CANADA-MANITOBA
Soil Survey

Soils of the
Carman Research Station
N ½ 23-6-5W

Special Report Series 93-1
SOILS OF THE
CARMAN RESEARCH STATION

N 1/2 23-6-5W

by

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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.
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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.

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)

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

<table>
<thead>
<tr>
<th>Station Location</th>
<th>Probability Level</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td>(1 in 10)</td>
</tr>
<tr>
<td>Graysville</td>
<td>June 5</td>
</tr>
<tr>
<td>Morden</td>
<td>June 1</td>
</tr>
<tr>
<td>Morris</td>
<td>June 1</td>
</tr>
<tr>
<td>Roland</td>
<td>June 3</td>
</tr>
<tr>
<td>Winnipeg</td>
<td>June 10</td>
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Spring Frost on or after ......

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<th>June</th>
<th>July</th>
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<tr>
<td>Graysville</td>
<td>92</td>
<td>106</td>
<td>112</td>
</tr>
<tr>
<td>Morden</td>
<td>106</td>
<td>119</td>
<td>124</td>
</tr>
<tr>
<td>Morris</td>
<td>106</td>
<td>114</td>
<td>126</td>
</tr>
<tr>
<td>Roland</td>
<td>96</td>
<td>108</td>
<td>120</td>
</tr>
<tr>
<td>Winnipeg</td>
<td>92</td>
<td>111</td>
<td>122</td>
</tr>
</tbody>
</table>

Frost free period (days) equal to or less than ......

<table>
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<th>Oct</th>
<th>Nov</th>
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<tr>
<td>Graysville</td>
<td>128</td>
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</tr>
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<td>Morden</td>
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</tr>
<tr>
<td>Roland</td>
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</tr>
<tr>
<td>Winnipeg</td>
<td>132</td>
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Table 3. Climatic Parameters Relevant to Crop Growth at Selected Climate Stations in South Central Manitoba (Ash, 1991)

<table>
<thead>
<tr>
<th>Climatic Parameter</th>
<th>Probability Level</th>
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<th>Morden</th>
<th>Morris</th>
<th>Roland</th>
<th>Winnipeg</th>
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<tr>
<td>Corn Heat Units</td>
<td>50</td>
<td>2463</td>
<td>2686</td>
<td>2651</td>
<td>2542</td>
<td>2575</td>
</tr>
<tr>
<td></td>
<td>25</td>
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<td>2533</td>
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<td></td>
<td>10</td>
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<td>2394</td>
<td>2342</td>
<td>2229</td>
<td>2302</td>
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<tr>
<td>Growing Degree-Days</td>
<td>50</td>
<td>1660</td>
<td>1783</td>
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<td>1609</td>
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<tr>
<td>(base 5°C)</td>
<td>10</td>
<td>1495</td>
<td>1610</td>
<td>1561</td>
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<td>1530</td>
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<tr>
<td>Frost-free period days</td>
<td>50</td>
<td>137</td>
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<td>135</td>
<td>136</td>
<td>135</td>
</tr>
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<td></td>
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<td>128</td>
<td>134</td>
<td>126</td>
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<td>128</td>
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<tr>
<td>(base -2.2°C)</td>
<td>10</td>
<td>121</td>
<td>128</td>
<td>119</td>
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<td>122</td>
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<tr>
<td>Plant moisture stress, mm at soft dough stage for wheat</td>
<td>50</td>
<td>-28</td>
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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 (DNI)

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 Ab 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 Black earth associates of the Rathwell Association in the Carberry (1957) soil report or the well drained
member of the Altona heavy subsoil phase soils in the South Central (1943) soil report.

**Eighenhof Series (EGF)**

The Eighenhof 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. Eighenhof 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 Eighenhof 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.

Eighenhof 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. Eighenhof 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 (HNN)**

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 Cea horizon, 8 to 13 cm thick and a Ckg 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 grayish to dark greyish brown Bmgj 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 silt 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 Black earth 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 Guadenthal 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 Black earth 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 Bm horizon, 20 to 30 cm thick, a transitional BC horizon, 10 to 15 cm thick, with faint mottles and a light olive brown Ckg 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 Bm 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 Black earth associates of the Horndean Complex in the Winnipeg-Morris (1953) soil report, Black earth 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

<table>
<thead>
<tr>
<th>Soil Drainage</th>
<th>Soil Subgroup (^2)</th>
<th>Coarse Loamy LFS,FS,FSL</th>
<th>Sandy-Coarse Loamy/Clayey FS,LFS,FSL/C</th>
<th>Loamy VFSL,L,Sil</th>
<th>Loamy/Clayey VFSL,L,Sil/C</th>
<th>Fine Loamy L,Sil,CL,CL,L</th>
<th>Loamy, Fluvial Stratified</th>
<th>Clayey, Fluvial Stratified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Well to moderately well</td>
<td>Orthic Black</td>
<td>Hochfeld (HHF) 13.0 ha, 13.5%</td>
<td>Hibbs (HIN) 9.1 ha, 9.5%</td>
<td>Reinfeld (RFD) 5.9 ha, 6.2%</td>
<td>Donham (DNH) 21.6 ha, 22.4%</td>
<td>Eigenhof (EGF) 8.6 ha, 8.9%</td>
<td>Gervais (GVS)</td>
<td>Winkler (WIK) 16.5 ha, 17.2%</td>
</tr>
<tr>
<td>Imperfect</td>
<td>Cumolic Regosol</td>
<td>Kronstal (KOT) 2.2 ha, 2.3%</td>
<td>Elm Creek (EKe)</td>
<td></td>
<td>Rignold (RGD) 11.2 ha, 11.6%</td>
<td></td>
<td></td>
<td>Plum Coulee (PME) 1.0 ha, 1.0%</td>
</tr>
<tr>
<td>Gleyed Black</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Deadhorse (DHO)</td>
</tr>
<tr>
<td>Gleyed Rego Black</td>
<td>Reinland (RLD)</td>
<td></td>
<td>Rosebank (RBK)</td>
<td>Guadenthal (GDH)</td>
<td>Graysville (GYV)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gleyed Cumolic Regosol</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

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

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.

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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:

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, i.e. 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 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.

<table>
<thead>
<tr>
<th>Map Symbol</th>
<th>Soil Name</th>
<th>Areal Extent</th>
<th>Agricultural Capability</th>
<th>Irrigation Suitability</th>
<th>General Rating</th>
<th>Potential Environmental Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>ha</td>
<td>%</td>
<td>Class</td>
<td>3kxA</td>
<td>Fair</td>
</tr>
<tr>
<td>DNH</td>
<td>Denham</td>
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<td>22.4</td>
<td>1</td>
<td>3kxA</td>
<td>Fair</td>
</tr>
<tr>
<td>EGF</td>
<td>Eigenhof</td>
<td>8.6</td>
<td>8.9</td>
<td>1</td>
<td>2kA</td>
<td>Good</td>
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<tr>
<td>HHF</td>
<td>Hochfeld</td>
<td>13.0</td>
<td>13.5</td>
<td>3M</td>
<td>1A</td>
<td>Excellent</td>
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<tr>
<td>HIN</td>
<td>Hibcin</td>
<td>9.1</td>
<td>9.5</td>
<td>2M</td>
<td>3gxA</td>
<td>Fair</td>
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<tr>
<td>KOT</td>
<td>Kronstal</td>
<td>2.2</td>
<td>2.3</td>
<td>2M</td>
<td>2WA</td>
<td>Good</td>
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<tr>
<td>LSL</td>
<td>La Salle</td>
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<td>7.5</td>
<td>2X</td>
<td>2kA</td>
<td>Good</td>
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<tr>
<td>PME</td>
<td>Plum Coulee</td>
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<td>1.0</td>
<td>2W</td>
<td>3wkA</td>
<td>Fair</td>
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<tr>
<td>RFD</td>
<td>Reinfeld</td>
<td>5.9</td>
<td>6.2</td>
<td>1</td>
<td>1A</td>
<td>Excellent</td>
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<tr>
<td>RGD</td>
<td>Rignold</td>
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<td>WIK</td>
<td>Winkler</td>
<td>16.5</td>
<td>17.2</td>
<td>1</td>
<td>3kxA</td>
<td>Fair</td>
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<tr>
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</table>


Table 6. Selected Surface Soil Properties

<table>
<thead>
<tr>
<th>Soil Symbol</th>
<th>Soil Name</th>
<th>Organic Matter Content %</th>
<th>pH</th>
<th>Particle Size Distribution %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>Mean</td>
<td>Range</td>
<td>n</td>
</tr>
<tr>
<td>DNH</td>
<td>Denham</td>
<td>7</td>
<td>5.78</td>
<td>4.9 - 7.1</td>
</tr>
<tr>
<td>EGF</td>
<td>Eigenhof</td>
<td>3</td>
<td>6.68</td>
<td>5.5 - 7.5</td>
</tr>
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<td>HHF</td>
<td>Hochfeld</td>
<td>4</td>
<td>4.74</td>
<td>2.7 - 6.5</td>
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<tr>
<td>HIN</td>
<td>Hibsin</td>
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<td>3.53</td>
<td>1.8 - 6.1</td>
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<td>Plum Coulee</td>
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<td>4.90</td>
<td>-</td>
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<td>RFD</td>
<td>Reinfeld</td>
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<td>Winkler</td>
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<td>6.52</td>
<td>4.6 - 8.4</td>
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</table>

* 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

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<tr>
<th>Class</th>
<th>Description</th>
<th>Range</th>
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</thead>
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<td>ST. AC.</td>
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<td>5.1-5.5</td>
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<td>ME. AC.</td>
<td>medium acid</td>
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<td>SL. AC.</td>
<td>slightly acid</td>
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<td>N</td>
<td>neutral</td>
<td>6.6-7.3</td>
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<tr>
<td>M. ALK.</td>
<td>mildly alkaline</td>
<td>7.4-7.8</td>
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</table>

Figure 8. pH of Surface Soils

22
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

<table>
<thead>
<tr>
<th>Soil Series</th>
<th>Depth cm</th>
<th>OM %</th>
<th>CaCO₃ %</th>
<th>Sand %</th>
<th>Silt %</th>
<th>Clay %</th>
<th>Texture Class</th>
<th>BD g/cc</th>
<th>FC %</th>
<th>PWP %</th>
<th>AW mm</th>
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<th>Ksat cm/hr</th>
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</tbody>
</table>

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**

<table>
<thead>
<tr>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 1</td>
<td>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.</td>
</tr>
<tr>
<td>Class 2</td>
<td>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.</td>
</tr>
<tr>
<td>Class 3</td>
<td>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.</td>
</tr>
</tbody>
</table>

**Table 9. Agricultural Capability Subclass Limitations**

<table>
<thead>
<tr>
<th>Subclass</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>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.</td>
</tr>
<tr>
<td>W</td>
<td>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.</td>
</tr>
<tr>
<td>X</td>
<td>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.</td>
</tr>
</tbody>
</table>
Table 10. Description of Irrigation Suitability Classes

<table>
<thead>
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<th>General Rating</th>
<th>Class</th>
<th>Degree of Limitation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>1A</td>
<td>No soil or landscape limitations</td>
<td>These soils are medium textured, well drained and hold adequate available moisture. Topography is level to nearly level. Gravity irrigation methods may be feasible.</td>
</tr>
<tr>
<td>Good</td>
<td>2A</td>
<td>Slight soil and/or landscape limitations</td>
<td>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.</td>
</tr>
<tr>
<td></td>
<td>2B</td>
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</tr>
<tr>
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<td>1B</td>
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<tr>
<td>Fair</td>
<td>3A</td>
<td>Moderate soil and/or landscape limitations</td>
<td>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.</td>
</tr>
<tr>
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</tr>
<tr>
<td></td>
<td>1C</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td>4A</td>
<td>Severe soil and/or landscape limitations</td>
<td>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.</td>
</tr>
<tr>
<td></td>
<td>4B</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4C</td>
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<td>4D</td>
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<tr>
<td></td>
<td>1D</td>
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</tr>
<tr>
<td></td>
<td>2D</td>
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</tr>
<tr>
<td></td>
<td>3D</td>
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### Table 11. Soil Features Affecting Irrigation Suitability

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Soil Feature</th>
<th>Degree of Limitation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>None(1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Granular, Single</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grained, Prismatic,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Blocky, Subangular</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Blocky</td>
</tr>
<tr>
<td>d</td>
<td>Structure</td>
<td>&gt; 30</td>
</tr>
<tr>
<td>k</td>
<td>Ksat (mm/hr) (0 - 1.2m)</td>
<td>&gt; 15</td>
</tr>
<tr>
<td>x</td>
<td>Drainability (1.2 - 3m) (mm/hr)</td>
<td>&gt; 15</td>
</tr>
<tr>
<td>m</td>
<td>AWHC sub/semid mm/1.2m (% vol.) subarid</td>
<td>&gt; 120</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(&gt; 10)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(&gt; 150)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(&gt; 12)</td>
</tr>
<tr>
<td>q</td>
<td>Intake Rate (mm/hr)</td>
<td>&gt; 15</td>
</tr>
<tr>
<td>s</td>
<td>Salinity depth(m) (dS/m)</td>
<td>&lt; 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - 6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.6 - 1.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.2 - 3</td>
</tr>
<tr>
<td>n</td>
<td>Soility (SAR) (m)</td>
<td>&lt; 6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - 1.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.2 - 3</td>
</tr>
<tr>
<td>g</td>
<td>Geological Uniformity</td>
<td>1 Textural Group</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - 1.2m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.2 - 3m</td>
</tr>
<tr>
<td>r</td>
<td>Depth to Bedrock (m)</td>
<td>&gt; 3</td>
</tr>
<tr>
<td>h</td>
<td>Depth to Waterable (m)</td>
<td>&gt; 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(if salinity is a problem)</td>
</tr>
<tr>
<td>w</td>
<td>Drainage Class</td>
<td>Well, Moderately Well, Rapid, Excessive</td>
</tr>
<tr>
<td>w</td>
<td></td>
<td>Well, Moderately Well, Rapid, Excessive</td>
</tr>
<tr>
<td>w</td>
<td></td>
<td>Well, Moderately Well, Rapid, Excessive</td>
</tr>
<tr>
<td>w</td>
<td>Textures (Classes) 0 - 1.2m</td>
<td>L, SiL, VFSL, FSL</td>
</tr>
<tr>
<td>w</td>
<td>Organic Matter %</td>
<td>&gt; 2</td>
</tr>
<tr>
<td>w</td>
<td>Surface Crusting Potential</td>
<td>Slight</td>
</tr>
</tbody>
</table>

* 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

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Landscape Features</th>
<th>Degree of Limitation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>None (A)</td>
</tr>
<tr>
<td>t1</td>
<td>Slope - Simple %</td>
<td>&lt;2</td>
</tr>
<tr>
<td></td>
<td>Complex %</td>
<td>&lt;5</td>
</tr>
<tr>
<td>t2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e</td>
<td>Relief m (Average Local)</td>
<td>&lt;1</td>
</tr>
<tr>
<td>p</td>
<td>Stoniness -Classes -Cover (%)</td>
<td>0, 1 &amp; 2 (0-3%)</td>
</tr>
<tr>
<td>i</td>
<td>Inundation -Frequency of Flooding (period)</td>
<td>1:10 (yr)</td>
</tr>
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</table>

Table 13. Soil and Landscape Conditions Affecting Environmental Impact Rating

<table>
<thead>
<tr>
<th>Soil Property and Landscape Feature</th>
<th>None</th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
</tr>
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<tr>
<td>Textural Groups1 (Classes2)</td>
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<td></td>
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<td></td>
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<tr>
<td>Surface Strata (1.2 m)</td>
<td>MF (SCL, CL, SiCL)</td>
<td>M (Si, VFS, L, SiL)</td>
<td>MCo (CoSL, SL, FSL, VFS, LVFS)</td>
<td>VCo (VCoS, CoS); Co (LCoS, LS, FS, LFS)</td>
</tr>
<tr>
<td>Geological Uniformity Weighted textural groupings3</td>
<td>MF to VF / M to VF; M / MF to VF</td>
<td>MF / MCo to Co; F / Co; MCo to Co / MF to VF</td>
<td>M / MCo to Co; Co / M; MF / VCo</td>
<td>VCo to Co / VCo to Co; MCo / Co to VCo; Co / VCo to MCo; M / VCo</td>
</tr>
<tr>
<td>Surface Strata (1.2 m) / Substrata (1.2-3.0 m)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydraulic Cond Ksat (mm/hr)</td>
<td>&lt; 1.5</td>
<td>1.5 - 15</td>
<td>15 - 50</td>
<td>&gt;50</td>
</tr>
<tr>
<td>Depth to Water Table (m)</td>
<td>&gt; 2 m</td>
<td>(2 m ———— 1 m)</td>
<td></td>
<td>&lt;1 m</td>
</tr>
<tr>
<td>Salinity (ds/m)</td>
<td>0 - 4</td>
<td>4 - 8</td>
<td>8 - 15</td>
<td>&gt;15</td>
</tr>
<tr>
<td>Topography (% Slope)</td>
<td>0 - 2</td>
<td>2 - 5</td>
<td>5 - 9</td>
<td>&gt;9</td>
</tr>
</tbody>
</table>

1Textural Groups: VF = Very Fine, F = Fine, M = Moderately Fine, M = Medium, MCo = Moderately Coarse, Co = Coarse, VCo = Very Coarse
2Texture 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

  Medium - M
  Medium to Fine - MF
  Medium to Very Fine - VF
  Very Fine - VFS
  Fine - F
  Sandy Clay - SC
  Silty Clay - SiC
  Clay - C
  Heavy Clay - HC

3Slash indicates surface strata (1.2 m) overlying substrata (1.2-3.0 m), i.e: 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>
<thead>
<tr>
<th>Site No.</th>
<th>Soil Name (Symbol)</th>
<th>Depth (cm)</th>
<th>Texture</th>
<th>Particle Size Analysis</th>
<th>Organic C%</th>
<th>pH</th>
<th>EC $^3$ mS/cm</th>
<th>% Water at Saturation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>Rignold (RGD)</td>
<td>0-20</td>
<td>VFSL</td>
<td>Sand % 76 Silt % 8 Clay % 16</td>
<td>2.87</td>
<td>8.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>35-45</td>
<td>VFSL</td>
<td></td>
<td>0.70</td>
<td>7.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A2</td>
<td>Rignold (RGD)</td>
<td>0-20</td>
<td>SCL</td>
<td>Sand % 66 Silt % 10 Clay % 24</td>
<td>2.06</td>
<td>7.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>80-110</td>
<td></td>
<td></td>
<td>8.0</td>
<td>0.4</td>
<td>69.6</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>110-125</td>
<td></td>
<td></td>
<td>8.1</td>
<td>0.6</td>
<td>104.9</td>
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</tr>
<tr>
<td>A3</td>
<td>Rignold (RGD)</td>
<td>0-20</td>
<td>SCL</td>
<td>Sand % 58 Silt % 15 Clay % 27</td>
<td>4.59</td>
<td>5.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>55-100</td>
<td>C</td>
<td></td>
<td>8.0</td>
<td>5.1</td>
<td>47.5</td>
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</tr>
<tr>
<td>A4</td>
<td>Denham (DNH)</td>
<td>0-20</td>
<td>SCL</td>
<td>Sand % 59 Silt % 16 Clay % 25</td>
<td>4.13</td>
<td>5.2</td>
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<tr>
<td></td>
<td></td>
<td>45-70</td>
<td>SCL</td>
<td></td>
<td>0.87</td>
<td>7.5</td>
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</tr>
<tr>
<td>A5</td>
<td>Denham (DNH)</td>
<td>0-20</td>
<td>SCL</td>
<td>Sand % 62 Silt % 14 Clay % 24</td>
<td>3.72</td>
<td>5.6</td>
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<tr>
<td></td>
<td></td>
<td>20-45</td>
<td>SCL</td>
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</tr>
<tr>
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<td>45-65</td>
<td>SCL</td>
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<td>7.9</td>
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<tr>
<td>A6</td>
<td>Gnadenthal (GDH)</td>
<td>0-20</td>
<td>VFSL</td>
<td>Sand % 83 Silt % 3 Clay % 14</td>
<td>1.76</td>
<td>4.7</td>
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<tr>
<td></td>
<td></td>
<td>60-80</td>
<td>VFSL</td>
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<td>1.18</td>
<td>7.7</td>
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<td>90-130</td>
<td>VFSL</td>
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<td>7.8</td>
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<td>130-180</td>
<td>SiCL</td>
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<td>7.9</td>
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<tr>
<td>A7</td>
<td>Eigenhof (EGF)</td>
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<td>SCL</td>
<td>Sand % 67 Silt % 12 Clay % 21</td>
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<td>VFSL</td>
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<td>SiC</td>
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<tr>
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<td>CL</td>
<td>Sand % 3.50 Silt % 1.10</td>
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<td>76.7</td>
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<td>80-120</td>
<td>SiC</td>
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<tr>
<td>A9</td>
<td>Plum Coulee (PME)</td>
<td>0-20</td>
<td>C</td>
<td>Sand % 2.85 Silt % 0.82</td>
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<td>25-60</td>
<td>CL</td>
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<td>60-110</td>
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<td>120-135</td>
<td>SiC</td>
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<td>7.9</td>
<td>1.2</td>
<td>82.3</td>
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<td>Plum Coulee (PME)</td>
<td>0-20</td>
<td>C</td>
<td>Sand % 8.1 Silt % 0.4</td>
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<td></td>
<td>70-110</td>
<td>C</td>
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<tr>
<td>Site No.</td>
<td>Soil Name</td>
<td>Soil Name (Symbol)</td>
<td>Depth (cm)</td>
<td>Texture</td>
<td>Particle Size/Analysis</td>
<td>Org. C (%)</td>
<td>C (%)</td>
<td>pH</td>
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<tr>
<td>B1</td>
<td>Reinfeld</td>
<td>(RFD)</td>
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<td>VFSL</td>
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<td>74</td>
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<td>50-160</td>
<td>LVFS</td>
<td>Clay %</td>
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<td>8</td>
<td>7</td>
</tr>
<tr>
<td>B2</td>
<td>Hochfeld</td>
<td>(HHF)</td>
<td>0-20</td>
<td>LVFS</td>
<td></td>
<td>61</td>
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<td>13</td>
</tr>
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<td>11</td>
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<td>B3</td>
<td>Hochfeld</td>
<td>(HHP)</td>
<td>0-20</td>
<td>VFSL</td>
<td></td>
<td>74</td>
<td>9</td>
<td>17</td>
</tr>
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<td>40-90</td>
<td>LVFS</td>
<td></td>
<td>81</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>B4</td>
<td>Hibsins</td>
<td>(HIN)</td>
<td>0-20</td>
<td>VFSL</td>
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<td>80</td>
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<td>12</td>
</tr>
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<td>20-35</td>
<td>LVFS</td>
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<td>8</td>
<td>11</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>90-110</td>
<td>C</td>
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</tr>
<tr>
<td>B5</td>
<td>Hibsins</td>
<td>(HIN)</td>
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<td>LVFS</td>
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<td>7</td>
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<td>40-70</td>
<td>LVFS</td>
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Table 14. Soil Chemical and Physical Analysis at Survey Grid Points.  
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<sup>1</sup>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  
<sup>2</sup>Org. C = Organic Carbon  
<sup>3</sup>EC = Electrical Conductivity  
% Org. C x 1.72 = Organic Matter %
Table 15. EM 38 Background Readings at Survey Grid Points
(see Figure 3 for grid point location)

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<td>85</td>
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<td>116</td>
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<tr>
<td></td>
<td>H</td>
<td>67</td>
<td>27</td>
<td>83</td>
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</table>

<sup>1</sup> Readings are mean values of three EM 38 measurements at each grid point.

<sup>2</sup> V = Vertical, 0 - 120 cm depth.

H = Horizontal, 0 - 60 cm depth.
## SOIL LEGEND

<table>
<thead>
<tr>
<th>Soil Symbol</th>
<th>Soil Name</th>
<th>Surface Texture</th>
<th>Soil Drainage</th>
<th>Mode of Deposition</th>
<th>Family Particle Size</th>
<th>Soil Subgroup</th>
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<tr>
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<td>Well</td>
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<td>Loamy/clayey</td>
<td>Orthic Black</td>
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<td>Eigenhof</td>
<td>Clay Loam</td>
<td>Well</td>
<td>Lacustrine</td>
<td>Fine loamy</td>
<td>Orthic Black</td>
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<td>Hochfeld</td>
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<td>Well</td>
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<tr>
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<td>Hibsin</td>
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<td>Well</td>
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<td>Orthic Black</td>
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<td>Kronstal</td>
<td>Loamy very fine sand</td>
<td>Imperfect</td>
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<td>Mod. Well</td>
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<td>Cumulic Regosol</td>
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BIBLIOGRAPHY


SOIL SURVEY REPORTS:


