CANADA-MANITOBA
Soil Survey

Soils of the Carman Research Station N½ 23-6-5W

Special Report Series 93-1

Government of Canada | Gouvernement du Canada
Government of Manitoba | Gouvernement du Manitoba

Special Report Series No. 93-1 1993

SOILS OF THE CARMAN RESEARCH STATION

N 1/2 23-6-5W

by

G. F. Mills and P. Haluschak

MANITOBA SOIL SURVEY UNIT
and
MANITOBA LAND RESOURCE UNIT

AGRICULTURE CANADA
MANITOBA DEPARTMENT OF AGRICULTURE
DEPARTMENT OF SOIL SCIENCE, UNIVERSITY OF MANITOBA

PREFACE

The detailed soil survey of the Carman Research Station was carried out by staff of the Manitoba Soil Survey Unit, Soils and Crops Branch, Manitoba Agriculture and the Land Resource Unit, Centre for Land Resource and Biological Resource Research, Agriculture Canada at the request of the Department of Plant Science, University of Manitoba. The soil map at a scale of 1:5 000 and the accompanying report provides detailed soil resource information required for planning and managing the soils on the station to support ongoing agronomic research in Manitoba.

This report contains descriptive information for the major soils that occur on the research station as well as interpretations for dryland and irrigation agriculture. A brief discussion of soil properties and management relationships is included.

During the course of this survey, a significant volume of site specific information was gathered that for practical reasons cannot be included in this report. Much of this data has been input into the Canada Soil Information System (CanSIS). This system of soil resource data management permits automated manipulation and analysis for both map and soil characterization and interpretation. Several thematic interpretative maps showing soil properties such as texture, pH and organic matter content have been derived from the basic soil map and other data files in CanSIS. Additional requests for such data should be directed to: Manitoba Soil Survey Unit, Department of Soil Science, 362 Ellis Building, University of Manitoba, Winnipeg, Manitoba, R3T 2N2.

ACKNOWLEDGEMENTS

The report on the Soils of the Carman Research Station was conducted as a joint project of the Manitoba Department of Agriculture, the Canada Department of Agriculture and the Soil Science Department, University of Manitoba.

The soils were mapped in the summer of 1992 by G. F. Mills assisted by J. Muir and G. Steinke. Detailed soil characterization and moisture studies were carried out by P. Haluschak and E. St. Jacques.

Laboratory analysis were provided by R. Mirza and E. St. Jacques under the direction of P. Haluschak.

Map compilation and digitization in preparation for publication and addition to CanSIS cartographic file was provided by J. Griffiths.

Assistance in soil correlation was provided by W. Michalyna.

Cheryl Fraser for inputting tabular data.

C. L. Aglugub for providing computer processing, programming and report formatting.

R. G. Eilers for reviewing the manuscript.

HOW TO USE THIS SOIL REPORT

This soils report contains considerable information about the soils, their origin and formation, their classification and their potential for various uses such as dryland agriculture and irrigation. The report is divided into four parts: Part 1 provides a general description of the area; Part 2 describes the methodology used in the study; Part 3 discusses the development, scientific classification and morphological characteristics of the soils in the study area, and Part 4 provides an interpretation of soil properties and associated landscape features as they affect soil capability or suitability for various uses.

The accompanying soil map is presented at a 1:5 000 scale on an air photo base to assist the user in locating the soil areas in relation to roads and field boundaries. The following steps are suggested to assist the user in retrieving soil information from the map and report:

STEP 1 Consult the soil map in pocket of report folder. Locate the area(s) of interest on the map and identify the pertinent map unit symbols. Arabic numerals placed as superscripts following map symbols indicate the approximate proportion of each soil type within the map unit.

STEP 2 Consult the extended legend accompanying the soil map for an alphabetical listing of soil symbols giving the soil name, surface texture, drainage, related information concerning landform and stratigraphy of the soil materials and soil classification.

STEP 3 For interpretive information about the soils capability for dryland agriculture and suitability for irrigation, consult the appropriate section in Part 4. Criteria utilized as guidelines in making these interpretations are provided in Appendix A.

STEP 4 Further information concerning the morphological properties and extent of the soils is presented in Part 3 where the soils are described alphabetically according to soil name.

STEP 5 Additional site specific information not contained in this report is available on request from the Canada-Manitoba Soil Survey, Ellis Bldg., University of Manitoba.

SUMMARY

The Carman Research Station is located immediately southwest of the Town of Carman in the N 1/2 Section 23, Township 6, Range 5W. The Station covers an area of 96.3 ha and consists of well drained to imperfectly drained sandy, coarse loamy, fine loamy and clayey lacustrine and deltaic sediments. A clay substrate underlies the soils of the Station at depths ranging from the surface to about 2 meters. The topography is level with an average slope of less than one percent.

The climate is subhumid with a definite summer maximum of precipitation. Long-term climatic records observed at five locations within a 70 km radius of Carman indicate total precipitation varies from 472 mm to 530 mm. Growing season precipitation, accounting for 61 to 66 percent of the annual total, is particularly variable due to the local occurrence of storm events which account for much of the summer rainfall. Mean annual air temperature observed at the five climatic stations ranges from 2.2 to 3.3°C and the average length of the frost-free season varies from 119 to 126 days.

The soils on the station are dominantly well and imperfectly drained Orthic Blacks developed on sandy, coarse loamy, fine loamy and clayey sediments. A small area of Regosol soils occurs on the floodplain of the Boyne River. The loamy and clayey soils have high organic matter content and moisture holding capacity. The coarse loamy and sandy soils have lower organic matter and moisture retention.

Although the soils on the Station are dominantly well drained, groundwater may be within 1 to 2 meters of the surface in spring and early summer on the east and south side of the study area. Surface ponding may occur for short periods following heavy rainfall or rapid spring snowmelt, particularly on soils in which the clay substrate is at or close to the surface.

The soil conditions on the research station and the prevailing climate of the area combine to provide growing conditions with no major limitation for a wide range of crops commonly grown in southern Manitoba.

TABLE OF CONTENTS

PREFACE i

ACKNOWLEDGEMENTS ii

HOW TO USE THIS SOIL REPORT iii

SUMMARY iv

PART 1 1

GENERAL DESCRIPTION OF STUDY AREA 1
- 1.1 LOCATION AND EXTENT 1
- 1.2 PHYSIOGRAPHY AND SURFACE DEPOSITS 1
- 1.3 RELIEF AND DRAINAGE 1
- 1.4 CLIMATE 1

PART 2 7

METHODOLOGY 7
- 2.1 Soil Survey and Mapping 7
- 2.2 Soil Map 7
- 2.3 Soil Salinity 7

PART 3 9

DEVELOPMENT, CLASSIFICATION AND DESCRIPTION OF SOILS 9
- 3.1 INTRODUCTION 9
- 3.2 SOIL DESCRIPTIONS 9
  - Denham Series (DNH) 9
  - Eigenhof Series (EGF) 10
  - Hochfeld Series (HHF) 10
  - Hibsin Series (HIN) 10
  - Kronstal Series (KOT) 11
  - La Salle Series (LSL) 11
  - Plum Coulee Series (PME) 11
  - Reinfeld Series (RFD) 12
  - Rignold Series (RGD) 12
  - Winkler Series (WIK) 12

PART 4 15

USE AND MANAGEMENT INTERPRETATIONS OF SOILS 15
- 4.1 INTRODUCTION 15
- 4.2 SOIL CAPABILITY FOR AGRICULTURE 15
  - 4.2.1 Soil Capability Classes 15
  - 4.2.2 Soil Capability subclasses 15
  - 4.2.3 Soil Capability 15
- 4.3 IRRIGATION SUITABILITY 16
  - 4.3.1 Irrigation Suitability Rating 16
  - 4.3.2 Environmental Impact 17
- 4.4 SOIL PROPERTIES AFFECTING CROP MANAGEMENT 17
  - 4.4.1 Particle Size Distribution 17

4.4.2 Soil pH 23
4.4.3 Soil Organic Matter 23
4.4.4 Depth to Clay Substrate 23
4.4.5 Soil Drainage 23
4.4.6 Soil Moisture Properties 23
4.4.7 Soil Salinity 23

APPENDIX A 26
GUIDES FOR EVALUATING AGRICULTURAL CAPABILITY AND IRRIGATION SUITABILITY 26

APPENDIX B 32
SOIL CHEMICAL AND PHYSICAL ANALYSIS 32

SOIL LEGEND 38

BIBLIOGRAPHY 39

LIST OF TABLES

Table 1.	Climatic Parameters at Selected Climate Stations in South-Central Manitoba (Atmospheric Environment Service, 1982)	4
Table 2.	Frost Data and Probability for Last Freezing Temperature, Spring and First Freezing Temperature, Fall at Selected Climate stations in South Central Manitoba (Atmospheric Environment Service, 1982).	5
Table 3.	Climatic Parameters Relevant to Crop Growth at Selected Climate Stations in South Central Manitoba (Ash, 1991)	6
Table 4.	Classification of Soil Series in Relation to Drainage and Parent Material	14
Table 5.	Agricultural Capability and Irrigation Suitability Rating.	18
Table 6.	Selected Surface Soil Properties	19
Table 7.	Physical, Chemical and Water Retention Properties of Soils	25
Table 8.	Description of the Agricultural Capability Classes	27
Table 9.	Agricultural Capability Subclass Limitations	27
Table 10.	Description of Irrigation Suitability Classes	28
Table 11.	Soil Features Affecting Irrigation Suitability	29
Table 12.	Landscape Features Affecting Irrigation Suitability	30
Table 13.	Soil and Landscape Conditions Affecting Environmental Impact Rating	30
Table 14.	Soil Chemical and Physical Analysis at Survey Grid Points.	33
Table 15.	EM 38 Background Readings at Survey Grid Points	37

LIST OF FIGURES

Figure 1.	Location of Study Area	2
Figure 2.	Depth to Clay Substrate and Stratigraphic Cross-Section	3
Figure 3.	Location of Groundtruth and Sampling Sites	8
Figure 4.	Selected Chemical and Physical Characteristics of Surface Soils	20
Figure 5.	Distribution of Soil Drainage Regime	21
Figure 6.	Surface Soil Texture	21
Figure 7.	Organic Matter Content of Surface Soils.	22
Figure 8.	pH of Surface Soils	22

PART 1

GENERAL DESCRIPTION OF STUDY AREA

1.1 LOCATION AND EXTENT

The Carman Research Station is located in the N 1/2 of Section 23, Township 6, Range 5, west of the Principal Meridian (Figure 1). The area of the research station is 96.3 ha excluding the portion of Section 23 to the north of the Boyne River.

The soils of this part of Manitoba were initially mapped at a reconnaissance scale of 1:125 000 (Ellis and Shafer, 1943). Subsequently the area was resurveyed at a detailed scale of 1:20 000 (Michalyna et al., 1988).

1.2 PHYSIOGRAPHY AND SURFACE DEPOSITS

The study area is located in the Red River Valley subsection of the Red River Plain. The Red River Valley is characterized by level, deltaic and lacustrine deposits occurring at elevations between 263 and 270 m a.s.l. The dominant surface deposits in the study area occur on level terrain and range in particle size from coarse loamy to clayey; the entire study area is underlain by lacustrine clay at depths varying from the surface to about 2 m. The stratigraphic relationship of the surface lacustrine and deltaic sediments to the underlying clay substrate is shown in Figure 2. A small area of recent fluvial (alluvial) sediments is associated with the floodplain of the Boyne River.

1.3 RELIEF AND DRAINAGE

The study area is characterized by dominantly level (0 - 0.5 % slope) to nearly level (0.5 - 2.5 % slope) terrain. A subdued, very gently to gently sloping escarpment (2.5 - 9 % slope) in the western part of the study area forms the boundary between the lacustrine sediments of the Red River Plain and the fluvial deposits associated with the Boyne River. The land surface outside the river channel slopes to the east at about 1.5 to 2 meters per kilometer whereas the land surface within the Boyne channel slopes gently towards the river channel.

Surface drainage in the study area is weakly developed although better drained conditions occur in the proximity of the incised channel of the Boyne River. The soils in the study area are dominantly well to imperfectly drained. In some years it is normal for the water table to be within a meter of the soil surface throughout the spring and early summer. In fall and winter, groundwater levels are commonly between 1.5 to 2 m. The water tables in this area are shallow and usually perched on the surface of the underlying clay substrate. The depth to the groundwater and its persistence near the soil surface and in the rooting zone is very dependent on the depth to the underlying clay. In parts of the study area, notably the southwest corner and along the eastern edge, a shallow water table was observed in May and early June of 1992.

1.4 CLIMATE

The study area is characterized by a continental climate affected by extreme variability of weather pattern within each season. Climatic conditions are reasonably well represented by long term meteorological data from weather stations within a 70 km radius of the study area. Climatological data from five of these stations are presented in Tables 1 and 2. Other climatic parameters relevant to crop growth in the study area are presented in Table 3.

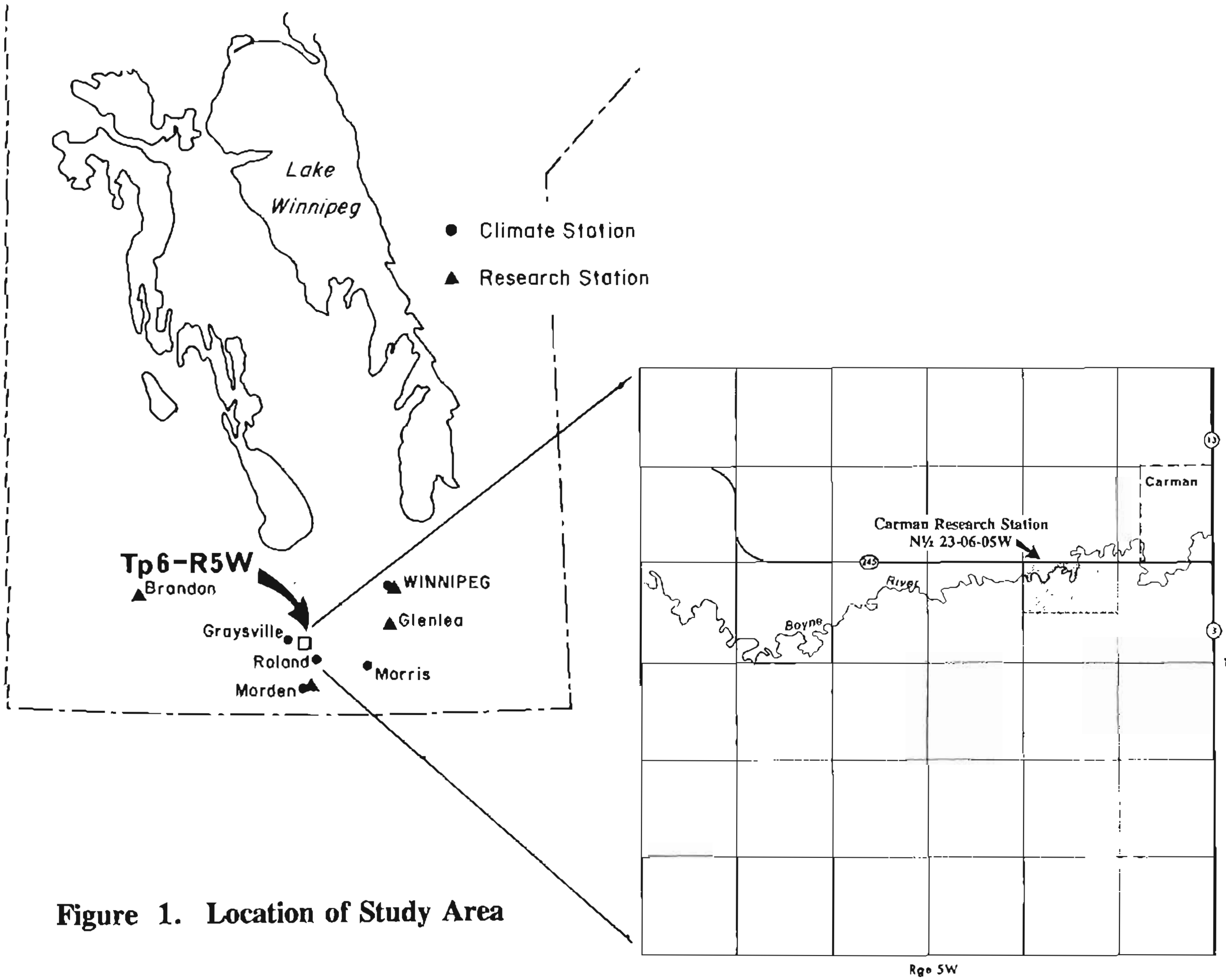

Figure 1. Location of Study Area

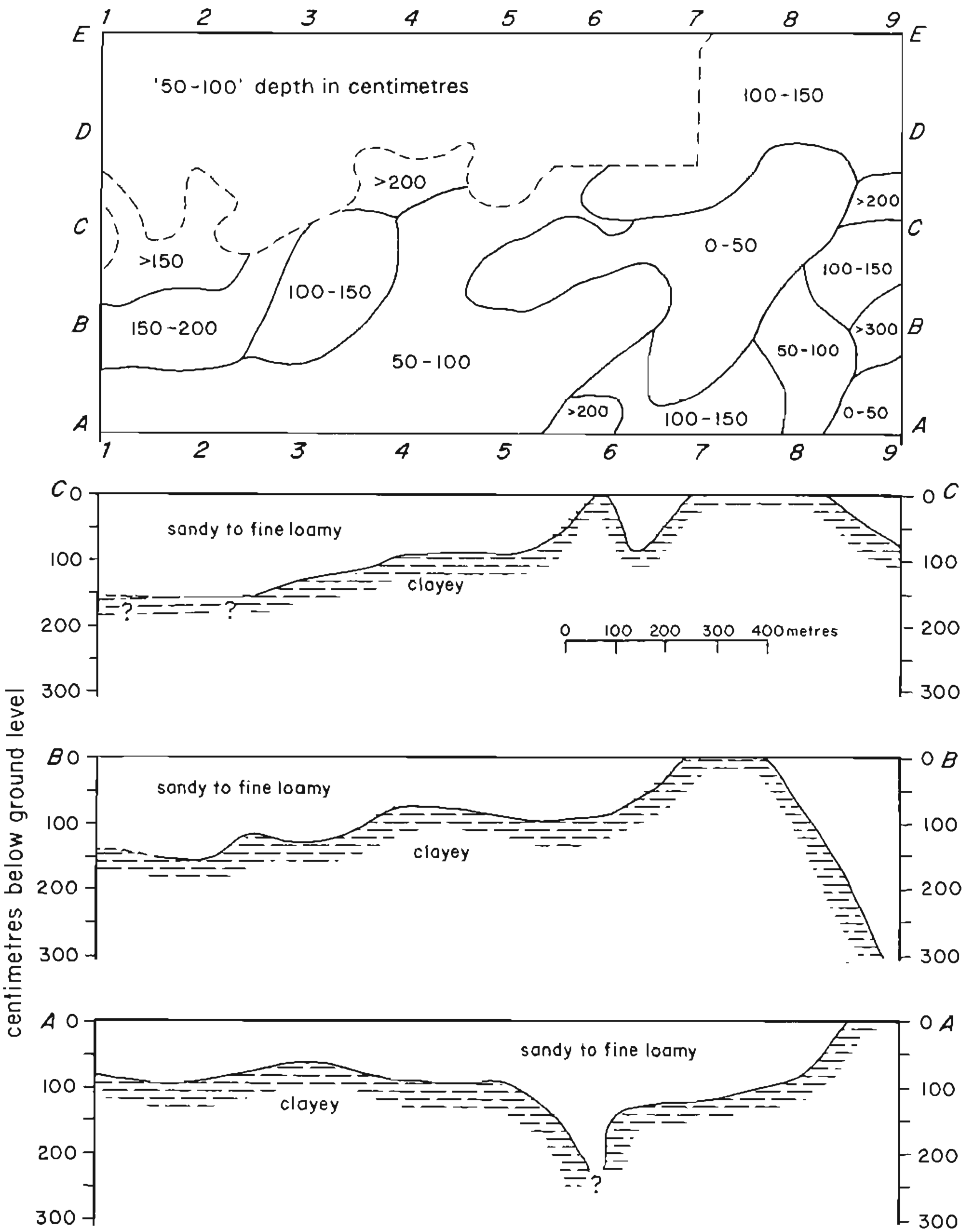

Figure 2. Depth to Clay Substrate and Stratigraphic Cross-Section

Table 1. Climatic Parameters at Selected Climate Stations in South-Central Manitoba (Atmospheric Environment Service, 1982)

Climatic Parameter	Climate Station				
	Graysville	Morden	Morris	Roland	Winnipeg
Elevation m.a.s.l	279	297	233	262	236
Temperature, °C:					
mean annual	2.4	3.3	2.6	2.8	2.2
mean maximum	8.6	8.7	8.6	8.7	7.8
mean minimum	-3.8	-2.2	-3.4	-3.1	-3.4
Precipitation:					
mean annual, mm	515	530	516	472.2	525.5
rainfall, mm (May 1-Sept 30)	318	336	323	298	347
Mean Monthly rainfall, mm					
• May	56.1	64.0	59.5	54.7	63.2
• June	75.4	75.8	74.3	73.5	80.1
• July	70.9	73.2	76.6	66.3	75.9
• August	63.7	71.1	65.3	55.8	75.2
• September	51.6	51.6	47.1	47.5	53.0

Table 2. Frost Data and Probability for Last Freezing Temperature, Spring and First Freezing Temperature, Fall at Selected Climate stations in South Central Manitoba (Atmospheric Environment Service, 1982).

Station Location	Probability Level						
	10% (1 in 10)	25% (1 in 4)	33% (1 in 3)	50% (1 in 2)	66% (2 in 3)	75% (3 in 4)	90% (4 in 10)
Spring Frost on or after							
Graysville	June 5	May 29	May 24	May 19	May 15	May 15	May 9
Morden	June 1	May 26	May 21	May 17	May 14	May 12	May 8
Morris	June 1	May 26	May 24	May 19	May 14	May 12	May 9
Roland	June 3	May 25	May 23	May 19	May 17	May 15	May 9
Winnipeg	June 10	May 31	May 26	May 23	May 17	May 12	May 7
Fall Frost on or before							
Graysville	Sept 4	Sept 10	Sept 13	Sept 16	Sept 21	Sept 22	Sept 25
Morden	Sept 11	Sept 19	Sept 21	Sept 23	Sept 24	Sept 28	Oct 4
Morris	Sept 11	Sept 15	Sept 18	Sept 21	Sept 24	Sept 27	Oct 4
Roland	Sept 6	Sept 11	Sept 12	Sept 18	Sept 21	Sept 24	Oct 1
Winnipeg	Sept 11	Sept 17	Sept 18	Sept 21	Sept 22	Sept 27	Oct 3
Frost free period (days) equal to or less than							
Graysville	92	106	112	119	124	128	134
Morden	106	119	124	125	133	134	137
Morris	106	114	114	126	128	134	137
Roland	96	108	114	120	125	126	133
Winnipeg	92	111	114	122	128	132	141

Table 3. Climatic Parameters Relevant to Crop Growth at Selected Climate Stations in South Central Manitoba (Ash, 1991)

Climatic Parameter	Probability Level	Climate Station				
		Graysville	Morden	Morris	Roland	Winnipeg
Corn Heat Units	50	2463	2686	2651	2542	2575
	25	2338	2533	2489	2380	2432
	10	2225	2394	2342	2229	2302
Growing Degree-Days (base 5°C)	50	1660	1783	1778	1673	1697
	25	1573	1692	1664	1596	1609
	10	1495	1610	1561	1524	1530
Frost-free period days (base -2.2°C)	50	137	140	135	136	135
	25	128	134	126	128	128
	10	121	128	119	121	122
Plant moisture stress, mm at soft dough stage for wheat	50	-28	-19	-31	-18	-9
	25	-51	-37	-55	-34	-23
	10	-71	-53	-77	-49	-36

PART 2

METHODOLOGY

Field investigations for the current study were carried out in 1992 and involved the following activities: firstly, a detailed soil survey was conducted utilizing routine procedures for inspecting, describing and sampling soil profiles to determine the variability of the soils for a detailed soil map. Secondly, the grid established for the soil map was utilized as a base for a series of site-specific field measurements and sampling. A third activity included a soil salinity survey conducted using an EM 38 electromagnetic induction instrument to assess the presence and level of salinity in the 0 to 60 cm and 0 to 120 cm depths. The grid points utilized for the soil survey were sampled to determine selected chemical and physical properties of the surface soils. Following completion of the initial soil map, selected soils were sampled for detailed characterization of soil properties.

2.1 Soil Survey and Mapping

Soils were inspected along a 200 m grid comprised of five east-west transects across the study area. This grid survey resulted in an average soil inspection density of 1 site per 1.8 ha. The soil inspections were made with a hand spade to a depth of at least 120 cm at all sites and a hand auger was employed to determine the depth to the underlying clay substrate at sites where it was encountered at lower depths. Soil characteristics were recorded and each soil profile was classified according to standard soil survey procedures (Agriculture Canada, 1987). Surface soil samples were collected at each grid point for laboratory analysis using standard analytical methods (McKeague, 1978). The location of the survey grid points and sampling sites is shown in Figure 3.

2.2 Soil Map

The soils were mapped on an air photograph enlarged to a scale of 1:5 000. Ten soil series were identified and shown on the detailed soil map included in the pocket of the report. A number of derived and interpretive maps were generated from the basic soil map and supporting data. These include the following: depth to clay, soil drainage, surface soil texture, pH and organic matter.

2.3 Soil Salinity

A limited number of samples were analyzed for electrical conductivity (Appendix B, Table 14). In addition, electrical conductance measurements using an EM 38 instrument were made along the five transects through the study area. This resulted in a total of 32 grid point measurements of Electrical Conductance (EC) of the bulk soil. The EM 38 readings recorded for the 0-60 cm and the 0-120 cm depths are presented in Appendix B, Table 15.

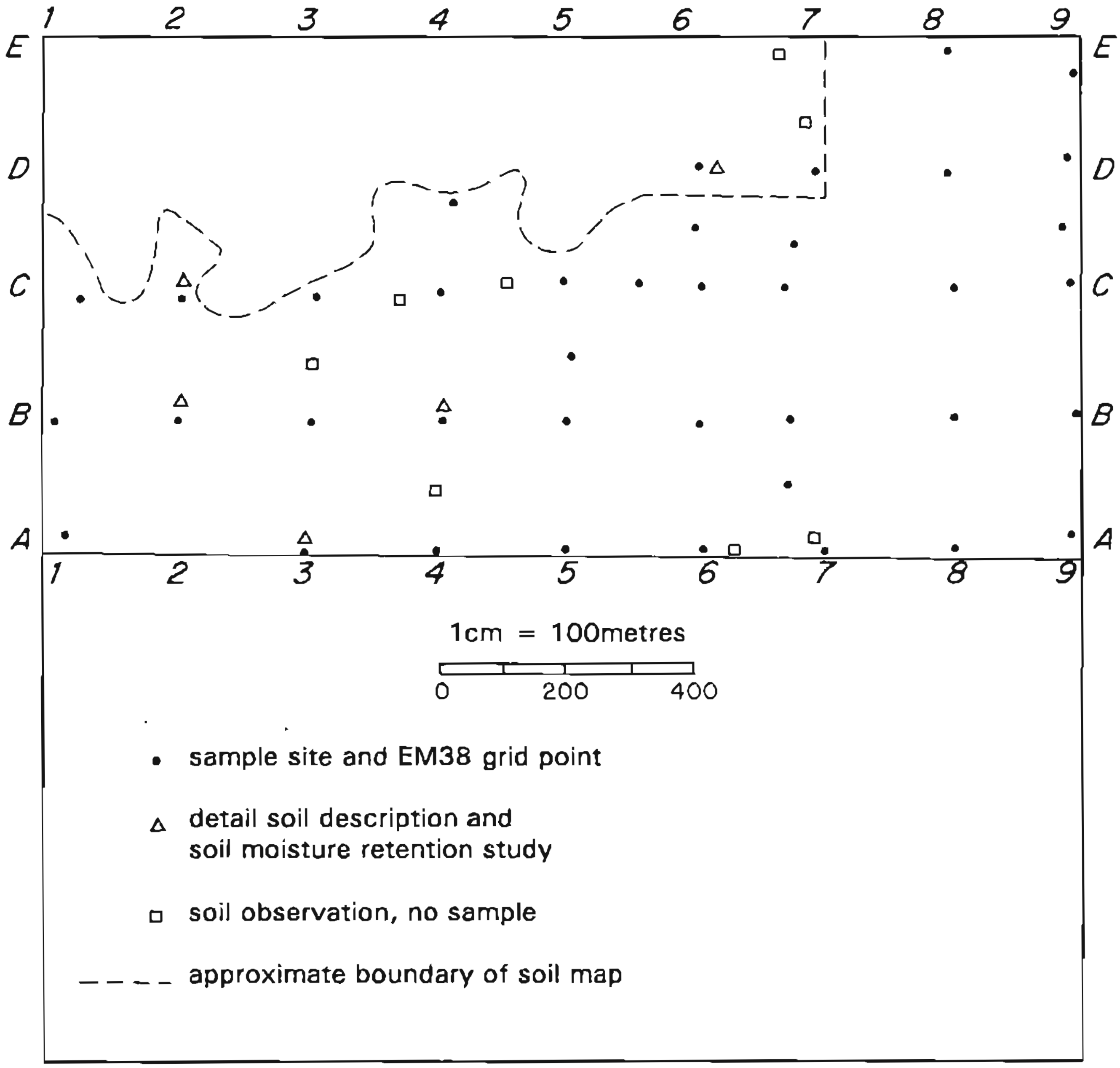

Figure 3. Location of Groundtruth and Sampling Sites

PART 3

DEVELOPMENT, CLASSIFICATION AND DESCRIPTION OF SOILS

3.1 INTRODUCTION

This section describes the important characteristics of the soils and the relationship of soil parent material and drainage to soil profile type (genetic soil subgroup classification) and soil series in the study area. The soils on the research station have been mapped and classified (Ellis and Shafer, 1943) as members of the Almasippi and Riverdale Soil Associations. The 1:20 000 scale detailed resurvey of this area resulted in the identification and mapping of six soil series within the study area (Michalyna et al., 1988).

The present detailed study of the soils recognized ten soil series to describe the soil variability on the research station. The detailed mapping at 1:5 000 scale indicates that the soils are dominantly well to imperfectly drained Black Chernozems with a small area of Cumulic Regosols occurring in the floodplain of the Boyne River. The soils are developed on lacustrine and deltaic sediments which vary in particle size from coarse loamy to fine loamy and clayey; all of the soils are underlain by clayey sediments occurring at depths ranging from the surface to in excess of 2 m.

3.2 SOIL DESCRIPTIONS

A general description of each soil series is given in this section. A key to the classification of the soils in the study area in relation to their parent material and drainage is provided in Table 4. The approximate area in hectares and proportionate extent of each soil series is included.

Characteristics of the soil, including genetic profile type and the material in which the soil formed are described. Surface texture, parent material type and texture, topography and drainage are discussed for each series. These characteristics were determined from soil inspections on the research station so may be expected to vary slightly from the modal characteristics of each soil as defined from a larger sample over a broader geographic area. Soil chemical and physical analysis obtained from soil samples taken at grid points during the survey are presented in Appendix B, Table 14 (texture, particle size analysis, organic carbon, pH, electrical conductivity and saturation percentage).

Information on the suitability and management requirement of each soil for dryland and irrigation agriculture is presented in Part 4.

Denham Series (DNH)

The Denham series consists of moderately well to well drained Orthic Black soil developed on a mantle (60 to 90 cm) of moderately to strongly calcareous, shallow, loamy (VFSL, L, SiL, CL, SiCL, SCL), lacustrine sediments over moderately to strongly calcareous, deep, clayey (C, SiC), lacustrine sediments. These soils occur in upper positions of very gentle slopes on undulating landscapes and have moderate to moderately slow permeability overlying slowly permeable clays; moderate to moderately rapid surface runoff, and a low water table during the growing season. Denham soils are noneroded, nonstony, and nonsaline. They have medium available water holding capacity, high organic matter content, and high natural fertility. The majority of these soils are currently cultivated for grain and forage crop production.

In a representative profile of Denham soil the solum is approximately 60 cm thick. The profile is characterized by a very dark gray to black Ap horizon, 15 to 20 cm thick, usually underlain by 10 to 15 cm of dark gray Ah horizon and a very dark grayish brown to brown Bm horizon, 25 to 35 cm thick, a weakly calcareous BC horizon, 5 to 10 cm thick, and a yellowish brown to pale brown, moderately to strongly calcareous Ck horizon. The parent material is typically faintly mottled at depth.

Denham soils occur in close association with Rignold and Graysville soils. They are similar to Hibsin soils by having an Orthic Black profile and clayey substrate but differ from them in having a loamy mantle rather than a coarse loamy mantle. Denham soils were previously mapped as Blackearth associates of the Rathwell Association in the Carberry (1957) soil report or the well drained menber of the Altona heavy subsoil phase soils in the South Central (1943) soil report.

Eigenhof Series (EGF)

The Eigenhof series consists of moderately well to well drained Orthic Black soil developed on moderately to strongly calcareous, deep, stratified, fine loamy (CL, SiCL, SCL), lacustrine sediments. These soils occur in upper positions of nearly level to very gentle slopes on undulating landscapes and have moderate to moderately slow permeability, moderate surface runoff, and a low water table during the growing season. Eigenhof soils are noneroded, nonstony and nonsaline. They have a medium available water holding capacity, medium organic matter content, and high natural fertility. The majority of these soils are currently cultivated for grain crop production.

In a representative profile of Eigenhof soil the solum varies from 40 to 70 cm thick. The profile is characterized by a very dark gray to black Ah horizon, 20 to 50 cm thick, a grayish brown Bm horizon, 15 to 35 cm thick, a weakly calcareous, transitional BC horizon 5 to 15 cm thick, and a moderately calcareous Ck horizon with stratified VFS, SiL and SiCL textures. A typical profile also contains thin layers of fine sand to silt below the solum.

Eigenhof soils are closely similar to Denham soils in having an Orthic Black profile but differ from them in lacking the clayey substrate diagnostic of Denham soils. Eigenhof soils were previously mapped as Blackearth associates of the Rathwell Association in the Carberry (1957) soils report and inclusions within the Morden Association in the South Central (1943) soil report.

Hochfeld Series (HHF)

The Hochfeld series consists of moderately well drained Orthic Black soil developed on moderately calcareous, coarse loamy (VFS, LVFS, FSL, SL), lacustrine deposits. These deposits range in thickness from 1.5 to 5 meters over clayey lacustrine sediments. The Hochfeld soils occur in upper positions of very gentle slopes on undulating landscapes and have moderately rapid permeability, moderate surface runoff, and a low water table during the growing season. Hochfeld soils are often slightly eroded or overblown and are usually nonstony and nonsaline. They have a medium available water holding capacity, medium organic matter content, and medium natural fertility. The majority of these soils are currently cultivated for grain and forage crop production.

In a representative profile of Hochfeld soil the solum is approximately 50 to 90 cm thick. The profile is characterized by a dark gray to very dark gray Ah horizon, 30 to 50 cm thick, a brown Bm horizon, 15 to 40 cm thick, usually a light brown Cca horizon, 5 to 8 cm thick, and a brown Ck horizon, with many faint mottles.

Hochfeld soils occur in close association with Reinland soils. These soils were previously mapped as Blackearth associates of the Almasippi Association in the Carberry (1957) soil report and the Altona (light) Association in the South Central (1943) soil report.

Hibsin Series (HIN)

The Hibsin series consists of moderately well drained Orthic Black soil developed on a mantle (40 to 90 cm) of moderately to strongly calcareous, shallow, sandy (FS, LFS, LS) to coarse loamy (VFS, LVFS, FSL, SL), lacustrine deposits overlying moderately calcareous, uniform, deep, clayey (SiC, C), lacustrine sediments. These soils occur in upper positions of very gentle slopes on undulating landscapes and have moderately rapid surface permeability decreasing to slow permeability with depth, moderate surface runoff, and a low water table during the growing season. Hibsin soils are slightly eroded or overblown, nonstony, and nonsaline. They have a medium available water holding capacity, high organic matter content, and medium natural fertility. The majority of these soils are currently cultivated for grain and forage crop production.

In a representative profile of Hibsin soil the solum is approximately 70 cm thick. The profile is characterized by a very dark gray to dark gray Ah horizon, 30 to 40 cm thick, a brown Bm horizon, 30 to 40 cm thick, a Cca horizon, 8 to 13 cm thick with lime accumulation and a Ck horizon. The profile is usually developed entirely in the sandy to coarse loamy material.

Hibsin soils occur in close association with Hochfeld soils, differing mainly in the more shallow depth to the underlying clayey material. They are similar to Elm Creek soils by having a B horizon in coarse loamy deposits but differ from them in lacking mottles in the Bm horizon. Hibsin soils were previously mapped as Blackearth associates of the Almasippi, clay substrate phase, Association in the Carberry (1957) soil report.

Kronstal Series (KOT)

The Kronstal series consists of an imperfectly drained Gleyed Black soil developed on moderately calcareous, deep, stratified, coarse loamy (VFS, LVFS, FSL, SL), lacustrine deposits. These soils occur in middle positions of nearly level slopes on undulating landscapes and have moderate to moderately rapid permeability, moderately slow surface runoff, and a high water table during the growing season. Kronstal soils are noneroded, nonstony, and occasionally slightly saline at lower depths. They have medium available water holding capacity, high organic matter content, and medium natural fertility. The majority of these soils are currently cultivated for grain crop production.

In a representative profile of a Kronstal soil the solum is approximately 55 cm thick. The profile is characterized by a very dark gray Ah horizon, 20 to 30 cm thick, a grayish brown to brown Bmgj horizon, 20 to 40 cm thick with fine to medium yellowish mottles, a Cca horizon, 8 to 13 cm thick and a Ckgj horizon with distinct mottles. The parent material is typically stratified with layers of FS to LFS texture.

Kronstal soils occur in close association with Reinland soils. Kronstal soils were previously mapped as Black Meadow associates of the Almasippi Association in the Carberry (1957) soil report and one of the imperfectly drained members of the Altona Association in the South Central (1943) soil report.

La Salle Series (LSL)

The La Salle series consists of moderately well drained Cumulic Regosol soil developed on moderately to strongly calcareous, deep, stratified, loamy (VFSL, SiL, L, SiCL, CL), recent alluvial sediments. These soils occur in upper positions of gentle slopes on meander scrolls and levee landscapes, have moderate permeability, moderate surface runoff, and a low water table during the growing season. La Salle soils are slightly eroded, nonstony, and non-saline. They have a medium available water holding capacity, medium organic matter content, and medium natural fertility. The majority of these soils are currently cultivated for forage and grain crops.

In a representative profile of La Salle soil the solum is very weakly developed. The profile is characterized by a weakly developed, dark gray Ah horizon, 5 to 15 cm thick, and a grayish brown Ck horizon with strata of Sil, SiCL, VFS and FS textures.

La Salle soils occur in close association with Gervais and Willowbend soils. They are similar to Gervais soils by having stratified layers of variable texture and organic matter content on loamy alluvium but are better drained and lack mottles within the profile. La Salle soils were previously mapped as well drained associates of the Riverdale Association in the Carberry (1957) soil report.

Plum Coulee Series (PME)

The Plum Coulee Series consists of imperfectly drained Gleyed Black soil developed on moderately to strongly calcareous, deep, stratified, clayey (C, SiC, SC), fluvial and lacustrine sediments. These soils occur in the western part of the Red River Plain in middle positions of level to very gently sloping landscapes. Surface runoff is slow, permeability is slow and many of these soils have a high water table during the growing season. The Plum Coulee soils are noneroded, nonstony, and frequently slightly saline in the subsoil. They have a high available water holding capacity, high organic matter content, and medium natural fertility. The majority of these soils are currently cultivated for grain crop production.

In a representative profile of Plum Coulee soil the solum is approximately 50 to 70 cm thick. The profile is characterized by a very dark gray Ah horizon, 30 to 45 cm thick; a dark gray to dark grayish brown Bmgjg horizon, 15 to 30 cm thick with weakly developed medium prismatic and moderate medium granular structure. Faint mottles are apparent in the lower B horizon and are more noticeable with increasing depth. The mottled Ckgj horizon is usually weakly stratified with thin silty layers and dominantly clay textures. Gypsum crystals may also occur in the C horizon.

Plum Coulee soils occur in close association with Deadhorse soils. They are similar to Deadhorse soils by having an imperfectly drained clayey profile but differ from them in having a weak, colour Bmgj horizon. Plum Coulee soils were previously mapped as intermediately drained clayey Blackearth associates of the Morden Association in the South Central (1943) soil report.

Reinfeld Series (RFD)

The Reinfeld series consists of moderately well to well drained Orthic Black soil developed on moderately to strongly calcareous, shallow, stratified, loamy (VFSL, L, SiL) lacustrine sediments grading to moderately calcareous, fine loamy (CL, SiCL, SCL), lacustrine sediments. These soils occur in upper positions of very gentle slopes on undulating landscapes and have moderate permeability, moderate surface runoff, and a low water table during the growing season. Reinfeld soils are noneroded, nonstony, and nonsaline. They have medium available water holding capacity, medium organic matter content, and high natural fertility. The majority of these soils are currently cultivated for grain and forage crop production.

In a representative profile of Reinfeld soil the solum is approximately 70 cm thick. The profile is characterized by a very dark gray Ah horizon, 35 to 45 cm thick, a brown Bm horizon, 25 to 35 cm thick, and a pale brown Ck horizon with occasional faint mottles.

Reinfeld soils occur in close association with Gnadenthal soils. They are similar to Denham soils by having a well drained Orthic Black profile and a loamy surface but differ from them in having no clayey substrate. Reinfeld soils were previously mapped as Blackearth associates of the Rathwell Association in the Carberry (1957) soil report and well drained members of the Altona Association in the South Central (1943) soil report.

Rignold Series (RGD)

The Rignold series consists of imperfectly drained Gleyed Black soil developed on a mantle (60 to 90 cm) of moderately calcareous, shallow, uniform, loamy (VFSL, L, SiL, CL, SiCL, SCL), fluvial and lacustrine sediments over moderately calcareous, deep, uniform, clayey (SiC,C), lacustrine sediments. These soils occur in middle positions of nearly level to very gently sloping landscapes and have moderate surface permeability and slow to very slow permeability at depth, slow surface runoff, and a high water table during the growing season. Rignold soils are noneroded, nonstony, and occasionally slightly saline. They have medium available water holding capacity, medium organic matter content, and medium natural fertility. The majority of these soils are currently cultivated for grain and forage crop production.

In a representative profile of Rignold soil the solum is approximately 50 cm thick. The profile is characterized by a very dark gray Ah horizon, 20 to 50 cm thick, a light brown Bmgj horizon, 20 to 30 cm thick, a transitional BC horizon, 10 to 15 cm thick, with faint mottles and a light olive brown Ckgj horizon with fine yellowish brown mottles.

Rignold soils occur in close association with Denham and Graysville soils. They are similar to Graysville soils by having imperfect drainage and loamy surface soil over clayey sediments but differ from them in having a prominent Bmgj horizon. Rignold soils were previously mapped as Black Meadow associates of the Rathwell Association in the Carberry (1957) soil report and as imperfectly drained members of the Altona heavy subsoil phase in the South Central (1943) soil report.

Winkler Series (WIK)

The Winkler series consists of moderately well drained Orthic Black soil developed on moderately calcareous, deep, stratified, clayey (SiC, C), lacustrine deposits. These soils occur in middle to upper slope positions of level to very gently sloping landscapes and have moderately slow permeability, moderately slow surface runoff, and a medium water table during the growing season. Winkler soils are noneroded, nonstony, and nonsaline and have high available water holding capacity, high organic matter content, and medium natural fertility. The majority of these soils are currently cultivated for grain and forage crop production.

In a representative profile of Winkler soil the solum is approximately 40 cm thick. The profile is characterized by a very dark gray Ah horizon, 13 to 25 cm thick, a dark brown Bm horizon, 20 to 35 cm thick with moderate medium granular to prismatic structure, and a Ck horizon with dominantly SiC to C textures. The parent material is typically stratified with lighter (SiL, SiCL) textures at depth.

Winkler soils occur in close association with Plum Coulee soils. Winkler soils were previously mapped as Blackearth associates of the Horndean Complex in the Winnipeg-Morris (1953) soil report, Blackearth associates of the Rathwell Association in the Carberry (1957) soil report and the moderately well drained member of the Morden Association in the South Central (1943) soil report.

Table 4. Classification of Soil Series in Relation to Drainage and Parent Material[1]

Soil Drainage	Soil Subgroup[2]	Parent Materials						
		Coarse Loamy LFS,FS,FSL	Sandy-Coarse Loamy/Clayey FS,LFS,FSL/C	Loamy VFSL,L,Sil	Loamy/Clayey VFSL,L,Sil/C	Fine Loamy L,SiL,CL,SiCL	Loamy,Fluvial Stratified	Clayey, Fluvial Stratified
Well to moderately well	Orthic Black	**Hochfeld** (HHF) 13.0 ha, 13.5%	**Hibsin** (HIN) 9.1 ha, 9.5%	**Reinfeld** (RFD) 5.9 ha, 6.2%	**Denham** (DNH) 21.6 ha, 22.4%	**Eigenhof** (EGF) 8.6 ha, 8.9%		**Winkler** (WIK) 16.5 ha, 17.2%
	Cumulic Regosol						**La Salle** (LSL) 7.2 ha, 7.5%	
Imperfect	Gleyed Black	**Kronstal** (KOT) 2.2 ha, 2.3%	Elm Creek (EEK)		**Rignold** (RGD) 11.2 ha, 11.6%			Plum Coulee (PME) 1.0 ha, 1.0% Deadhorse (DHO)
	Gleyed Rego Black	Reinland (RLD)	Rosebank (RBK)	Gnadenthal (GDH)	Graysville (GYV)			
	Gleyed Cumulic Regosol						Gervais (GVS)	

1 Soil types mapped and observed in study area. Dominant soils describing map units indicated in bold print with estimated areal extent in hectares.

2 The Canadian System of Soil Classification 2nd Ed., Agric. Canada Publ., 1646. 164pp.

PART 4

USE AND MANAGEMENT INTERPRETATIONS OF SOILS

4.1 INTRODUCTION

This section provides predictions of performance or soil suitability ratings for various land uses based on soil and landscape characteristics, laboratory data and on soil behaviour under specified conditions of land use and management. Suitability ratings or interpretations are intended to serve as guides for planners and managers.

Soil properties determine to a great extent the potential and limitations for both dryland and irrigation agriculture. In this section, interpretive soil information is provided for the following agricultural land use evaluations:

a) soil capability for agriculture
b) irrigation suitability

4.2 SOIL CAPABILITY FOR AGRICULTURE

The classification of soil capability for agriculture is based on an evaluation of both soil characteristics and landscape conditions that influence soil suitability and limitations for agricultural use. In this classification, mineral soils are grouped into classes of capability or general suitability; subclasses describe the type of limitation or properties that affect dryland farming. These ratings imply a risk to regional production capacity when the soils are used and the way they respond to management (Anon, 1965). There are seven capability classes, each of which groups soils together that have the same relative degree of potential for agricultural use or risk or hazard for use as indicated by the subclass limitation. The subclass limitation becomes progressively greater from Class 1 to Class 7.

4.2.1 Soil Capability Classes

The class indicates the general suitability of the soils for agriculture. The first three classes are considered capable of sustained production of common field crops, the fourth is marginal for sustained arable agriculture, the fifth is suitable only for improved permanent pasture, the sixth is capable of use only for native pasture while the seventh class is for soils and land types considered incapable of use for arable agriculture or permanent pasture. A description of the capability classes is provided in Appendix A, Table 8.

4.2.2 Soil Capability subclasses

Soil capability classes identify the soil properties or landscape conditions that may limit use or be a hazard and to which soils these properties or conditions are assigned. The various kinds of limitations recognized at the subclass level are defined in Appendix A, Table 9.

4.2.3 Soil Capability

The soils on the research station were evaluated and classified as dominantly class 1 with several local areas of class 2 and 3 soils. The main limitation for agriculture is a moderate moisture limitation due to low water holding capacity (class 2M and 3M). The class 2M and 3M soil areas are sufficiently sandy that they are also subject to potential degradation due to erosion by wind.

The soils developed on the floodplain of the Boyne River experience a cumulative effect of two or more adverse characteristics which singly are not serious enough to affect the capability and are rated in class 2X.

Imperfectly drained clayey soils on the Station are characterized by level terrain and low relief, resulting in slow rates of runoff which combines with very slow percolation rates resulting in a continuing moderate limitation due to excess water (Class 2W).

A summary of the soils in the study area showing their areal extent and their interpretive classification for dryland agriculture is presented in Table 5.

4.3 IRRIGATION SUITABILITY

The irrigation suitability classification is an interpretive assessment of land suitability for irrigated agriculture and is made from soil survey data. The irrigation rating provided in this section is an initial rating based on general information about specific soils indicated on the soil map. **The decision to irrigate a parcel of land will require additional field investigation that utilizes the same criteria but will include on site examination of water tables, salinity and stratigraphy to a depth of 3 meters.**

The rating guidelines in this section are derived from "An Irrigation Suitability Classification System for the Canadian Prairies" (ISC, 1987). This classification system takes into account recent advances in irrigation management and technology and provides general guidelines for irrigation suitability classification that are applicable to both local and regional conditions. The irrigation suitability rating of the soils is based on soil and landscape characteristics. These characteristics are ranked in terms of their sustained quality under long-term management under irrigation. It does not consider factors such as method of water application, water availability, water quality or economics of this type of land use.

Soil properties considered important for evaluating irrigation suitability are: texture, soil drainage, depth to water table, salinity and geological uniformity. **Landscape features** considered important for rating irrigation suitability relate mainly to the influence of topography and stoniness.

The irrigation suitability classification of the soil and landscape characteristics in the study area will assist in making initial irrigation plans. The decision to irrigate a parcel of land should first be based on a ranking of suitability based on information presented in this report. The next step should involve on site field investigation to examine the depth to water table, salinity and geological uniformity to a depth of 3 m. Drainability, drainage outlet requirement, organic matter status and potential for surface crusting are other factors to consider. This assessment should also consider potential impact of irrigation on "Non-target" non-irrigated areas as well as on the irrigated area.

4.3.1 Irrigation Suitability Rating

The most limiting soil property or landscape feature is combined to determine the placement of a land area in one of 16 classes of irrigation suitability which are grouped and described by 4 ratings of general suitability as **Excellent, Good, Fair and Poor** (Appendix A, Table 10). The guidelines utilized for evaluating the effect of soil properties and landscape features on long term irrigation are included in Appendix A, (Tables 11 and 12 respectively).

An example of an irrigation suitability class rating is shown below:

Soil Limitation — Landscape Limitation

3 g x B t — Landscape feature

Soil factors

A maximum of 3 codes is used to identify the subclass rating. Geological uniformity (g) and drainability (x) are soil factors contributing to the soil rating of Class 3, Moderate. Complex topography is the limiting landscape characteristic of the area for rating irrigation suitability. As the soil factor (Class 3, Moderate) is more limiting than the landscape feature (Class B, Slight) the general rating for this land area is Fair (Table 10).

An ideal soil area to be used for irrigation will have the following characteristics:

- -loam texture
- -uniform texture both vertically and horizontally
- -uniformly well drained
- -non saline
- -permeable
- -nearly level
- -non stony

Any departure from these characteristics, ie sandy and clayey soils, presence of contrasting textural layers vertically in the soil, horizontal variation in soil texture within the landscape, imperfect and poor drainage, salinity, reduced soil permeability, undulating and hummocky topography and surface stoniness will lower the irrigation suitability. These factors may not only influence the sustainability of irrigation but can also affect the type of irrigation system that can be used and the type of management needed.

Areas with no or slight soil and/or landscape limitations are rated **Excellent** to **Good** and can usually be considered irrigable. Areas with moderate soil and/or landscape limitations are rated as **Fair** and considered marginal for irrigation providing adequate management exists so that the soil and adjacent areas are not adversely affected by water application. Soil and landscape areas rated as **Poor** have severe limitations for irrigation.

The irrigation suitability ratings in Table 5 are based largely on soil characteristics in the upper 1.2 m and the main landscape features for each soil series and phase. Limited information available to the 3 m depth was used to characterize the geological uniformity of major soil types. Following the initial ranking of irrigation suitability, a more detailed investigation may indicate that portions of the area are significantly better or poorer than the general rating indicated. For example, within an area with an overall Poor rating (due to low water holding capacity), there may be local areas of more favourable soils that could be utilized for smaller-scale irrigation.

4.3.2 Environmental Impact

An assessment of potential environmental impact from irrigation is provided in Table 5. The environmental impact from irrigation on either the irrigated land or on "non-target", non irrigated areas and crops is an important aspect to consider prior to irrigation development. The guidelines for environmental impact assessment provide relative general ratings ranging from **"none to low, moderate and high"** (Table 13). This rating recognizes soil and/or landscape conditions which under irrigation could impact on the irrigated area as well as a "non-target" non-irrigated area. Examples of adverse environmental impact are higher water tables, more persistent soil saturation, increased soil salinity and contamination of groundwater or surface water.

Use of this rating is intended to serve as a warning of possible environmental impact but it is not part of the initial irrigation suitability classification. The evaluation of potential environmental impact has been separated from the initial irrigation suitability rating provided in the ISC system (1987) since it may be possible to design and manage the irrigation system to overcome these limitations. The irrigator must determine the nature or cause of a specific environmental concern and then give special consideration to soil-water-crop management practices that will mitigate the possibility for any adverse impact.

Soil factors and landscape features considered in providing a potential environmental impact evaluation are:

1. Soil Texture
2. Geological Uniformity
3. Hydraulic Conductivity
4. Depth to Water Table
5. Salinity
6. Topography

4.4 SOIL PROPERTIES AFFECTING CROP MANAGEMENT

This section provides a summary of specific soil properties that affect various management and associated tillage activities for crop production. Selected chemical and physical characteristics of the surface soils (organic matter content, pH and particle size distribution) are summarized in Table 6 and plotted at each grid point in Figure 4. Depth to clay is shown in Figure 2 and soil drainage characteristics are shown in Figure 5. Surface soil texture is mapped in Figure 6, the organic matter content of the surface soils is shown in Figure 7 and the pH of the surface soils is shown in Figure 8. Soil moisture properties determined from 5 soil types in the study area are summarized in Table 7. Soil chemical and physical analysis at the survey grid points (see location on Figure 3) are presented in Appendix B, Table 14.

4.4.1 Particle Size Distribution

Particle size distribution (proportion of sand, silt and clay) affects soil tilth, moisture holding capacity, permeability and susceptibility to erosion. Clay soils, if cultivated when too moist or dry, will form large massive sticky lumps or very hard clods, resulting in a poor seedbed and usually poor germination. Therefore, timing and ease of tillage on some of the heavier clay soils, e.g. Winkler and Plum Coulee series, becomes a significant management factor. Soil structure and tilth on the clay soils may be improved through residue management which includes incorporation of stubble or green manure crops.

All cultivated soils are subject to erosion if

Table 5. Agricultural Capability and Irrigation Suitability Rating.

Map Symbol	Soil Name	Areal Extent		Agricultural Capability Class	Irrigation Suitability		
		ha	%		Class	General Rating	Potential Environmental Impact
DNH	Denham	23.6	22.4	1	3kxA	Fair	None
EGF	Eigenhof	8.6	8.9	1	2kA	Good	None
HHF	Hochfeld	13.0	13.5	3M	1A	Excellent	Moderate
HIN	Hibsin	9.1	9.5	2M	3gxA	Fair	Low
KOT	Kronstal	2.2	2.3	2M	2wA	Good	Moderate
LSL	La Salle	7.2	7.5	2X	2kA	Good	Low
PME	Plum Coulee	1.0	1.0	2W	3wkA	Fair	None
RFD	Reinfeld	5.9	6.2	1	1A	Excellent	Low
RGD	Rignold	11.2	11.6	1	3wxA	Fair	None
WIK	Winkler	16.5	17.2	1	3kxA	Fair	None
Total Area		96.3	100.0				

Table 6. Selected Surface Soil Properties

Soil Symbol	Soil Name	Organic Matter Content %			pH			Particle Size Distribution %						
		n	Mean	Range	n	Mean	Range	n	Mean			Range		
									Sand	Silt	Clay	Sand	Silt	Clay
DNH	Denham	7	5.78	4.9 - 7.1	6	5.4	4.8 - 6.1	6	63.2	14.5	22.3	52-74	9-20	15-28
EGF	Eigenhof	3	6.68	5.5 - 7.5	4	6.3	5.6 - 7.0	2	56.5	18.0	25.5	46-67	12-24	21-30
HHF	Hochfeld	4	4.74	2.7 - 6.5	3	5.2	5.1 - 5.5	3	76.0	10.3	13.7	69-85	8-14	7-17
HIN	Hibsin	3	4.34	1.5 - 7.6	3	5.4	4.9 - 6.0	3	77.0	9.7	13.3	64-87	6-15	7-21
KOT	Kronstal	1	3.97	-	1	7.4	-	-						
LSL	LaSalle	3	3.53	1.8 - 6.1	2	7.4	7.3 - 7.4	-						
PME	Plum Coulee	1	4.90	-	2	6.7	6.2 - 7.1	-						
RFD	Reinfeld	1	3.92	-	2	6.3	5.9 - 6.6	1	74.0	9.0	17.0			
RGD	Rignold	4	5.60	3.5 - 7.9	5	6.5	5.2 - 8.0	4	67.0	11.0	22.0	58-76	8-15	16-27
WIK	Winkler	4	6.52	4.6 - 8.4	3	5.8	5.2 - 6.6	1*	60.0	15.0	25.0			

* Thin sandy clay loam surface underlain by clay.

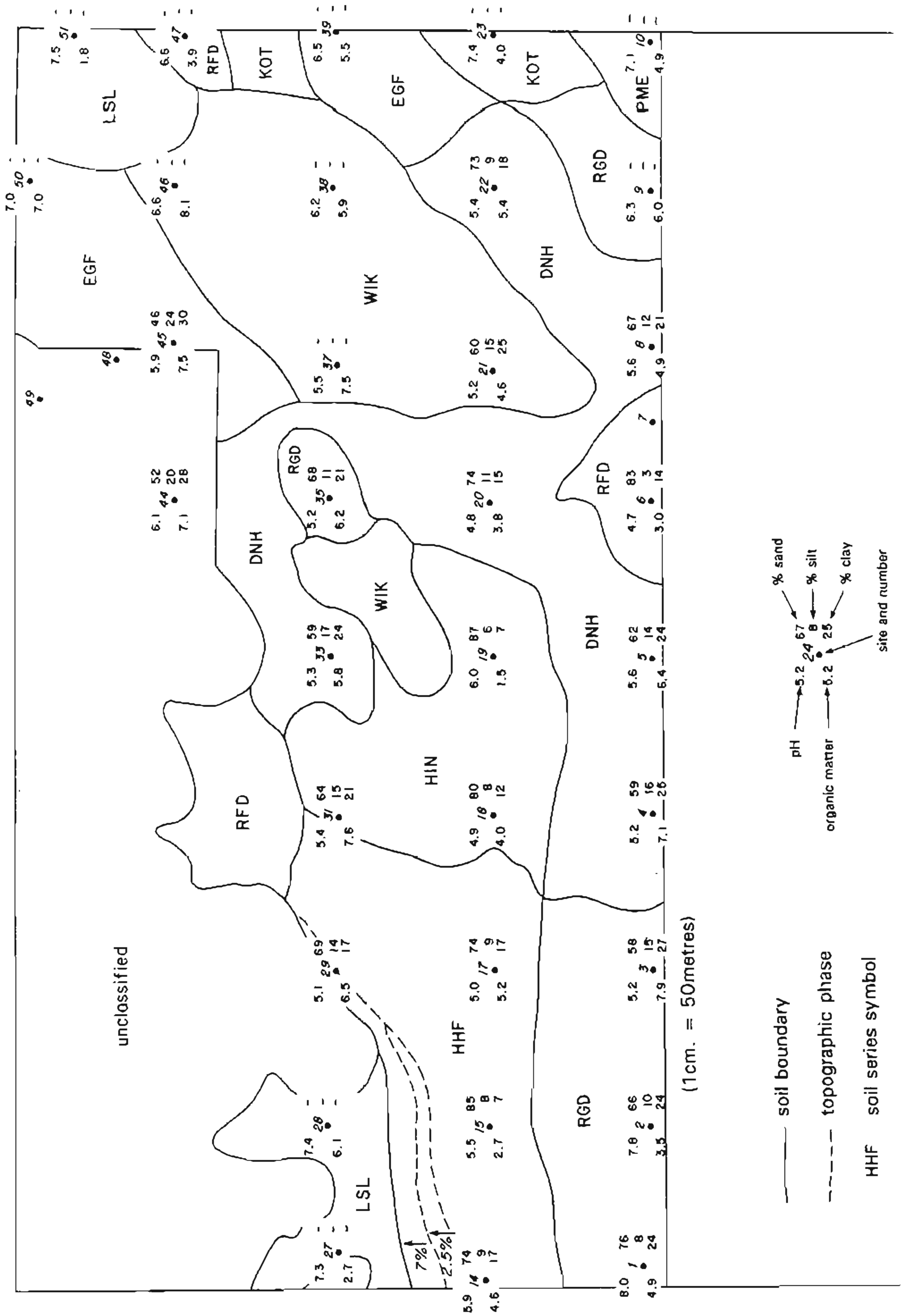

Figure 4. Selected Chemical and Physical Characteristics of Surface Soils

Soil Drainage Classes

W	well drained
W-MW	well to moderately well drained
MW	moderately well drained
I	imperfectly drained

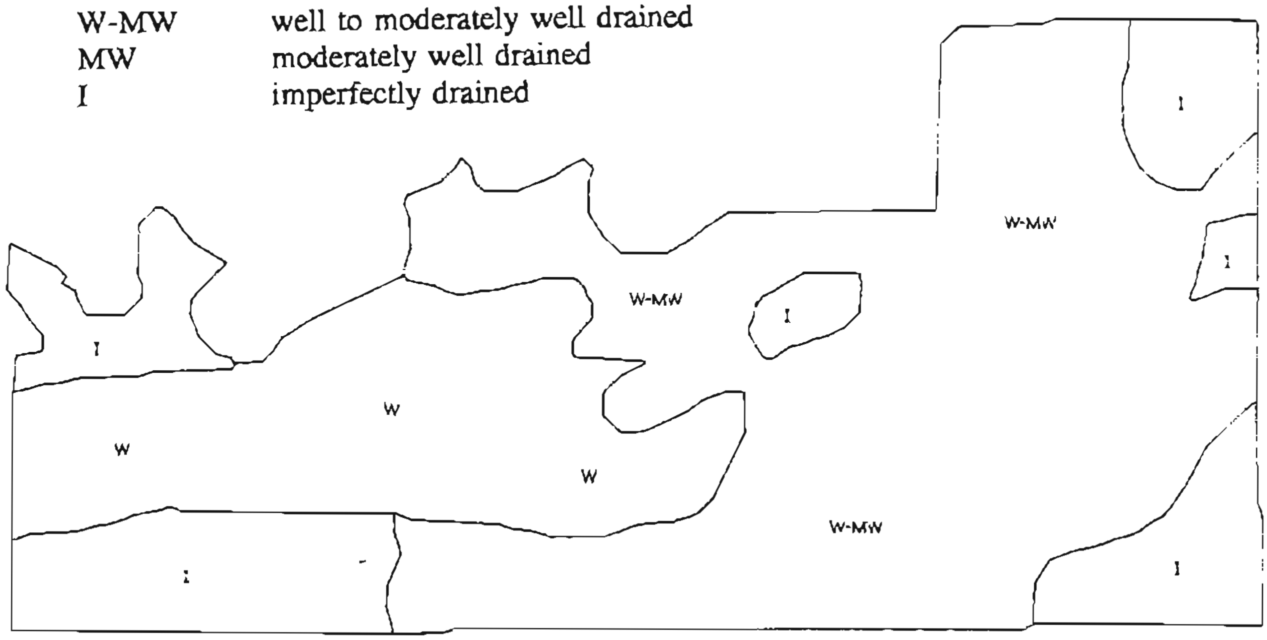

Figure 5. Distribution of Soil Drainage Regime

Surface Soil Texture

C	clay
CL	clay loam
L-SiCL	loam to silty clay loam
L	loam
FSL	fine sandy loam
LVFS	loamy very fine sand

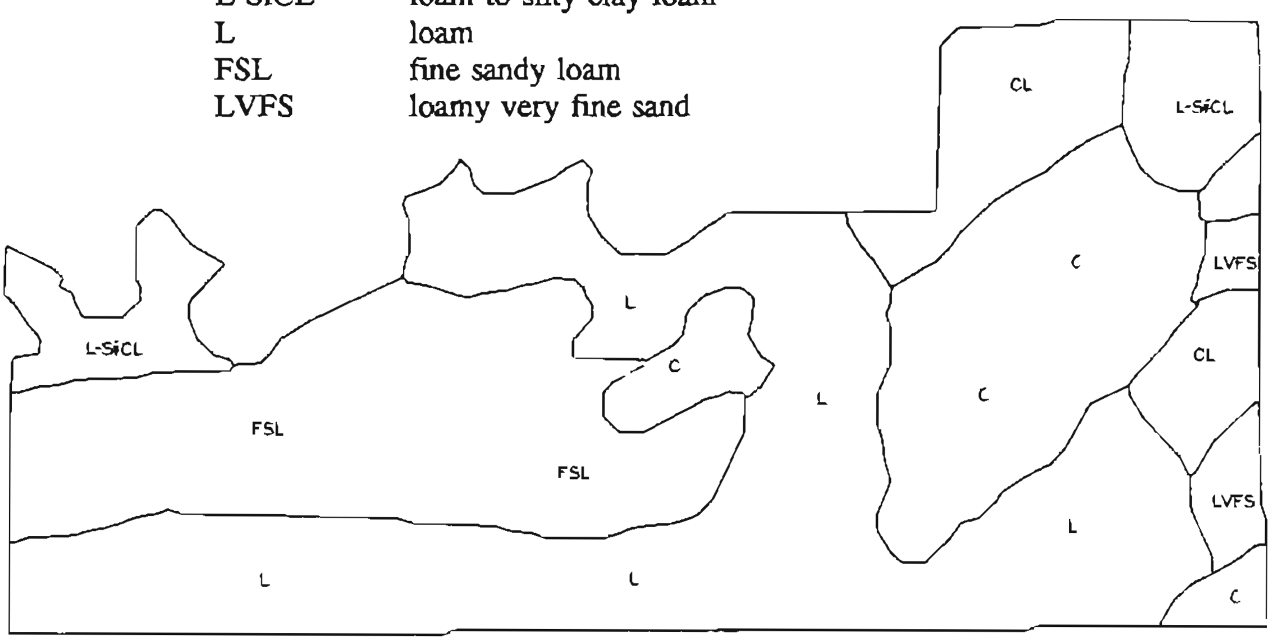

Figure 6. Surface Soil Texture

Organic Matter Classes

1	3.5-4.0%
2	4.1-4.5%
3	4.6-5.0%
4	5.1-5.5%
5	5.6-6.0%
6	6.1-6.5%
7	6.6-7.0%

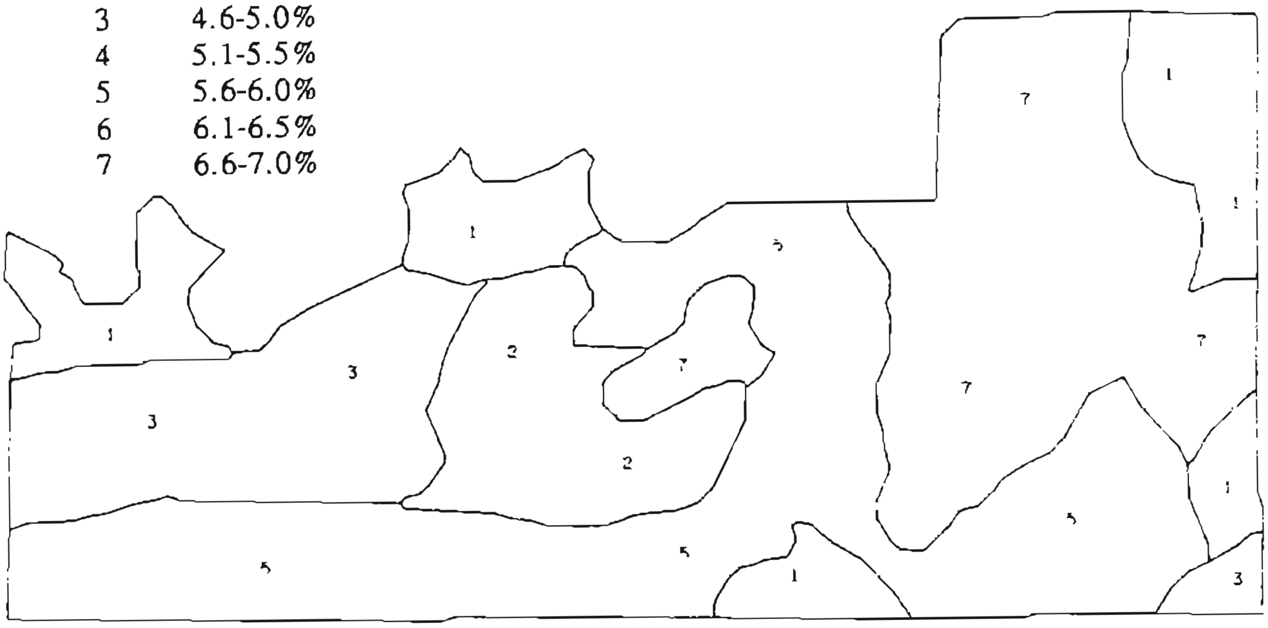

Figure 7. Organic Matter Content of Surface Soils.

pH Class and Range

ST. AC.	strongly acid	5.1-5.5
ME. AC.	medium acid	5.6-6.0
SL. AC.	slightly acid	6.1-6.5
N	neutral	6.6-7.3
M. ALK.	mildly alkaline	7.4-7.8

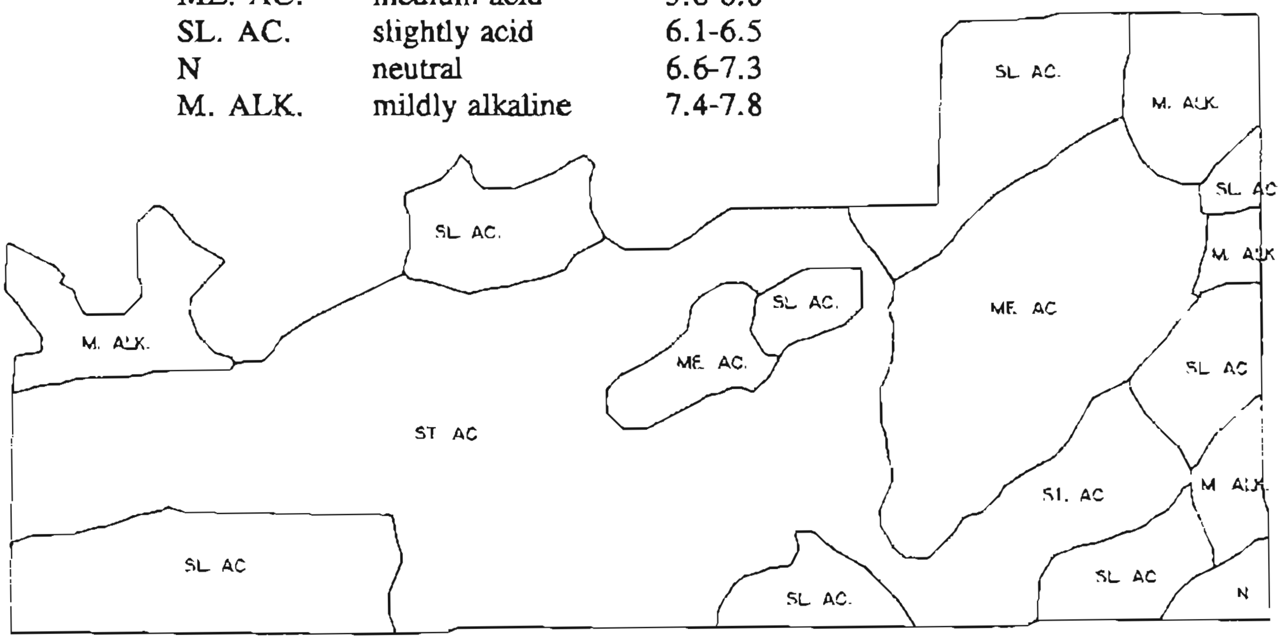

Figure 8. pH of Surface Soils

the soil surface is not covered by vegetation or crop residues. Sandy and coarse loamy soils, eg. Hochfeld, Hibsin and Kronstal series, if left unprotected with low residues are most susceptible to wind erosion. Practices to minimize the risk of erosion include continuous cropping and minimum or zero tillage to maximize residue cover. Other practices to reduce the risk of wind erosion include shelter belts, crop rotations and strip cropping.

Soils with lower clay content also are characterized by lower water holding capacity and are more susceptible to droughtiness. Well drained soils of the Hochfeld and Hibsin series may be somewhat droughty during drier periods of the growing season. It is important to maintain organic matter in these soils through the addition of organic residues to increase water retention capacity, to build up fertility and to prevent wind erosion. A generalized map of surface soil texture is presented in Figure 6.

4.4.2 Soil pH

Surface soil pH values measured on the research station range from 4.8 to 7.4 in the well and moderately well drained soils. Surface soil pH measurements from well drained sandy and coarse loamy soils (Hochfeld and Hibsin) range from 4.9 to 6.0. The imperfectly drained soils (Rignold, Kronstal and Plum Coulee) range in pH from 5.2 to 8.0. Classes of surface soil pH are mapped in Figure 8.

4.4.3 Soil Organic Matter

The organic matter content of the surface soils in the study area ranges from 1.5 to 8.4 percent. In general, the loamy and clayey soils have higher concentrations of organic matter and the sandy and coarse loamy soils have lower amounts, particularly if they have been subject to erosion. a generalized map showing the content of organic matter in the surface soil is presented in Figure 7.

4.4.4 Depth to Clay Substrate

The clay substrate underlying the soil on the research station occurs at the surface at a few locations and occasionally below 2 m at sites along the southern and eastern boundaries of the study area. Classes indicating the depth to clay are shown in both map form and stratigraphic cross-section in Figure 2. The shallow depth to this relatively impermeable layer represents a risk of possible perched water tables and restricted soil drainability under both dryland agriculture and irrigation. During prolonged dry periods, the clay substrate may enhance the soil moisture holding capacity and its ability to withstand drought.

4.4.5 Soil Drainage

The distribution of well, moderately well and imperfectly drained soil conditions is shown on the map in Figure 5. Approximately 85 % of the study area is well drained to moderately well drained and 15 % is imperfectly drained. The imperfectly drained soils may be affected by a seasonally high water table for short durations in some years. Well and moderately well drained soils are not expected to experience a water table close to the surface except during snowmelt when the subsoil may be frozen resulting in a perched water table condition for short periods in spring. Surface ponding may occur on all soils following spring snowmelt when the soils are frozen. Periodic inundation may also result on the clayey soils following a heavy rainfall during the growing season.

4.4.6 Soil Moisture Properties

Soil moisture properties were measured in the field for five soil types on the research station (Table 7). Physical properties (organic carbon content, particle size distribution and bulk density) were determined on soil horizons to a depth of 1.2 m. The soil moisture content at field capacity and permanent wilting point was measured and available water was calculated for each soil to a depth of 1.2 m.

4.4.7 Soil Salinity

The status of salinity in soils on the research station is indicated in Appendix B, Table 14 and Table 15. The salinity values determined by the laboratory analysis are very low for all sites examined (Table 14). The upper 50 to 60 cm of all soils are essentially free of soluble salts. Weak subsoil salinity was observed at depths below about 50 cm at a few sites in the eastern half of the Station.

The EM 38 readings at each grid point (Appendix B, Table 15) are useful for extrapolation of the limited electrical conductivity data obtained from the soil analysis. The EM readings are affected by the salinity in the soil as well as soil texture, soil moisture and soil temperature. A calibration procedure involving soil sampling to 120 cm and laboratory analysis to determine electrical conductivity was carried out to establish the relationship between the EM readings and the actual salinity status of the soil. The very low salinity values determined by the laboratory analysis were not significantly differentiated by the EM 38 measurements. Extrapolation of the EM 38 data reflects relatively similar background levels of salinity on the Station. As all soils were uniformly moist during the survey no calibrations were made for moisture content. Because the salinity values are relatively low, temperature calibrations would not significantly alter the final values. The variability observed in the EM data can be attributed mainly to textural variability and in particular, variation in the occurrence of the underlying clay substrate at depths ranging from the surface to beyond 2 meters.

Table 7. Physical, Chemical and Water Retention Properties of Soils

Soil Series	Horizon	Depth cm	OM %	$CaCO_3$ %	Sand %	Silt %	Clay %	Texture Class	BD g/cc	FC %	PWP %	AW mm	AW %vol	Ksat cm/hr
Hochfeld	Ap	00- 16	2.67	0.0	81	5	14	VFSL	1.23	12.5	4.2	16	10	1.2
	Ah	16- 30	1.46	0.0	87	5	8	LVFS	1.51	10.8	3.7	15	11	7.3
	Bm	30- 60	0.46	0.5	91	4	5	VFS	1.52	9.1	2.9	28	9	
	Ck1	60- 90		8.7	83	11	6	LVFS	1.42	8.5	2.6	25	8	
	Ck2	90-120		21.4	60	34	6	VFSL	1.48	12.3	3.3	40	13	
												124		
Hibson	Ap	00- 16	3.76	0.0	79	8	13	VFSL	1.25	17.2	5.1	24	15	
	Ah	16- 32	2.72	1.6	73	8	19	VFSL	1.42	17.5	5.8	27	17	
	Bm	32- 70	1.24	1.2	77	7	16	VFSL	1.40	16.2	4.8	60	16	
	2Ck	70-120		16.9	4	44	52	SIC	1.31	29.2	13.4	103	21	
												214		
La Salle	Ap	00- 17	5.91	2.8	32	31	37	CL	1.13	30.4	12.7	34	20	2.9
	Ahb1	17- 32	6.33	2.6	20	38	42	C	1.14	33.5	14.0	33	22	
	Ahb2	32- 61	4.10	1.7	9	43	48	SIC	1.09	33.5	14.7	59	20	4.0
	Ck1	61- 91		15.3	11	33	36	SICL	1.13	30.0	12.9	58	19	
	Ck2	91-120		19.7	3	58	39	SICL	1.10	34.0	13.1	66	23	
												250		
Rignold	Ap	00- 16	6.57	0.0	52	17	31	SCL	1.12	26.7	10.4	29	18	1.4
	Ah	16- 31	3.67	0.0	52	16	32	SCL	1.33	23.4	10.0	27	18	2.5
	Bm	31- 55	1.67	0.4	48	16	36	SC	1.39	22.7	10.9	39	16	
	2Ck1	55- 89		15.1	10	32	58	C	1.41	30.0	13.6	79	23	
	2Ck2	89-120		15.9	7	33	60	C	1.41	31.0	13.6	77	25	
												251		
Denham	Ap	00- 17	8.16	0.0	49	19	32	SCL	1.13	28.1	11.1	33	19	
	Ah	17- 33	5.17	0.0	47	20	33	SCL	1.21	25.0	10.3	28	18	
	Bm	33- 60	1.88	0.4	53	19	28	SCL	1.29	23.3	8.6	51	19	
	2Ck1	60- 84		9.8	24	33	43	C	1.35	30.5	12.0	60	25	
	2Ck2	84-120		14.2	8	36	56	C	1.37	31.0	13.2	88	24	
												260		

OM = Organic Matter; BD = Bulk Density; FC = Field Capacity(% by wt.); PWP = Permanent Wilting Point(% by wt.); AW = Available Water; Ksat = Sat'd Hydraulic Conductivity

APPENDIX A

GUIDES FOR EVALUATING AGRICULTURAL CAPABILITY AND IRRIGATION SUITABILITY

Table 8. Description of the Agricultural Capability Classes

Class 1	Soils in this class have no important limitations for crop use. The soils have level or gently sloping topography; they are deep, well to imperfectly drained and have moderate water holding capacity. The soils are naturally well supplied with plant nutrients, easily maintained in good tilth and fertility; soils are moderately high to high in productivity for a wide range of cereal and special crops.
Class 2	Soils in this class have moderate limitations that reduce the choice of crops or require moderate conservation practices. The soils have good water holding capacity and are either naturally well supplied with plant nutrients or are highly responsive to inputs of fertilizer. They are moderate to high in productivity for a fairly wide range of crops. The limitations are not severe and good soil management and cropping practices can be applied without serious difficulty.
Class 3	Soils in this class have moderate limitations that restrict the range of crops or require moderate conservation practices. The limitations in Class 3 are more severe than those in Class 2 and conservation practices are more difficult to apply and maintain. The limitations affect the timing and ease of tillage, planting and harvesting, the choice of crops and maintenance of conservation practices. The limitations include one or more of the following: moderate climatic limitation, erosion, structure or permeability, low fertility, topography, overflow, wetness, low water holding capacity or slowness in release of water to plants, stoniness and depth of soil to consolidated bedrock. Under good management, these soils are fair to moderately high in productivity for a fairly wide range of field crops.

Table 9. Agricultural Capability Subclass Limitations

M -	Moisture limitation: This subclass consists of soils where crops are adversely affected by droughtiness owing to inherent soil characteristics. They are usually soils with low water-holding capacity.
W -	Excess water: Subclass W is made up of soils where excess water other than that brought about by inundation is a limitation to their use for agriculture. Excess water may result from inadequate soil drainage, a high water table, seepage or runoff from surrounding areas.
X -	Cumulative minor adverse characteristics: This subclass is made up of soils having a moderate limitation caused by the cumulative effect of two or more adverse characteristics which singly are not serious enough to affect the class rating.

Table 10. Description of Irrigation Suitability Classes

General Rating	Class	Degree of Limitation	Description
Excellent	1A	No soil or landscape limitations	These soils are medium textured, well drained and hold adequate available moisture. Topography is level to nearly level. Gravity irrigation methods may be feasible.
Good	2A 2B 1B	Slight soil and/or landscape limitations	The range of crops that can be grown may be limited. as well, higher development inputs and management skills are required. Sprinkler irrigation is usually the only feasible method of water application.
Fair	3A 3B 3C 1C 2C	Moderate soil and/ or landscape limitations	Limitations reduce the range of crops that may be grown and increase development and improvement costs. Management may include special conservation techniques to minimize soil erosion, limit salt movement, limit water table build-up or flooding of depressional areas. Sprinkler irrigation is usually the only feasible method of water application.
Poor	4A 4B 4C 4D 1D 2D 3D	Severe soil and/ or landscape limitations	Limitations generally result in a soil that is unsuitable for sustained irrigation. Some lands may have limited potential when special crops, irrigation systems, and soil and water conservation techniques are used.

Table 11. Soil Features Affecting Irrigation Suitability

Symbol	Soil Feature	Degree of Limitation			
		None(1)	Slight(2)	Moderate(3)	Severe(4)
d	Structure	Granular, Single Grained, Prismatic, Blocky, Subangular Blocky	Columnar Platy	Massive	Massive
k	Ksat (mm/hr) (0 - 1.2m)	>50	50 - 15	15 - 1.5	<1.5
x	Drainability (1.2 - 3m) (mm/hr)	>15	5 - 15	0.5 - 5	<0.5
m	AWHC mm/1.2m (% vol.) subhumid subarid	>120 (>10) >150 (>12)	120 - 100 (8 - 10) 120 - 150 (12 - 10)	100 - 75 (6 - 8) 100 -120 (10 - 8)	<75 (<6) <100 (<8)
q	Intake Rate (mm/hr)	>15	1.5 - 15	1.5 - 15	<1.5
s	Salinity (dS/m) depth(m) 0 - .6 .6 - 1.2 1.2 - 3	<2 <4 <8	2 - 4 4 - 8 8 - 16	4 - 8 8 - 16 >16	>8 >16 >16
n	Sodicity (SAR) (m) 0 - 1.2 1.2 - 3	<6 <6	6 - 9 6 - 9	9 - 12 9 - 12	>12 >12
g	Geological Uniformity 0 - 1.2m	1 Textural Group	2 Textural Groups, Coarser Below	2 Textural Groups Finer Below 3 Textural Groups Coarser Below	3 Textural Groups Finer Below
	1.2 - 3m	2 Textural Groups	3 Textural Groups Coarser Below	3 Textural Groups Finer Below	
r	Depth to Bedrock (m)	>3	3 - 2	2 - 1	<1
h	Depth to Watertable (m)	>2	2 - 1.2 (if salinity is a problem)	2 - 1.2 (if salinity is a problem)	<1.2
w	Drainage Class	Well, Moderately Well, Rapid, Excessive	Imperfect	Imperfect	Poor, Very Poor
	*Texture (Classes) 0 - 1.2m	L, SiL, VFSL, FSL	CL, SiCL, SCL, FSCL, SL, LVFS	C, SC, SiC VFS, LS, CoSL	HvC GR, CoS, LCoS, S
	*Organic Matter %	>2	1 - 2	1 - 2	<1
	Surface Crusting Potential	Slight	Low	Low	Moderate

* Other important factors used to interpret type and degree of limitation but which do not present a limitation to irrigation themselves. No symbol is proposed for these factors since they will not be identified as subclass limitations.

Table 12. Landscape Features Affecting Irrigation Suitability

Symbol	Landscape Features	Degree of Limitation			
		None (A)	Slight (B)	Moderate (C)	Severe (D)
t1	Slope - Simple %	<2	2 - 10	10 - 20	>20
t2	- Complex %	<5		5 - 15	>15
e	Relief m (Average Local)	<1	1 - 3	3 - 5	>5
p	Stoniness -Classes -Cover (%)	0, 1 & 2 (0-3%)	3 (3-15%)	4 (15-50%)	5 (>50)
i	Inundation -Frequency of Flooding (period)	1:10 (yr)	1:5 (yr)	1:1 (annual-spring)	1:<1 (seasonal)

Table 13. Soil and Landscape Conditions Affecting Environmental Impact Rating

Soil Property and Landscape Feature	Potential Degree of Impact			
	None	Low	Moderate	High
Textural Groups[1] (Classes[2]) Surface Strata (1.2 m)	MF (SCL,CL,SiCL) F (SC,SiC,C)	M (Si,VFS,L,SiL)	MCo (CoSL,SL, FSL,VFS, LVFS)	VCo (VCoS,CoS); Co (LCoS,LS, FS,LFS)
Geological Uniformity Weighted textural groupings[3] Surface Strata (1.2 m) / Substrata (1.2-3.0 m)	MF to VF / M to VF; M / MF to VF	MF / MCo to Co; F / Co; MCo to Co / MF to VF	M / MCo to Co; Co / M; MF / VCo	VCo to Co / VCo to Co; MCo / Co to VCo; Co / VCo to MCo; M / VCo
Hydraulic Cond Ksat (mm/hr)	< 1.5	1.5 - 15	15 - 50	>50
Depth to Water Table (m)	> 2 m	(2 m ——— 1 m)		<1 m
Salinity (dS/m)	0 - 4	4 - 8	8 - 15	>15
Topography (% Slope)	0 - 2	2 - 5	5 - 9	> 9

[1]Textural Groups: VF=Very Fine, F=Fine, MF=Moderately Fine, M=Medium, MCo=Moderately Coarse, Co=Coarse, VCo=Very Coarse

[2]Texture Classes:

Very Coarse - VCo
- VCoS -Very Coarse Sand
- CoS -Coarse Sand
- S -Sand

Coarse - Co
- LCoS -Loamy Coarse Sand
- LS -Loamy Sand
- FS -Fine Sand
- LFS -Loamy Fine Sand

Moderately Coarse - MCo
- CoSL -Coarse Sandy Loam
- SL -Sandy Loam
- FSL -Fine Sandy Loam
- VFS -Very Fine Sand
- LVFS -Loamy Very Fine Sand

Medium - M
- Si -Silt
- VFSL -Very Fine Sandy Loam
- L -Loam
- SiL -Silt Loam

Moderately Fine - MF
- SCL -Sandy Clay Loam
- SiCL -Silty Clay Loam
- CL -Clay Loam

Fine - F
- SC -Sandy Clay
- SiC -Silty Clay
- C -Clay

Very Fine - VF
- HC -Heavy Clay

[3]Slash indicates surface strata (1.2 m) overlying substrata (1.2-3.0 m), ie: MF to VF / M to VF

Notes for Table 13.

1. Guidelines developed for making this impact rating employ four relative degrees of risk of degradation: **None, Low, Moderate and High.** This rating is not part of the irrigation suitability classification, but rather is intended to serve as a warning of possible adverse impact on the soil, adjacent crops or the environment. Since all situations cannot be completely covered by general guidelines, an on-site inspection is recommended for the evaluation of potential adverse environmental impact.

2. A major concern for land under irrigation is the possibility of adverse impact on the groundwater and surface water quality in and adjacent to the irrigated area. The soil factors selected for impact evaluation include those properties that determine water retention and movement through the soil and topographic characteristics that affect runoff and redistribution of moisture in the landscape. The risk of altering the soil drainage regime and soil salinity or the potential for runoff, erosion or flooding is determined by the detailed criteria for each property. Soil factors and landscape features considered in determining an environmental impact evaluation are:

    1. Soil Texture
    2. Geological Uniformity
    3. Hydraulic Conductivity
    4. Depth to Water Table
    5. Salinity
    6. Topography

3. **Soil texture** and the **thickness and uniformity of geological deposits** (assessed by weighting textures in surface strata and subsurface strata) combine to affect the soil's water holding capacity and **hydraulic conductivity** (ability to transmit water and leachate either vertically or laterally in the soil). The presence and sequence of strongly contrasting soil textures within 3 m of the surface (**geological uniformity**) are used to determine the potential for downward movement (moderately coarse to fine materials underlain by coarse materials) or lateral movement (very coarse and coarse materials underlain by fine materials) of water and leachate. Uniform, highly permeable materials with low water holding capacity present the highest potential for adverse impact on groundwater quality. Uniform materials of low permeability provide the best buffer against impact on groundwater quality.

    A shallow **depth (< 1 m) to water table** has a higher risk for contamination than soils with a deep water table. Soils with high levels of **salinity** may adversely impact on groundwater quality due to the leaching associated with irrigation practices (ie: applied leaching fraction).

    Topographic patterns with slopes in excess of 2 percent require special consideration for soil and water management to reduce the potential for runoff and erosion. The risk of runoff and potential for local flooding, build-up of water tables and soil erosion increases with slope gradient. Soil erosion results in loss of topsoil and transport of nutrients and pesticides to non-target areas.

APPENDIX B

SOIL CHEMICAL AND PHYSICAL ANALYSIS

Table 14. Soil Chemical and Physical Analysis at Survey Grid Points.

(see Figure 3 for grid point location)

Site No.	Soil Name (Symbol)	Depth (cm)	Texture[1]	Particle Size Analysis			Org. C[2] %	pH	EC[3] mS/cm	% water at Saturation
				Sand %	Silt %	Clay %				
A1	Rignold (RGD)	0-20	VFSL	76	8	16	2.87	8.0		
		35-45	VFSL	69	11	20	0.70	7.3		
A2	Rignold (RGD)	0-20	SCL	66	10	24	2.06	7.8		
		80-110						8.0	0.4	69.6
		110-125						8.1	0.6	104.9
A3	Rignold (RGD)	0-20	SCL	58	15	27	4.59	5.2	0.3	47.5
		55-100	C					8.0	5.1	102.4
A4	Denham (DNH)	0-20	SCL	59	16	25	4.13	5.2		
		45-70	SCL	58	16	26	0.87	7.5		
A5	Denham (DNH)	0-20	SCL	62	14	24	3.72	5.6		
		20-45	SCL	57	13	30	2.79	7.6		
		45-65	SCL	63	12	25	0.79	7.9		
A6	Gnadenthal (GDH)	0-20	VFSL	83	3	14	1.76	4.7		
		60-80	VFSL	74	10	16	1.18	7.7		
		90-130	VFSL					7.8		
		130-180	SiCL					7.9		
A7	Eigenhof (EGF)	0-20	SCL	67	12	21	2.84	5.6		
		35-60	VFSL	66	14	20	0.86	7.3		
		60-120	CL					8.0		
		120-135	SiC					1.1		
A8	Rignold (RGD)	0-25	CL				3.50			
		25-45	L				1.10			
		45-80	L						1.2	44.8
		80-120	SiC						2.8	76.7
A9	Plum Coulee (PME)	0-20	C				2.85	7.1		
		25-60	CL				0.82	7.5		
		60-110	C					7.9	1.2	82.3
AB7	Plum Coulee (PME)	0-20	C							
		70-110	C					8.1	0.4	86.2

Table 14. Soil Chemical and Physical Analysis at Survey Grid Points. (Continued)

Site No.	Soil Name (Symbol)	Depth (cm)	Texture[1]	Particle Size Analysis			Org. C[2] %	pH	EC[3] mS/cm	% water at Saturation
				Sand %	Silt %	Clay %				
B1	Reinfeld (RFD)	0-20	VFSL	74	9	17	2.65	5.9		
		35-90	VFSL	73	8	19	0.80	7.3		
B2	Hochfeld (HHF)	0-20	LVFS	85	8	7	1.59	5.5		
		50-160	VFSL	61	26	13		7.8		
B3	Hochfeld (HHF)	0-20	VFSL	74	9	17	3.02	5.0		
		40-90	LVFS	81	8	11	0.30	7.8		
B4	Hibsin (HIN)	0-20	VFSL	80	8	12	2.32	4.9		
		20-35	VFSL	77	10	13	1.92	6.5		
		35-65	LVFS	81	8	11	0.57	7.7		
		90-110	C							
B5	Hibsin (HIN)	0-20	LVFS	87	6	7	0.86	6.0		
		40-70	LVFS	90	5	5	0.26	6.8		
		80-95	VFS				0.15	7.4		
		95-110	C							
B6	Denham (DNH)	0-20	VFSL	74	11	15	2.18	4.8	0.3	35.7
		35-60	VFSL	72	11	17	0.59	7.9	0.4	37.4
		80-130	SiC					7.9	4.2	65.5
B7	Winkler (WIK)	0-20	SCL	60	15	25	2.67	5.2		
		20-35	C	18	24	58	0.44	5.2		
		55-70	C					8.2	1.3	91.9
B8	Denham (DNH)	0-20	VFSL	73	9	18	3.15	5.4		
		45-65	SCL	69	10	21	0.47	7.9		
		75-90	SiCL					8.1	0.7	54.4
		90+	C							
B9	Kronstal (KOT)	0-20	L				2.31	7.4		
		30-60	L				0.68	8.2		
		95-130	VFSL					8.1		
		130-300	VFSL					8.1	0.3	35.1
BC5	Plum Coulee (PME)	65-100	C				0.87	7.6	6.0	75.8

Table 14. Soil Chemical and Physical Analysis at Survey Grid Points. (Continued)

Site No.	Soil Name (Symbol)	Depth (cm)	Texture[1]	Particle Size Analysis			Org. C[2] %	pH	EC[3] mS/cm	% water at Saturation
				Sand %	Silt %	Clay %				
C1	LaSalle (LSL)	0-20	L				1.55	7.3		
		20-50	VFSL				1.07	7.6		
C2	LaSalle (LSL)	0-20	CL				3.57	7.4		
		60-80	CL				1.55	7.7		
C3	Hochfeld (HHF)	0-20	VFSL	69	14	17	3.76	5.1		
		50-70	VFSL	74	13	13	1.21	7.5		
C4	Hibsin (HIN)	0-20	SCL	64	15	21	4.39	5.4		
		40-60	VFSL	68	15	17	0.63	7.7		
		85-100	C					8.1		
C5	Denham (DNH)	0-20	SCL	59	17	24	3.37	5.3		
		5-75	VFSL	68	14	18	0.68	7.7		
		95	C					7.6		
C5.5	Winkler (WIK)	35-70	C					8.1	1.6	79.8
C6	Rignold (RGD)	0-20	SCL	68	11	21	3.58	5.2	0.5	40.0
		50-65	SCL	60	15	25	1.02	7.8	1.7	46.7
		65-75	L					7.8	3.0	47.7
		75-90	L					8.0	3.1	39.7
		90-100	C					8.1	3.3	77.3
C7	Winkler (WIK)	0-20	C				4.34	5.5		
		20-40	C				2.17	6.6		
		55-75	C					7.8	0.5	96.5
C8	Plum Coulee (PME)	0-20	C				3.42	6.2		
		45-65	C				0.92	7.1		
		65-105	C					7.9	0.3	84.2
		105-120	VFSL					7.9	0.5	39.6
C9	Eigenhof (EGF)	0-20	CL				3.20	6.5		
		20-40	CL				1.45	7.4		
		40-65	SiCL					8.2	5.1	75.6
		65-90	L					8.1	4.9	54.8
		90-125	VFS					8.2	3.4	36.1
		125-135	C					8.0	3.1	108.3

Table 14. Soil Chemical and Physical Analysis at Survey Grid Points. (Continued)

Site No.	Soil Name (Symbol)	Depth (cm)	Texture[1]	Particle Size Analysis Sand %	Silt %	Clay %	Org. C[2] %	pH	EC[3] mS/cm	% water at Saturation
D6	Denham (DNH)	0-20	SCL	52	20	28	4.13	6.1		
		35-55	SCL	57	19	24	0.97	7.6		
		80-100	C					8.0		
D7	Eigenhof (EGF)	0-20	SCL	46	24	30	4.38	5.9		
		35-70	SCL	49	25	26	0.96	7.8		
		70-130	SiL					8.1	0.8	73.0
		130-150	C					8.0	1.2	103.4
D8	Winkler (WIK)	0-20	C				4.73	6.6		
		20-30	C				2.53	7.2		
		30-60	C				1.55	7.7		
D9	Reinfeld (RFD)	0-20	L				2.28	6.6		
		35-50	L				0.85	7.6		
		50-135	LFS					8.1		
		135-160	C					7.9	0.2	82.7
E8	Eigenhof (EGF)	0-20	CL				4.08	7.0		
		20-50	CL				0.82	7.5		
		50-105	SiL					7.9		
		105-125	VFSL					8.0		
		125-135	C					7.9		
E9	Gervais (GYS)	0-25	CL				1.04	7.5		
		25-65	SiL				0.45	7.8		

[1]Texture
S Sand
VFS Very Fine Sand
LFS Loamy Fine Sand
VFSL Very Fine Sandy Loam
LVFS Loamy Very Fine Sand
SCL Sandy Clay Loam
L Loam
SiL Silt Loam
SiCL Silty Clay Loam
CL Clay Loam

[2]Org.C = Organic Carbon
% Org.C x 1.72 = Organic Matter %

[3]EC = Electrical Conductivity

Table 15. EM 38 Background Readings at Survey Grid Points[1]

(see Figure 3 for grid point location)

Site No.	Depth[2] (cm)	Transect				
		A	B	C	D	E
1	V	54	32	23	-	-
	H	32	19	15	-	-
2	V	81	22	22	-	-
	H	41	13	18	-	-
3	V	58	26	19	-	-
	H	38	16	11	-	-
4	V	39	24	29	-	-
	H	25	16	17	-	-
5	V	48	24	30	-	-
	H	33	14	20	-	-
6	V	43	29	38	54	-
	H	27	20	26	35	-
7	V	41	33	51	29	-
	H	24	18	33	17	-
8	V	74	52	83	69	38
	H	52	35	58	56	30
9	V	85	36	116	37	-
	H	67	27	83	26	-

[1] Readings are mean values of three EM 38 measurements at each grid point.
[2] V = Vertical, 0 - 120 cm depth.
H = Horizontal, 0 - 60 cm depth.

CARMAN RESEARCH STATION - N1/2 23-6-5W

SOIL LEGEND

Soil Symbol	Soil Name	Surface Texture	Soil Drainage	Mode of Deposition	Family Particle Size	Soil Subgroup
DNH	Denham	Loam	Well	Lacustrine	Loamy/clayey	Orthic Black
EGF	Eigenhof	Clay Loam	Well	Lacustrine	Fine loamy	Orthic Black
HHF	Hochfeld	Fine Sandy Loam	Well	Lacustrine	Coarse loamy	Orthic Black
HIN	Hibsin	Fine Sandy Loam	Well	Lacustrine	Coarse loamy/clayey	Orthic Black
KOT	Kronstal	Loamy very fine sand	Imperfect	Lacustrine	Coarse loamy	Gleyed Black
LSL	La Salle	Loam to silty clay loam	Mod. Well	Fluvial	Loamy	Cumulic Regosol
PME	Plum Coulee	Clay	Imperfect	Lacustrine	Clayey	Gleyed Black
RFD	Reinfeld	Loam	Mod. Well	Lacustrine	Loamy	Orthic Black
RGD	Rignold	Loam	Imperfect	Lacustrine	Loamy/clayey	Gleyed Black
WIK	Winkler	Clay	Well	Lacustrine	Clayey	Orthic Black

BIBLIOGRAPHY

AES, 1981. Canadian Climate Normals, 1951-1980. Atmospheric Environment Service, Environment Canada.

Agriculture Canada, 1987. The Canadian System of Soil Classification. 2nd Ed. Expert Committee on Soil Survey. Agric. Can. Publ. 1646. 164 pp.

Anon, 1965. Soil Capability Classification for Agriculture. The Canada Land Inventory, Report No. 2. Department of Forestry, Ottawa, Canada.

Ash, Guy H. B., 1991. An Agroclimatic Risk Assessment of Southern Manitoba and Southeastern Saskatchewan. M. A. thesis, University of Manitoba, Winnipeg, Manitoba. 410 pp.

ISC, 1987. An Irrigation Suitability Classification System for the Canadian Prairies. Working Group on Irrigation Suitability Classification. Research Branch, Agriculture Canada, LRRC Contribution No. 87-83.

McKeague, J. A., 1978. Manual on Soil Sampling and Methods of Analysis. Soil Research Institute, Agriculture Canada, Ottawa, Ont., 212 pp.

SOIL SURVEY REPORTS:

Ehrlich, W. A., Poyser, E. A., Pratt, L. E. and Ellis, J. H., 1953. Report of the Reconnaissance Soil Survey of the Winnipeg and Morris Map Sheet Areas. Soils Report No. 5. Manitoba Department of Agriculture

Ehrlich, W. A., Poyser, E. A. and Pratt, L. E., 1957. Report of the Reconnaissance Soil Survey of the Carberry Map Sheet. Report No. 7. Manitoba Department of Agriculture

Ellis, J. H. and Shafer, W. H., 1943. Report of Reconnaissance Soil Survey of South-Central Manitoba. Manitoba soil Survey report No. 4. Manitoba Department of Agriculture.

Michalyna, W., Glenn Podolsky and E. St. Jacques, 1988. Soil of the Rural Municipalities of Grey, Dufferin, Roland, Thompson and part of Stanley. Soil Report No. D60. Manitoba Department of Agriculture.