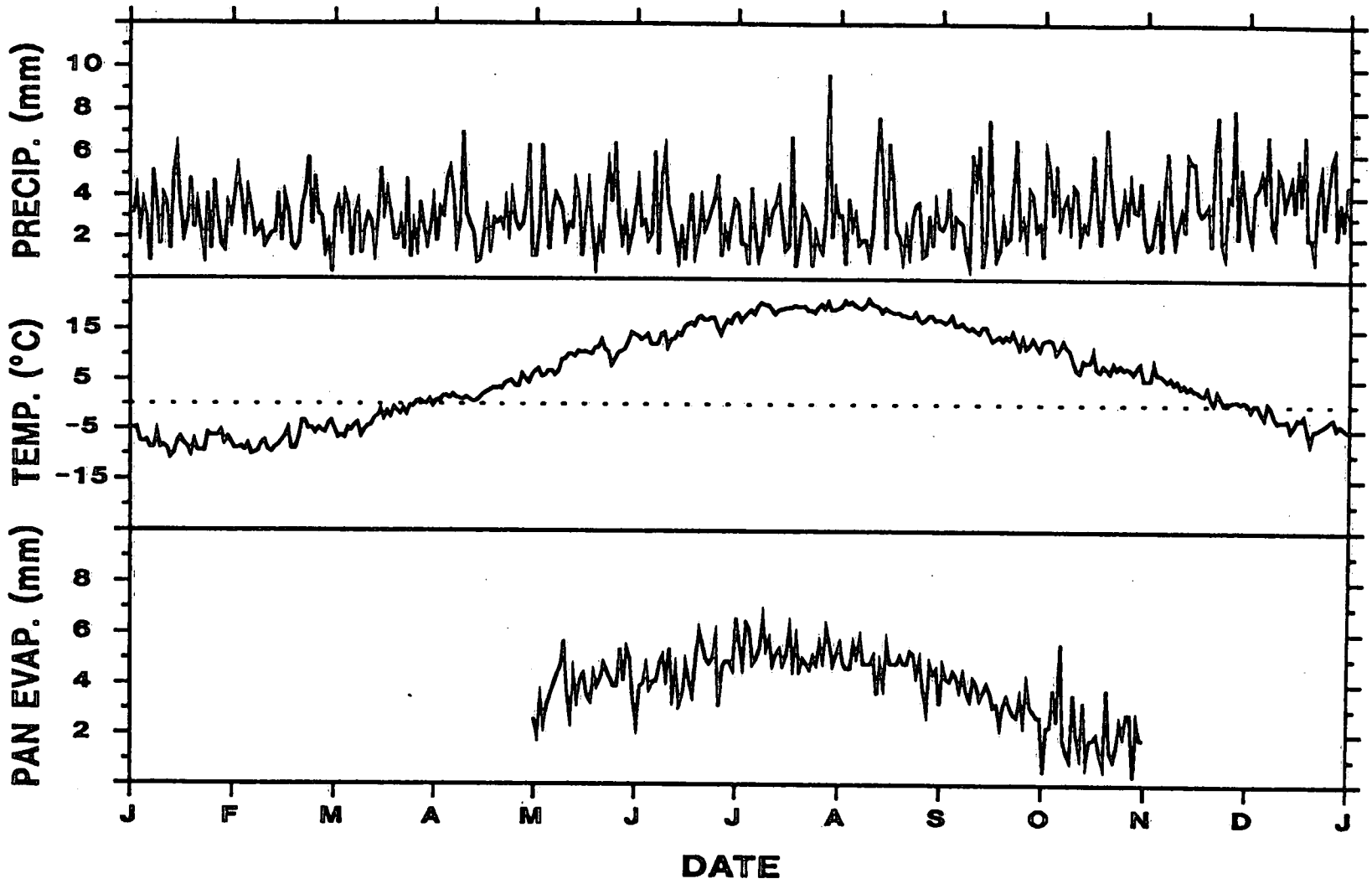


Figure 4. Twenty-year averaged and median values for meteorological data from the CDA weather station in Charlottetown, Prince Edward Island.

## 5.0 CONCLUSION

The data bases required for the evaluation of the basic EXPRES expert system have been developed so that personnel from the Pesticide Division can evaluate the system. The initial data bases are complete for one pesticide (aldicarb) and for one agricultural region (a potato field on Prince Edward Island). The remainder of the information for these data bases will be gathered in later phases of this project, after the Pesticide Division has finalized the list of typical agricultural zones across Canada.

Median values have been determined for the daily temperature and pan evaporation values for the site to provide a data set with typical conditions for the agricultural zone. The average daily precipitation values for the agricultural zone have been compiled since the averaged values appear to be more representative of typical conditions than do the 20-year median values. However, neither is truly representative, and it is therefore recommended, that the simulations performed by the Pesticide Division should make use of the actual meteorological data whenever possible.

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# APPENDIX A

## METEOROLOGICAL DATA FOR THE CDA WEATHER STATION

## IN

## CHARLOTTETOWN, PRINCE EDWARD ISLAND

# APPENDIX A.1

## TWENTY YEAR MEAN AND MEDIAN VALUES

## CDA WEATHER STATION

## CHARLOTTETOWN, P.E.I.

CHARLOTTETOWN CDA WEATHER STATION

20-YEAR MEAN VALUES

PRECIPITATION (mm)

YEARS: 1970 - 1989

| DAY | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3.1 | 5.2 | 3.3 | 1.8 | 1.1 | 4.6 | 3.6 | 3.1 | 2.8 | 6.1 | 1.6 | 1.9 |
| 2 | 4.2 | 4.0 | 3.8 | 3.4 | 2.5 | 2.6 | 1.7 | 0.7 | 4.4 | 5.3 | 2.7 | 4.2 |
| 3 | 2.4 | 2.6 | 2.6 | 3.1 | 6.4 | 2.8 | 1.7 | 3.9 | 1.5 | 3.1 | 3.5 | 4.4 |
| 4 | 3.7 | 4.2 | 4.1 | 4.8 | 3.8 | 1.9 | 0.7 | 2.5 | 3.0 | 5.5 | 1.4 | 5.1 |
| 5 | 3.0 | 3.4 | 3.6 | 5.3 | 1.4 | 2.2 | 4.4 | 3.1 | 2.8 | 2.8 | 4.4 | 4.2 |
| 6 | 0.8 | 2.1 | 1.1 | 4.2 | 3.4 | 6.1 | 2.1 | 1.7 | 2.7 | 3.6 | 6.1 | 6.9 |
| 7 | 5.2 | 2.3 | 3.2 | 1.8 | 4.1 | 1.2 | 1.0 | 1.9 | 1.4 | 4.0 | 2.8 | 2.6 |
| 8 | 3.7 | 2.6 | 3.7 | 2.7 | 3.8 | 5.0 | 1.7 | 1.9 | 0.7 | 2.7 | 1.8 | 2.2 |
| 9 | 1.6 | 1.6 | 1.2 | 7.0 | 3.4 | 6.1 | 3.4 | 1.1 | 6.0 | 4.5 | 2.7 | 5.2 |
| 10 | 4.0 | 1.9 | 2.5 | 3.1 | 2.0 | 3.6 | 2.4 | 2.3 | 4.7 | 4.3 | 3.3 | 4.8 |
| 11 | 3.6 | 2.2 | 3.1 | 2.6 | 2.7 | 2.8 | 3.3 | 5.5 | 6.4 | 2.0 | 2.3 | 3.6 |
| 12 | 1.4 | 2.2 | 2.8 | 2.2 | 2.5 | 2.0 | 3.6 | 7.7 | 0.6 | 2.7 | 5.9 | 4.2 |
| 13 | 5.1 | 4.1 | 1.4 | 0.8 | 4.6 | 1.0 | 4.3 | 5.1 | 1.9 | 2.4 | 5.6 | 4.8 |
| 14 | 6.1 | 1.8 | 3.0 | 0.9 | 3.9 | 2.6 | 2.7 | 1.5 | 7.6 | 3.8 | 5.6 | 3.3 |
| 15 | 3.5 | 4.0 | 5.3 | 2.1 | 1.1 | 0.9 | 1.4 | 6.5 | 3.0 | 6.0 | 3.4 | 5.8 |
| 16 | 2.1 | 3.3 | 3.3 | 3.2 | 3.1 | 2.7 | 1.6 | 5.0 | 1.0 | 3.4 | 3.1 | 3.6 |
| 17 | 2.8 | 1.6 | 4.2 | 1.7 | 4.4 | 4.1 | 6.8 | 2.3 | 1.4 | 1.7 | 3.3 | 6.9 |
| 18 | 4.8 | 1.4 | 3.2 | 2.9 | 2.4 | 1.3 | 0.6 | 2.1 | 2.8 | 4.1 | 3.6 | 2.0 |
| 19 | 2.4 | 1.7 | 1.9 | 2.7 | 0.8 | 2.2 | 1.7 | 1.0 | 1.8 | 7.2 | 1.6 | 2.0 |
| 20 | 3.6 | 3.5 | 1.9 | 2.9 | 2.3 | 3.7 | 3.5 | 2.4 | 2.0 | 4.9 | 6.2 | 1.2 |
| 21 | 2.4 | 4.2 | 2.8 | 2.5 | 1.6 | 2.4 | 3.2 | 1.3 | 4.5 | 3.2 | 7.8 | 4.2 |
| 22 | 1.3 | 5.8 | 1.4 | 3.7 | 4.3 | 2.8 | 2.7 | 3.1 | 6.7 | 2.3 | 1.8 | 5.1 |
| 23 | 4.1 | 2.6 | 4.8 | 2.4 | 5.5 | 3.4 | 0.6 | 3.6 | 2.3 | 3.0 | 1.2 | 2.5 |
| 24 | 1.4 | 4.9 | 1.0 | 4.0 | 3.7 | 3.9 | 2.2 | 3.7 | 2.9 | 4.1 | 4.0 | 4.2 |
| 25 | 4.7 | 3.1 | 2.6 | 2.8 | 6.5 | 5.0 | 1.6 | 1.1 | 1.8 | 3.1 | 3.8 | 5.7 |
| 26 | 3.0 | 3.0 | 1.6 | 2.4 | 3.1 | 1.1 | 1.3 | 1.2 | 4.3 | 4.6 | 8.1 | 6.1 |
| 27 | 1.6 | 1.3 | 3.7 | 2.6 | 1.9 | 2.4 | 3.0 | 3.1 | 4.0 | 3.3 | 2.0 | 2.0 |
| 28 | 1.4 | 1.8 | 2.5 | 3.8 | 2.9 | 1.7 | 9.7 | 1.6 | 2.4 | 3.2 | 5.4 | 3.8 |
| 29 | 3.5 | 0.3 | 1.7 | 6.4 | 1.5 | 2.9 | 2.0 | 3.6 | 2.7 | 4.7 | 3.9 | 2.4 |
| 30 | 2.8 | -99.0 | 2.5 | 1.1 | 2.2 | 3.8 | 4.1 | 2.5 | 1.1 | 2.1 | 2.5 | 4.6 |
| 31 | 4.1 | -99.0 | 3.7 | -99.0 | 3.4 | -99.0 | 3.0 | 2.4 | -99.0 | 1.5 | -99.0 | 2.2 |

CHARLOTTETOWN CDA WEATHER STATION

20-YEAR MEAN VALUES

TEMPERATURE (°C)

YEARS: 1970 - 1989

| DAY | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | -5.6 | -8.1 | -5.4 | 1.1 | 7.0 | 13.3 | 17.2 | 19.9 | 16.0 | 11.9 | 5.7 | -0.4 |
| 2 | -5.0 | -8.1 | -6.2 | 1.3 | 7.1 | 12.4 | 17.1 | 20.0 | 16.3 | 12.6 | 6.6 | -0.4 |
| 3 | -6.2 | -7.9 | -6.6 | 1.6 | 6.7 | 12.8 | 17.5 | 20.1 | 16.7 | 11.7 | 5.9 | -0.9 |
| 4 | -7.7 | -7.9 | -6.9 | 1.9 | 6.7 | 13.2 | 17.9 | 20.4 | 15.2 | 10.6 | 5.8 | -1.6 |
| 5 | -7.0 | -10.1 | -4.3 | 2.1 | 7.2 | 12.3 | 18.2 | 19.7 | 15.6 | 10.0 | 6.0 | -1.8 |
| 6 | -9.2 | -10.6 | -4.3 | 2.5 | 8.0 | 11.9 | 18.2 | 19.4 | 16.0 | 11.9 | 4.8 | -0.3 |
| 7 | -8.2 | -9.6 | -4.2 | 2.7 | 6.3 | 12.3 | 18.6 | 18.8 | 14.6 | 11.0 | 5.1 | 0.1 |
| 8 | -6.4 | -7.5 | -3.8 | 0.9 | 6.8 | 13.9 | 19.7 | 19.7 | 14.6 | 9.8 | 4.6 | -2.6 |
| 9 | -9.0 | -7.2 | -6.2 | 0.8 | 7.9 | 14.0 | 19.6 | 19.9 | 14.4 | 8.8 | 4.5 | -3.1 |
| 10 | -8.6 | -8.9 | -5.6 | 1.3 | 8.4 | 12.8 | 19.1 | 20.0 | 14.7 | 8.1 | 3.5 | -2.7 |
| 11 | -8.1 | -8.8 | -4.3 | 1.4 | 8.9 | 13.4 | 19.1 | 19.5 | 14.3 | 7.4 | 4.2 | -3.8 |
| 12 | -8.8 | -7.9 | -4.3 | 1.2 | 9.7 | 13.2 | 17.9 | 19.7 | 14.7 | 9.0 | 3.3 | -5.1 |
| 13 | -9.2 | -7.5 | -4.5 | 1.2 | 9.5 | 13.6 | 18.8 | 18.6 | 14.4 | 8.6 | 3.5 | -4.7 |
| 14 | -8.7 | -7.0 | -3.1 | 1.9 | 9.7 | 13.5 | 18.7 | 18.8 | 14.0 | 8.8 | 2.7 | -4.8 |
| 15 | -7.0 | -6.1 | -1.4 | 2.4 | 10.1 | 14.9 | 18.8 | 18.7 | 13.2 | 10.2 | 2.7 | -3.8 |
| 16 | -8.8 | -5.6 | -2.4 | 3.4 | 11.0 | 16.0 | 19.2 | 18.5 | 13.0 | 8.3 | 1.9 | -3.0 |
| 17 | -9.5 | -9.1 | -1.6 | 3.7 | 10.2 | 15.6 | 19.7 | 18.9 | 13.3 | 6.8 | 2.7 | -3.1 |
| 18 | -9.9 | -8.8 | -2.4 | 4.6 | 9.6 | 15.6 | 19.4 | 18.6 | 13.4 | 7.1 | 3.0 | -5.0 |
| 19 | -8.1 | -6.4 | -1.7 | 3.4 | 11.1 | 17.0 | 19.7 | 17.2 | 13.7 | 6.8 | 1.0 | -7.6 |
| 20 | -8.1 | -4.6 | -1.7 | 3.8 | 11.5 | 17.1 | 19.4 | 17.6 | 12.9 | 6.0 | 0.8 | -7.5 |
| 21 | -9.4 | -4.3 | -2.0 | 4.2 | 12.2 | 16.9 | 19.5 | 17.7 | 14.5 | 7.4 | 1.8 | -5.6 |
| 22 | -9.1 | -4.5 | -1.9 | 4.1 | 11.9 | 16.7 | 18.7 | 17.6 | 13.3 | 7.3 | 1.4 | -5.6 |
| 23 | -7.0 | -5.2 | -1.4 | 4.1 | 11.0 | 17.4 | 18.5 | 17.9 | 11.7 | 7.8 | 0.7 | -5.9 |
| 24 | -6.2 | -6.3 | -0.1 | 4.5 | 10.0 | 17.5 | 18.7 | 16.3 | 12.2 | 6.9 | 0.6 | -4.7 |
| 25 | -6.3 | -5.3 | -0.7 | 4.5 | 9.1 | 15.9 | 19.4 | 16.2 | 11.0 | 7.3 | 0.9 | -4.3 |
| 26 | -5.8 | -5.9 | 0.2 | 5.0 | 10.2 | 15.3 | 20.0 | 16.6 | 12.2 | 7.3 | 1.2 | -4.0 |
| 27 | -5.4 | -6.1 | -0.2 | 5.8 | 11.1 | 16.4 | 19.5 | 17.6 | 11.9 | 5.7 | 0.3 | -5.7 |
| 28 | -6.6 | -5.7 | -0.6 | 5.9 | 11.3 | 16.2 | 19.7 | 17.4 | 12.1 | 6.1 | 0.8 | -4.8 |
| 29 | -7.2 | -5.4 | 0.0 | 5.5 | 12.3 | 16.8 | 19.3 | 17.1 | 11.0 | 7.0 | 0.5 | -4.8 |
| 30 | -7.4 | -99.0 | 0.6 | 6.3 | 13.5 | 11.5 | 19.3 | 16.8 | 11.9 | 4.6 | 0.0 | -5.6 |
| 31 | -7.6 | -99.0 | 1.0 | -99.0 | 13.6 | -99.0 | 19.1 | 16.3 | -99.0 | 5.0 | -99.0 | -6.6 |

CHARLOTTETOWN CDA WEATHER STATION

20-YEAR MEAN VALUES

PAN EVAPORATION (mm)

YEARS: 1970 - 1989

| DAY | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | -99.0 | -99.0 | -99.0 | -99.0 | 2.6 | 2.8 | 6.0 | 4.3 | 4.1 | 0.5 | -99.0 | -99.0 |
| 2 | -99.0 | -99.0 | -99.0 | -99.0 | 2.4 | 3.9 | 5.2 | 4.0 | 3.5 | 2.3 | -99.0 | -99.0 |
| 3 | -99.0 | -99.0 | -99.0 | -99.0 | 2.9 | 4.3 | 5.1 | 3.8 | 3.7 | 2.3 | -99.0 | -99.0 |
| 4 | -99.0 | -99.0 | -99.0 | -99.0 | 2.3 | 4.6 | 6.0 | 3.9 | 4.3 | 3.8 | -99.0 | -99.0 |
| 5 | -99.0 | -99.0 | -99.0 | -99.0 | 3.4 | 3.5 | 5.9 | 4.3 | 3.4 | 2.5 | -99.0 | -99.0 |
| 6 | -99.0 | -99.0 | -99.0 | -99.0 | 4.0 | 4.1 | 4.8 | 4.3 | 3.4 | 5.6 | -99.0 | -99.0 |
| 7 | -99.0 | -99.0 | -99.0 | -99.0 | 4.0 | 3.9 | 5.0 | 4.7 | 4.2 | 1.8 | -99.0 | -99.0 |
| 8 | -99.0 | -99.0 | -99.0 | -99.0 | 3.8 | 4.7 | 5.3 | 4.2 | 3.7 | 1.3 | -99.0 | -99.0 |
| 9 | -99.0 | -99.0 | -99.0 | -99.0 | 4.1 | 4.9 | 5.6 | 4.0 | 3.3 | 1.0 | -99.0 | -99.0 |
| 10 | -99.0 | -99.0 | -99.0 | -99.0 | 4.7 | 3.9 | 5.2 | 3.9 | 3.4 | 3.6 | -99.0 | -99.0 |
| 11 | -99.0 | -99.0 | -99.0 | -99.0 | 3.7 | 5.1 | 5.0 | 3.9 | 3.6 | 2.0 | -99.0 | -99.0 |
| 12 | -99.0 | -99.0 | -99.0 | -99.0 | 3.0 | 4.3 | 4.7 | 3.6 | 3.1 | 1.3 | -99.0 | -99.0 |
| 13 | -99.0 | -99.0 | -99.0 | -99.0 | 4.2 | 4.4 | 5.5 | 3.7 | 3.8 | 3.3 | -99.0 | -99.0 |
| 14 | -99.0 | -99.0 | -99.0 | -99.0 | 3.8 | 3.8 | 5.0 | 4.0 | 3.9 | 1.0 | -99.0 | -99.0 |
| 15 | -99.0 | -99.0 | -99.0 | -99.0 | 4.1 | 3.8 | 4.9 | 5.1 | 2.9 | 1.8 | -99.0 | -99.0 |
| 16 | -99.0 | -99.0 | -99.0 | -99.0 | 4.8 | 4.9 | 5.0 | 3.5 | 2.7 | 1.8 | -99.0 | -99.0 |
| 17 | -99.0 | -99.0 | -99.0 | -99.0 | 3.6 | 4.8 | 4.8 | 3.9 | 3.4 | 2.0 | -99.0 | -99.0 |
| 18 | -99.0 | -99.0 | -99.0 | -99.0 | 3.6 | 4.7 | 5.2 | 4.0 | 2.7 | 1.3 | -99.0 | -99.0 |
| 19 | -99.0 | -99.0 | -99.0 | -99.0 | 4.3 | 4.9 | 5.5 | 4.5 | 3.2 | 0.8 | -99.0 | -99.0 |
| 20 | -99.0 | -99.0 | -99.0 | -99.0 | 4.2 | 5.8 | 4.9 | 3.8 | 3.5 | 3.8 | -99.0 | -99.0 |
| 21 | -99.0 | -99.0 | -99.0 | -99.0 | 4.4 | 5.1 | 5.0 | 4.5 | 3.0 | 1.3 | -99.0 | -99.0 |
| 22 | -99.0 | -99.0 | -99.0 | -99.0 | 4.6 | 4.7 | 4.3 | 4.4 | 2.7 | 1.0 | -99.0 | -99.0 |
| 23 | -99.0 | -99.0 | -99.0 | -99.0 | 4.5 | 5.0 | 4.6 | 4.0 | 2.6 | 1.5 | -99.0 | -99.0 |
| 24 | -99.0 | -99.0 | -99.0 | -99.0 | 4.0 | 5.0 | 5.6 | 3.7 | 3.0 | 2.5 | -99.0 | -99.0 |
| 25 | -99.0 | -99.0 | -99.0 | -99.0 | 3.9 | 5.2 | 5.7 | 4.2 | 2.5 | 2.0 | -99.0 | -99.0 |
| 26 | -99.0 | -99.0 | -99.0 | -99.0 | 4.0 | 3.5 | 5.7 | 3.2 | 3.9 | 2.8 | -99.0 | -99.0 |
| 27 | -99.0 | -99.0 | -99.0 | -99.0 | 4.8 | 4.1 | 5.6 | 3.6 | 2.8 | 2.8 | -99.0 | -99.0 |
| 28 | -99.0 | -99.0 | -99.0 | -99.0 | 3.8 | 4.1 | 6.1 | 4.1 | 3.0 | 0.3 | -99.0 | -99.0 |
| 29 | -99.0 | -99.0 | -99.0 | -99.0 | 4.9 | 4.9 | 4.8 | 3.8 | 2.7 | 2.5 | -99.0 | -99.0 |
| 30 | -99.0 | -99.0 | -99.0 | -99.0 | 4.6 | 4.3 | 5.6 | 3.6 | 2.5 | 1.8 | -99.0 | -99.0 |
| 31 | -99.0 | -99.0 | -99.0 | -99.0 | 3.4 | -99.0 | 4.4 | 3.1 | -99.0 | 1.8 | -99.0 | -99.0 |

CHARLOTTETOWN CDA WEATHER STATION

20-YEAR MEDIAN VALUES

PRECIPITATION (mm)

YEARS: 1970 - 1989

| DAY | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.5 | 0.4 | 0.1 | 0.0 | 0.0 | 2.6 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 |
| 2 | 0.3 | 0.2 | 0.2 | 1.3 | 0.0 | 0.0 | 0.2 | 0.0 | 0.8 | 0.2 | 0.5 | 0.8 |
| 3 | 0.5 | 0.6 | 0.0 | 0.4 | 0.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.8 | 0.0 | 1.4 |
| 4 | 0.6 | 0.1 | 0.8 | 1.3 | 0.6 | 0.1 | 0.0 | 0.4 | 0.0 | 0.4 | 0.4 | 0.3 |
| 5 | 0.3 | 0.0 | 1.0 | 3.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.0 | 0.2 | 0.8 | 0.3 |
| 6 | 0.0 | 0.1 | 0.2 | 2.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 | 4.6 |
| 7 | 0.8 | 0.0 | 0.6 | 0.3 | 0.0 | 0.4 | 0.0 | 0.4 | 0.0 | 0.4 | 0.0 | 0.5 |
| 8 | 0.5 | 0.3 | 0.2 | 0.5 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.4 | 0.0 |
| 9 | 0.1 | 0.2 | 0.0 | 0.4 | 0.0 | 0.8 | 0.0 | 0.2 | 0.2 | 0.2 | 0.4 | 2.6 |
| 10 | 0.0 | 0.0 | 0.0 | 1.5 | 0.0 | 0.0 | 0.0 | 0.3 | 0.2 | 0.0 | 0.0 | 0.6 |
| 11 | 0.4 | 0.4 | 1.0 | 1.9 | 0.0 | 0.0 | 0.0 | 0.4 | 1.0 | 0.0 | 0.5 | 1.3 |
| 12 | 0.4 | 0.0 | 0.2 | 0.0 | 0.3 | 0.1 | 0.0 | 1.8 | 0.0 | 0.2 | 1.0 | 2.0 |
| 13 | 0.5 | 0.3 | 0.0 | 0.0 | 2.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.0 | 0.8 |
| 14 | 1.5 | 0.0 | 0.4 | 0.0 | 0.4 | 0.2 | 0.4 | 0.0 | 1.8 | 0.4 | 1.2 | 1.5 |
| 15 | 0.5 | 2.7 | 1.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.4 | 0.8 |
| 16 | 0.0 | 0.2 | 0.3 | 0.0 | 1.1 | 0.2 | 0.0 | 0.4 | 0.0 | 0.4 | 1.2 | 1.0 |
| 17 | 0.0 | 0.0 | 3.0 | 0.0 | 0.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 1.0 | 1.4 |
| 18 | 0.3 | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.8 | 0.0 | 1.4 |
| 19 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 |
| 20 | 0.8 | 0.0 | 0.4 | 0.0 | 0.0 | 0.0 | 0.6 | 0.0 | 0.0 | 0.6 | 0.4 | 0.0 |
| 21 | 0.4 | 0.4 | 0.4 | 0.0 | 0.0 | 0.0 | 0.7 | 0.0 | 2.0 | 0.0 | 7.2 | 0.5 |
| 22 | 0.4 | 1.1 | 0.0 | 0.2 | 0.6 | 0.1 | 0.0 | 0.4 | 3.8 | 0.0 | 0.4 | 0.6 |
| 23 | 0.6 | 0.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.6 | 0.0 | 0.4 |
| 24 | 0.0 | 0.9 | 0.0 | 0.2 | 0.6 | 0.4 | 0.0 | 0.0 | 0.0 | 0.8 | 0.0 | 0.6 |
| 25 | 0.4 | 0.7 | 0.0 | 0.1 | 0.3 | 0.6 | 0.0 | 0.0 | 0.0 | 0.8 | 0.0 | 3.3 |
| 26 | 0.5 | 0.0 | 0.0 | 0.1 | 0.2 | 0.4 | 0.0 | 0.0 | 0.4 | 1.0 | 0.8 | 2.6 |
| 27 | 0.0 | 0.0 | 1.0 | 0.8 | 0.0 | 0.4 | 0.0 | 0.0 | 1.6 | 0.0 | 1.0 | 1.2 |
| 28 | 0.0 | 0.0 | 0.0 | 0.0 | 0.7 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 1.4 | 0.8 |
| 29 | 0.1 | 1.2 | 0.2 | 0.0 | 0.0 | 0.0 | 0.1 | 1.2 | 0.0 | 0.5 | 1.0 | 0.6 |
| 30 | 0.6 | -99.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.8 |
| 31 | 0.3 | -99.0 | 0.3 | -99.0 | 1.2 | -99.0 | 0.0 | 0.0 | -99.0 | 0.0 | -99.0 | 0.3 |

CHARLOTTETOWN CDA WEATHER STATION

20-YEAR MEDIAN VALUES

TEMPERATURE (°C)

YEARS: 1970 - 1989

| DAY | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | -5.0 | -8.9 | -5.0 | 0.8 | 6.7 | 13.7 | 18.2 | 19.5 | 16.0 | 10.3 | 4.8 | -1.5 |
| 2 | -4.7 | -8.6 | -6.8 | 0.8 | 7.2 | 12.9 | 16.6 | 20.8 | 15.5 | 12.0 | 7.3 | 0.0 |
| 3 | -7.5 | -9.3 | -6.3 | 1.7 | 5.6 | 13.4 | 17.5 | 20.0 | 17.8 | 12.2 | 5.9 | -0.5 |
| 4 | -7.7 | -8.1 | -6.8 | 1.8 | 5.9 | 14.0 | 18.3 | 20.5 | 15.3 | 10.3 | 4.5 | -1.4 |
| 5 | -7.3 | -10.1 | -4.7 | 1.2 | 6.8 | 12.0 | 18.8 | 19.8 | 15.3 | 10.3 | 5.3 | -2.8 |
| 6 | -8.9 | -9.9 | -5.3 | 2.0 | 6.8 | 12.0 | 18.0 | 19.4 | 16.0 | 12.8 | 4.0 | 0.0 |
| 7 | -8.9 | -9.5 | -4.2 | 1.4 | 5.9 | 12.1 | 19.6 | 19.2 | 15.5 | 11.1 | 4.5 | -1.0 |
| 8 | -5.6 | -7.9 | -3.7 | 1.2 | 6.6 | 14.1 | 20.3 | 19.8 | 14.2 | 11.0 | 3.7 | -2.8 |
| 9 | -8.8 | -7.4 | -6.4 | 1.0 | 9.0 | 14.4 | 19.9 | 21.1 | 14.2 | 8.5 | 5.0 | -3.8 |
| 10 | -8.4 | -9.3 | -5.2 | 1.5 | 9.1 | 11.5 | 19.9 | 20.0 | 14.5 | 6.8 | 3.3 | -4.0 |
| 11 | -8.9 | -9.7 | -4.4 | 1.0 | 10.1 | 13.0 | 19.0 | 19.8 | 14.0 | 6.3 | 3.8 | -4.0 |
| 12 | -10.8 | -8.8 | -4.3 | 0.6 | 10.1 | 13.1 | 18.0 | 19.5 | 15.0 | 9.0 | 2.5 | -5.9 |
| 13 | -10.1 | -8.4 | -2.8 | 0.7 | 9.6 | 14.3 | 18.8 | 18.4 | 15.0 | 8.1 | 3.3 | -5.0 |
| 14 | -7.7 | -7.5 | -2.4 | 1.3 | 10.7 | 13.8 | 19.0 | 19.3 | 13.3 | 7.5 | 1.5 | -5.0 |
| 15 | -6.7 | -6.6 | -1.1 | 2.0 | 10.4 | 15.4 | 19.2 | 18.8 | 12.5 | 10.8 | 2.3 | -3.0 |
| 16 | -8.1 | -5.0 | -2.9 | 2.5 | 10.6 | 16.0 | 19.4 | 18.4 | 12.5 | 7.0 | 2.2 | -2.8 |
| 17 | -8.6 | -9.1 | -1.4 | 2.9 | 10.3 | 16.3 | 19.3 | 18.3 | 13.5 | 6.5 | 2.0 | -2.3 |
| 18 | -10.1 | -9.1 | -2.5 | 3.4 | 10.1 | 15.8 | 19.8 | 18.4 | 12.5 | 8.0 | 3.4 | -5.8 |
| 19 | -7.4 | -7.0 | -0.6 | 3.2 | 11.4 | 17.3 | 19.5 | 17.8 | 13.8 | 5.6 | 1.2 | -8.9 |
| 20 | -9.4 | -3.3 | -1.3 | 3.5 | 11.4 | 17.6 | 19.6 | 17.8 | 12.0 | 6.2 | 0.0 | -5.3 |
| 21 | -9.4 | -3.3 | -2.0 | 3.1 | 12.9 | 16.9 | 19.6 | 17.5 | 14.3 | 8.3 | 2.5 | -5.0 |
| 22 | -9.5 | -5.0 | -0.9 | 4.3 | 11.0 | 16.9 | 18.7 | 17.5 | 12.8 | 6.8 | 1.4 | -4.5 |
| 23 | -5.9 | -4.8 | -2.0 | 4.6 | 10.6 | 17.3 | 18.8 | 18.5 | 11.0 | 7.3 | 0.0 | -5.6 |
| 24 | -6.4 | -5.9 | -0.2 | 4.8 | 7.9 | 17.4 | 18.3 | 17.0 | 13.1 | 6.7 | 0.3 | -3.6 |
| 25 | -6.4 | -4.8 | -0.4 | 3.7 | 9.1 | 15.4 | 19.4 | 16.1 | 11.3 | 7.2 | 0.5 | -5.0 |
| 26 | -6.4 | -5.4 | 0.6 | 3.6 | 10.4 | 13.9 | 20.0 | 16.0 | 11.8 | 6.5 | 1.0 | -5.3 |
| 27 | -5.4 | -5.8 | 0.8 | 6.1 | 10.7 | 15.8 | 19.1 | 17.8 | 12.8 | 6.0 | 1.0 | -5.0 |
| 28 | -7.9 | -3.9 | 0.3 | 5.2 | 11.1 | 16.9 | 20.5 | 17.8 | 11.0 | 5.5 | 0.3 | -3.9 |
| 29 | -6.7 | -3.4 | 0.1 | 4.4 | 12.6 | 16.3 | 18.8 | 16.7 | 10.8 | 6.7 | 0.8 | -4.5 |
| 30 | -7.8 | -99.0 | 1.0 | 6.0 | 14.4 | 17.8 | 19.0 | 17.0 | 10.3 | 5.0 | 0.3 | -5.8 |
| 31 | -9.0 | -99.0 | -0.3 | -99.0 | 14.0 | -99.0 | 19.2 | 15.5 | -99.0 | 4.7 | -99.0 | -5.5 |

CHARLOTTETOWN CDA WEATHER STATION

20-YEAR MEDIAN VALUES

PAN EVAPORATION (mm)

YEARS: 1970 - 1989

| DAY | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | -99.0 | -99.0 | -99.0 | -99.0 | 2.6 | 2.4 | 6.6 | 4.8 | 4.6 | 0.5 | -99.0 | -99.0 |
| 2 | -99.0 | -99.0 | -99.0 | -99.0 | 2.0 | 3.9 | 5.6 | 4.8 | 4.2 | 2.3 | -99.0 | -99.0 |
| 3 | -99.0 | -99.0 | -99.0 | -99.0 | 3.4 | 4.0 | 4.8 | 4.6 | 3.4 | 2.3 | -99.0 | -99.0 |
| 4 | -99.0 | -99.0 | -99.0 | -99.0 | 2.4 | 4.7 | 6.4 | 4.6 | 4.4 | 3.8 | -99.0 | -99.0 |
| 5 | -99.0 | -99.0 | -99.0 | -99.0 | 3.2 | 3.8 | 6.2 | 4.8 | 3.6 | 2.5 | -99.0 | -99.0 |
| 6 | -99.0 | -99.0 | -99.0 | -99.0 | 3.6 | 4.1 | 4.8 | 4.8 | 3.6 | 5.6 | -99.0 | -99.0 |
| 7 | -99.0 | -99.0 | -99.0 | -99.0 | 4.0 | 4.1 | 5.0 | 5.8 | 4.3 | 1.8 | -99.0 | -99.0 |
| 8 | -99.0 | -99.0 | -99.0 | -99.0 | 4.4 | 4.8 | 5.4 | 4.6 | 3.6 | 1.3 | -99.0 | -99.0 |
| 9 | -99.0 | -99.0 | -99.0 | -99.0 | 4.7 | 5.1 | 6.6 | 4.2 | 3.2 | 1.0 | -99.0 | -99.0 |
| 10 | -99.0 | -99.0 | -99.0 | -99.0 | 5.7 | 4.3 | 5.4 | 3.4 | 3.8 | 3.6 | -99.0 | -99.0 |
| 11 | -99.0 | -99.0 | -99.0 | -99.0 | 3.7 | 5.4 | 5.8 | 4.4 | 3.5 | 2.0 | -99.0 | -99.0 |
| 12 | -99.0 | -99.0 | -99.0 | -99.0 | 2.7 | 3.6 | 4.8 | 3.6 | 3.4 | 1.3 | -99.0 | -99.0 |
| 13 | -99.0 | -99.0 | -99.0 | -99.0 | 4.4 | 4.6 | 5.2 | 4.6 | 3.6 | 3.3 | -99.0 | -99.0 |
| 14 | -99.0 | -99.0 | -99.0 | -99.0 | 3.4 | 3.2 | 5.4 | 3.8 | 3.3 | 1.0 | -99.0 | -99.0 |
| 15 | -99.0 | -99.0 | -99.0 | -99.0 | 4.2 | 3.6 | 4.8 | 5.0 | 3.3 | 1.8 | -99.0 | -99.0 |
| 16 | -99.0 | -99.0 | -99.0 | -99.0 | 4.4 | 4.8 | 5.2 | 4.6 | 2.9 | 1.8 | -99.0 | -99.0 |
| 17 | -99.0 | -99.0 | -99.0 | -99.0 | 3.5 | 4.1 | 6.2 | 4.4 | 3.1 | 2.0 | -99.0 | -99.0 |
| 18 | -99.0 | -99.0 | -99.0 | -99.0 | 3.3 | 3.6 | 4.8 | 4.0 | 2.3 | 1.3 | -99.0 | -99.0 |
| 19 | -99.0 | -99.0 | -99.0 | -99.0 | 4.4 | 5.1 | 5.8 | 5.0 | 2.9 | 0.8 | -99.0 | -99.0 |
| 20 | -99.0 | -99.0 | -99.0 | -99.0 | 3.9 | 6.1 | 4.6 | 4.0 | 3.0 | 3.8 | -99.0 | -99.0 |
| 21 | -99.0 | -99.0 | -99.0 | -99.0 | 4.2 | 5.6 | 5.0 | 4.6 | 2.9 | 1.3 | -99.0 | -99.0 |
| 22 | -99.0 | -99.0 | -99.0 | -99.0 | 4.8 | 5.0 | 4.8 | 4.2 | -99.0 | 1.0 | -99.0 | -99.0 |
| 23 | -99.0 | -99.0 | -99.0 | -99.0 | 4.5 | 4.8 | 4.6 | 5.1 | 2.3 | 1.5 | -99.0 | -99.0 |
| 24 | -99.0 | -99.0 | -99.0 | -99.0 | 4.2 | 5.0 | 5.1 | 4.1 | 3.2 | 2.5 | -99.0 | -99.0 |
| 25 | -99.0 | -99.0 | -99.0 | -99.0 | 3.9 | 5.8 | 4.8 | 4.8 | 2.5 | 2.0 | -99.0 | -99.0 |
| 26 | -99.0 | -99.0 | -99.0 | -99.0 | 3.9 | 3.1 | 5.6 | 3.6 | 3.8 | 2.8 | -99.0 | -99.0 |
| 27 | -99.0 | -99.0 | -99.0 | -99.0 | 5.4 | 4.7 | 5.0 | 2.8 | 2.9 | 2.8 | -99.0 | -99.0 |
| 28 | -99.0 | -99.0 | -99.0 | -99.0 | 4.1 | 4.9 | 6.2 | 4.8 | 2.8 | 0.3 | -99.0 | -99.0 |
| 29 | -99.0 | -99.0 | -99.0 | -99.0 | 5.4 | 4.9 | 5.6 | 4.4 | 2.4 | 2.5 | -99.0 | -99.0 |
| 30 | -99.0 | -99.0 | -99.0 | -99.0 | 5.0 | 4.6 | 4.8 | 4.2 | 2.5 | 1.8 | -99.0 | -99.0 |
| 31 | -99.0 | -99.0 | -99.0 | -99.0 | 3.4 | -99.0 | 5.2 | 3.0 | -99.0 | 1.8 | -99.0 | -99.0 |

**APPENDICES A.2 , A.3 AND A.4**

**PRECIPITATION, TEMPERATURE**

**AND**

**PAN EVAPORATION DATA**

**CDA WEATHER STATION**

**CHARLOTTETOWN, P.E.I.**

(Precipitation, temperature and pan evaporation data available from authors)

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