Mr. Mart Cram, P.Eng.
Saskatchewan Water Corporation
P.O. Bag 1000
Outlook, Saskatchewan
S0L 2N0

Hydrogeologic Assessment of the
Hillcrest Irrigation Project

Dear Mart:

This letter accompanies our evaluation of the Hillcrest Irrigation Project which was carried out at your request.

If you have any questions concerning the interpretation of our findings please contact Les Henry directly as I will be out of the country until February 6, 1989.

Yours sincerely,

W.A. Meneley, P.Eng.

WAM/wp attachments
HYDROGEOLOGIC ASSESSMENT OF THE
HILLCREST IRRIGATION PROJECT

by

J.L. Henry, P. Ag., E.A. Christiansen, P. Eng.
and W.A. Meneley, P. Eng.

0094-054

December 5, 1988
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HYDROGEOLOGIC ASSESSMENT OF THE
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1.0 AREA OF STUDY AND TERMS OF REFERENCE

The original communication requesting a proposal for this
study (Wiens to Meneley, May 20, 1988) showed the area of
study to be:

Section 35-32-04-W3rd M
North 1/2 36-32-04-W3rd M
All of sections 1 and 2 33-04-W3rd M
SW 11-33-04-W3rd M
Section 12-33-04-W3rd M
East 1/2 13-33-04-W3rd M
Section 7-33-03-W3rd M

Based on those locations a two phase program of evaluation
was proposed. Phase I was a preliminary reconnaissance of
hydrogeologic and soil conditions on the project, and
Phase II was a groundwater survey with preparation of a
hydrogeologic cross section based on existing information.
It was recognized that a third phase involving exploration
drilling or installation of monitoring wells might be
required, but this could not be predicted until the first
two phases were completed.

At the time of obtaining authority to proceed (Cram to
Meneley, July 12, 1988) additional parcels of land were
added to the project. These parcels were:

SE 22-33-04-W3rd M
and
Two quarter section pivots in section 23-33-04-
W3rd M

The pivots in section 23 would be situated to take best
advantage of available terrain. They would include
portions of all four quarters but would be predominantly in the south half of the section.

The addition of these new parcels of land, along with information from Phase I, required that more detailed information be obtained. The original lands were predominantly above 1800 feet elevation, whereas the new lands added were predominantly below 1775 feet elevation. The SE 22-33-04-W3rd M was almost all below 1750 feet elevation and a portion was below 1725 feet elevation.

Thus, a third phase was instituted, which involved hydraulic rotary drilling to a suitable geologic datum, and test hole augering to document the near surface stratigraphy.
2.0 METHODS OF INVESTIGATION AND INFORMATION UTILIZED

2.1 Phases I and II

Phases I and II involved procurement and analysis of all available hydrogeology and related soils information. This included all the documents listed in the references section plus soil investigation reports obtained from the files of the Saskatchewan Water Corporation. The availability of a recent water well survey in the area (Remenda, 1987) meant that only four wells had to be sampled for this study.

In addition, on July 1, 1988 preliminary field inspection was carried out by J. L. Henry and E. A. Christiansen. This inspection was based on the original parcels of land and did not include SE 22 and Section 23-33-04W3 M.

Based on existing information and reconnaissance field inspection, a preliminary geologic cross section was prepared (Drawing 0121-001-01, E.A. Christiansen Consulting Ltd.). This preliminary drawing was used as a guide to direct test hole drilling and is not included with this report.

2.2 Phase III

Phase III involved the drilling of one deep test hole (Dundurn 01) to a suitable geologic datum using hydraulic rotary drilling equipment and standard techniques thereto (Sauer and Beckie, 1975; Hogg and Henry, 1985). This information was used to establish the base of exploration for subsequent test hole augering to the top of the Floral Formation.

One piezometer was installed using hydraulic rotary equipment and two piezometers were installed using the auger. These installations utilized 2" PVC 10 slot screen connected to 2" PVC schedule 40 casing. They were packed with frac sand and sealed with cement or barite.
3.0 RESULTS AND RECOMMENDATIONS

3.1 Results

Examination of existing hydrogeology and soils information established that all lands except SE 22 and Section 23-33-04-W3 were at elevations well above the piezometric surface of aquifers within the area. The very few saline conditions that are encountered within the southern land parcels are associated with slow drainage of sloughs and evaporite rings forming around these sloughs. Thus, surface drainage will be an important consideration in the irrigation of these lands.

Detailed test hole drilling on SE 22 and Section 23-33-04-W3 established the existence of a bedrock aquifer which is the Ard kenneth member of the Bearpaw Formation and in which both Jacob Willms and Dan Willms currently have producing wells. The piezometric surface of that aquifer is 1727' (J. Willms, 28/08/81).

In addition, the test hole drilling and piezometer construction program established that a glacial aquifer (Test Hole Dundurn 01, Appendix A) was present with a piezometric surface of 1736 feet above sea level. Cross section A - A' (Figure 1) and cross section B - B' (Figure 2) showed the position of these aquifers relative to the parcels of land under consideration.

Based on the information assembled to this stage, it was considered not feasible to proceed with irrigation of SE 22-33-04-W3 because a large portion of that quarter section occurs below the piezometric surface of the known aquifer systems. Based on detailed studies elsewhere, irrigation of such a hydrogeologic environment will cause soil salinization (Henry et al, 1988).

The rotary test hole drilling program also established the base of exploration for test hole augering as the top of the Floral Formation. Fifteen auger test holes were completed on Section 23 and N 1/2 14 and SE 22-33-04-W3. The detailed logs of the augering program are in Appendix A and cross section C - C' (Figure 3) illustrates the findings of the test hole augering.

The test hole augering showed the existence of sandy material on top of the till. It also showed that the existing topography is a good reflection of the Floral Formation surface. The very sharp texture break between sand and glacial till of the Floral surface will control the flow patterns of any excess irrigation water applied.
Thus, any excess water applied will infiltrate downward to the till surface and then tend to migrate laterally in a downslope direction. This water will tend to accumulate beneath the topographic depressions, causing waterlogging and salinization.

3.2 Recommendations

1. That irrigation proceed on all parcels outlined except SE 22-33-04-W3rd M.

2. That the question of surface drainage be addressed throughout the project. This is particularly crucial in the southern portion of the project where the topography is a rolling moraine with numerous undrained depressions. Drainage of these depressions will be required to ensure the long term viability of the project.

3. That careful monitoring be conducted in the irrigation of Section 23 and NW 14-33-04-W3rd M. One piezometer currently exists within the sand on top of the till (Test Hole Dundurn No. 06), and this and other piezometers installed as part of this project should be monitored on a weekly basis throughout the growing season and a monthly basis throughout the rest of the year. We recommend that the operator (Dan Willms) be provided with the equipment and recording forms and carry out this monitoring. Additional shallow piezometers may be required to monitor shallow water tables.

4. To avoid excessive migration of water at the till surface, the irrigation should be carefully scheduled to avoid over-irrigation.
4.0 REFERENCES

CHRISTIANSEN, E.A., 1967. Geology and groundwater resources of the Saskatoon area (73-B), Saskatchewan. Saskatchewan Research Council, Saskatoon.


SWC 720/16 1988
DUNDURN NO.01
SE-11-23-33-04-W3
627.02 mE/864.65 mN: SEC22
TESTHOLE & PIEZOMETER

ELEVATION 1777.76 FT.
SURVEY
SP COND MUD 1.2 m/ft
SP COND WATER 1.2 m/ft
SP 10 MV R 10 OHMS

DRILLING AND PIEZOMETER INSTALLATION
BY WATER DRILLING LTD.
AUGUST 23-25, 1988

E.A. Christiansen Consulting Ltd.
SWC 720/16 1988
DUNDBURN NO.03
NW-15-23-33-04-W3
967.99ME/1416.8MN:SEC22
AUGERHOLE

AUGERFLIGHT SAMPLE DESCRIPTION

0
SAND, FINE-V. FINE, SILTY, CALC.,
LT. BR. GR.

15'
TILL, SANDY, CALC., LT. BR. GR., SOFT,
GRavel, CO-V. CO. SANDY, SILTY, CALC.,
TILL, CALC., GR. BR., SOFT, UNSTAINED

10
TILL, CLAYEY, CALC., GYP,

1807.05' SWC SURVEY

DK. GR. BR. STAINS, HARD

AUGERHOLE DRILLED BY
DON MACRAE AND SON
SEPTEMBER 1, 1988

GEOLoGY BY
E.A. CHRISTIANSEN CONSULTING LTD.
SEPTEMBER 4, 1988
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<td>lt. Ol. Br. Stains, hard</td>
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**Geology by**

E.A. Christiansen Consulting Ltd.

September 4, 1988

**Augerhole Drilled by**

Don MacRae and Son

September 1, 1988
SWC 720/16 1988
DUNDURN NO.05
SE-15-23-33-04-W3
1121.1ME/1204.3MN:SEC22
AUGERHOLE

AUGERFLIGHT SAMPLE DESCRIPTION

MUCK, SILTY, NONCALC., EK,

1785.53' (GMC SURVEY)

MOLLUSK SHELLS

CLAY, SILTY, CALC., V. EK. GR.

MOLLUSK SHELLS, CALCIUM CORC.

SILT, CLAYEY, ST. CALC., LT. BR. GR.,

LT. OL. BR. STAINS

SAND, FIN.-V. FINE, CALC., LT. BR. GR.,

OL. - GR., LT. OL. BR. STAINS

SAND, V. FINE, SILTIER DOWNWARD,

OL.

SILT, V. FINE SANDY, CALC., OC.

TILL, SANDY, CALC., GR.

TILL, CALC., GR., HARDER

AUGERHOLE DRILLED BY
DOM MACRAE AND SON
SEPTEMBER 2, 1988

GEOLOGY BY
E.A. CHRISTIANSSEN CONSULTING LTD.
SEPTEMBER 4, 1998
SWC 720/16 1988
DUNDBURN NO. 06
NE-06-23-33-04-W3
773.52'ME/770.71'MN: SEC22
AUGERHOLE & PIEZOMETER

AUGERFLIGHT SAMPLE DESCRIPTION

1773.64'(TOP OF PIPE)
2" PVC PIPE
1770.41'(SWC SURVEY)

SAND, V. FINE, SILTY, NONCALC., GYP...
GR. BR.

10'

SAND, V. FINE-MED., SILTY, CALC...

SILT, CALC., GYP., LT. BR. GR.

TILL + SAND, CALC., LT. BR. GR.

TILL, SANDY, CALC., LT. BR. GR.

TILL, CLAYEY, CALC., GR. BR.

0'

10'

1760.62'(STATIC WATER LEVEL, 05/09/88)

SCREEN
WASHDOWN VALVE

SAND PACK
BENTONITE SEAL
LT. BR. GR.

HOLE SKIDDED FOR PIEZOMETER
VEL. BR. STAINS

AUGERHOLE DRILLED BY
DON MACRAE AND SON
SEPTEMBER 1-2, 1988

GEOLOGY BY
E.A. CHRISTIANSEN CONSULTING LTD.
SEPTEMBER 5, 1988
SWC 720/16 1988
DUNDURN NO.07
SE-01-23-33-04-W3
1606.8mE/125.77mN:SEC22
AUGERHOLE

AUGERFLIGHT SAMPLE DESCRIPTION

TILL, CALC., LT. BR. GR., SOFT.
GROD, FINE-GD., GR. BR. H.

TILL, CALC., GR. BR., YEL. BR. STAINS

AUGERHOLE DRILLED BY
DOM MACRAE AND SON
SEPTEMBER 1, 1988

GEOLOGY BY
E.A. CHRISTIANSEN CONSULTING LTD.
SEPTEMBER 4, 1988

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**AUGERHOLE**

SWC 720/16 1988
DUNDURN NO.08
NE-15-14-33-04-W3
1057.66'ME/73.28'MS:SEC22

**AUGERFLIGHT SAMPLE DESCRIPTION**

SAND, FINE-V. FINE, SILTY, ST. CALC., SYP., LT. YEL. BR., LT. OL. STAINS
SILT, SANDY, CALC., LT. YEL. BR.
TILL, SANDY, CALC., LT. YEL. BR.
TILL, CALC., GR.+OL., MOTTLED

**AUGERHOLE DRILLED BY**
DON MACRAE AND SON
SEPTEMBER 1, 1988

**GEOLOGY BY**
E.A. CHRISTIANSEN CONSULTING LTD.
SEPTEMBER 4, 1988

E.A. Christiansen Consulting Ltd.
SWC 720/16 1988
DUNDURN NO.11
SE-11-23-33-04-W3
620.68'ME/B26.14'MN:SEC22
AUGERHOLE

AUGERFLIGHT SAMPLE DESCRIPTION

SAND, FINE-V. FINE, CALC., GR. BR.

SAND, V. FINE-MED., CALC., DK. GR. BR.

SAND, V. FINE-MED., LT. BR. GR.

SILT, CALC., LT. BR. GR.

TILL, CALC., LT. BR. GR., UNSTAINED

TILL, CALC., LT. YEL. BR., HARD

1773.20' (SWC SURVEY)

SILTIER TOWARD BASE

WITH DK. GR. BR. CLAY AT BASE

25'

AUGERHOLE DRILLED BY
DON MACRAE AND SON
SEPTEMBER 1, 1988

GEOLOGY BY
E.A. CHRISTIANSEN CONSULTING LTD.
SEPTEMBER 4, 1988
SWC 720/16 1988
DUNDURN NO.14
NE-02-22-33-04-W3
404.4 mW/397.00 mN: SEC22
AUGERHOLE

AUGERFLIGHT SAMPLE DESCRIPTION

0' = 1742.32' (SWC SURVEY)

SAND, V. FINE, SILTY, CALC., ➤  ➤ LT. BR. GR.

SAND, V. FINE-MED., SL. CALC., GR. BR. ➤ ➤

SILT, SANDY, CALC., LT. BR. GR. ➤ ➤

SAND, MED.-CO., LT. CL. GR. ➤ ➤

TILL, CLAYEY, CALC. ➤  ➤  20' GR., GR. BR., CL. GR., HARD

AUGERHOLE DRILLED BY
DON MACRAE AND SON
SEPTEMBER 3, 1988

GEOLGY BY
E.A. CHRISTIANSEN CONSULTING LTD.
SEPTEMBER 4, 1988

E.A. Christiansen Consulting Ltd.
SWC 720/16 1988
DUNDURN NO.15
SE-01-22-33-04-W3
81.6MW / 81.0MN:SEC22
AUGERHOLE

AUGERFLIGHT SAMPLE DESCRIPTION

0
1764.86' (SCW SURVEY)

SAND, FINE-V. FINE, SILTY, CALC.,

LT. BR. GR.

SAND, CO.-V. CO., PEBBLY, GR. BR.

10

TILL, CALC., SYR., LT. BR. GR.

UNSTAINED

TILL, CLAYEY, CALC., GR. BR.,

LT. OL. BR. STAINS, HARD

AUGERHOLE DRILLED BY
DON MACRAE AND SON
SEPTEMBER 3, 1988

GEOLOGY BY
E.A. CHRISTIANSSEN CONSULTING LTD.
SEPTEMBER 4, 1988

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<th>CONCENTRATION OF IONS (mg/L)</th>
<th>S.A.R.</th>
</tr>
</thead>
<tbody>
<tr>
<td>WB-00132</td>
<td>DUNDURN #1 P SAMPLE #1</td>
<td>1178</td>
<td>8.0</td>
<td>1.8</td>
<td>172  149  72  11  14  681  495  2.9</td>
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</tbody>
</table>

#### Water Sample #2

<table>
<thead>
<tr>
<th>Lab #</th>
<th>Client Identification</th>
<th>T.D.S.</th>
<th>T.S.</th>
<th>COND.</th>
<th>CONCENTRATION OF IONS (mg/L)</th>
<th>S.A.R.</th>
</tr>
</thead>
<tbody>
<tr>
<td>WB-00133</td>
<td>DUNDURN #1 P SAMPLE #2</td>
<td>1088</td>
<td>8.2</td>
<td>1.7</td>
<td>162  113  61  10  14  620  429  3.1</td>
<td></td>
</tr>
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</table>

### Water Analysis

#### Water Sample #3

<table>
<thead>
<tr>
<th>Lab #</th>
<th>Client Identification</th>
<th>T.D.S.</th>
<th>T.S.</th>
<th>COND.</th>
<th>CONCENTRATION OF IONS (mg/L)</th>
<th>S.A.R.</th>
</tr>
</thead>
<tbody>
<tr>
<td>WB-00155</td>
<td>DUNDURN #13</td>
<td>1510</td>
<td>7.9</td>
<td>2.4</td>
<td>76  350  139  16  12  1235  386  0.9</td>
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</table>

#### Water Sample #4

<table>
<thead>
<tr>
<th>Lab #</th>
<th>Client Identification</th>
<th>T.D.S.</th>
<th>T.S.</th>
<th>COND.</th>
<th>CONCENTRATION OF IONS (mg/L)</th>
<th>S.A.R.</th>
</tr>
</thead>
<tbody>
<tr>
<td>WB-00156</td>
<td>DUNDURN #25</td>
<td>1568</td>
<td>8.1</td>
<td>2.4</td>
<td>215  213  157  6  12  1143  416  2.7</td>
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</tr>
</tbody>
</table>
Analyses of water samples from farm wells

<table>
<thead>
<tr>
<th>LAB #</th>
<th>CLIENT IDENTIFICATION</th>
<th>T.D.S.</th>
<th>pH</th>
<th>COND.</th>
<th>CONCENTRATION OF IONS (ug/ml)</th>
<th>S.A.R.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>mS/cm</td>
<td></td>
<td>Na+</td>
<td>Ca++</td>
<td>Mg++</td>
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<tr>
<td>WB-00112</td>
<td>Well No. 1</td>
<td>1901</td>
<td>8.00</td>
<td>3.0</td>
<td>545</td>
<td>124</td>
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<tr>
<td>WB-00113</td>
<td>Well No. 2</td>
<td>1830</td>
<td>8.00</td>
<td>2.9</td>
<td>455</td>
<td>154</td>
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<tr>
<td>WB-00116</td>
<td>Well No. 3</td>
<td>2829</td>
<td>7.05</td>
<td>4.4</td>
<td>658</td>
<td>336</td>
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<tr>
<td>WB-00137</td>
<td>Well No. 4</td>
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<td>8.10</td>
<td>1.1</td>
<td>190</td>
<td>36</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>WELL NO.</th>
<th>OWNER</th>
<th>LOCATION</th>
<th>DEPTH</th>
<th>STATIC</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>feet</td>
<td>LEVEL (ft)</td>
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</tr>
<tr>
<td>1</td>
<td>Dan Willms</td>
<td>SW 04-22-33-04-w3</td>
<td>225</td>
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<tr>
<td>2</td>
<td>Jacob Willms</td>
<td>SE 04-23-33-04-w3</td>
<td>255</td>
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<tr>
<td>3</td>
<td>W. Falk</td>
<td>SW 04-18-33-03-w3</td>
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<td>68</td>
</tr>
<tr>
<td>4</td>
<td>L. Qualman</td>
<td>SW 01-27-33-04-w3</td>
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<td>42</td>
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</tbody>
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