

HYDROGEOLOGY OF THE EASTEND TO RAVENSCRAG FORMATIONS IN SOUTHERN SASKATCHEWAN

by

W.A. Meneley, P.Eng.

0089-001

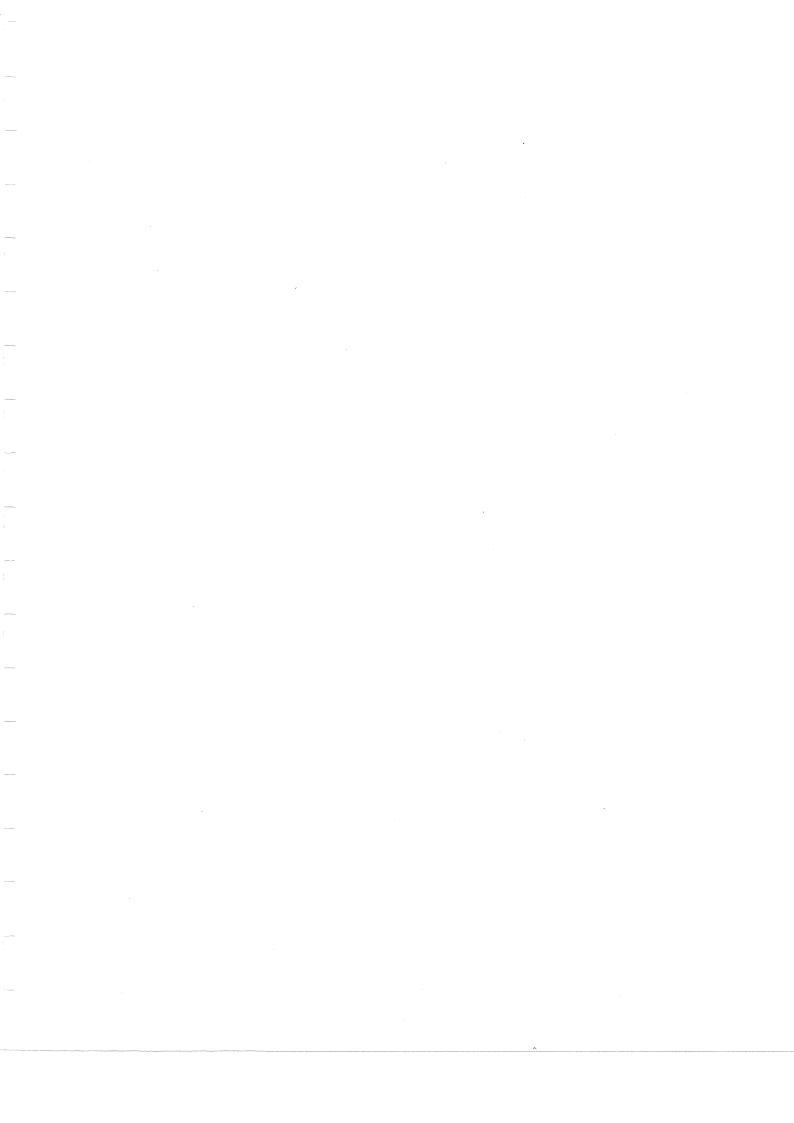
W. A. Meneley Consultants Ltd.

CONSULTING HYDROGEOLOGISTS AND GEOLOGICAL ENGINEERS

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March 30, 1983

Mr. A.L. Jones, P.Eng. Director, Water Rights Branch Environment Saskatchewan 5th Floor, 1855 Victoria Avenue Regina, Saskatchewan S4P 3V5

Ravenscrag Bedrock Aguifer Study

Dear Mr. Jones:

This letter accompanies my report 0089-001 titled "Hydrogeology of the Eastend to Ravenscrag Formations in southern Saskatchewan" which was executed under Contract 46(82-83). After you have had an opportunity to review the report I would be pleased to meet with you to discuss it.

> N. A. MENELEY SASKATOON W.A. Meneley, P.Eng.

Yours sincerely

PROFESSIONAL ENGINEERS OF SASKATCHEWAN

ERTIFICATE NUMBER 297

THE ASSOCIATION OF

W. A. MENELEY CONSULTANTS LTD.

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HYDROGEOLOGY OF THE EASTEND TO RAVENSCRAG FORMATIONS IN SOUTHERN SASKATCHEWAN

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1.0

INTRODUCTION

1.1

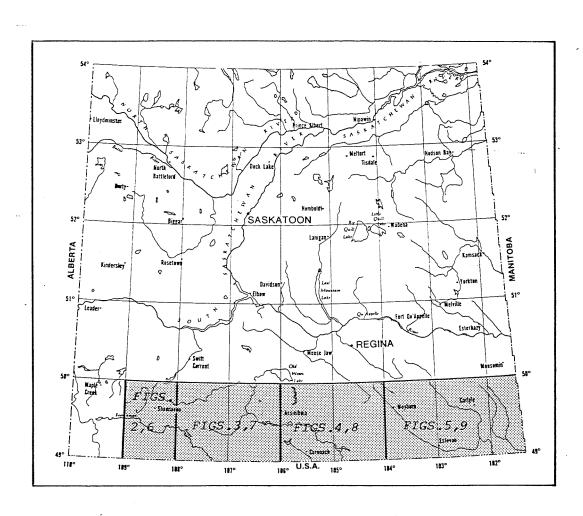
Scope

This study was undertaken under Contract No. 46 (82-83) between Environment Saskatchewan and W.A. Meneley Consultants Ltd. The area of study, shown in Fig. 1, is somewhat larger than defined in the contract in order to include all of the Shaunavon Aquifer System.

The scope of the contract included the following items:

The Contractor shall:

- a) Compile and correlate relevant existing data on the geology of the Ravenscrag System.
- b) Analyse and evaluate the data to determine the stratigraphy of the Ravenscrag System.
- c) Construct preliminary isopach maps of the Ravenscrag System.
- d) Construct two separate east-west geological cross-sections and six north-south separate geological cross-sections.
- e) Identify, where possible, individual significant aquifer units in the Ravenscrag System.
- f) Construct a "first run" piezometric map of the Ravenscrag System.
- g) Review and comment on the geochemistry of the Ravenscrag System.
- h) Identify geological, hydrological and chemical informational gaps.
- i) Prepare preliminary evaluation of the quantity and quality of the groundwater resources in the Ravenscrag System.
- j) Prepare Phase 1 report.



- Figure 1. Location of the study-area.

1.2 Division of Responsibility and Methods of Study

E.A. Christiansen defined the geology of the Eastend to Ravenscrag Formations in the study area. W.A. Meneley carried out the hydrogeological studies and provided the overall project supervision. Technical assistance in compiling the geologic and hydrologic information was provided by V.F. Allen. L.E. Cochran supervised the computer data compilation and graphics output.

The study format involved dual use of the base maps and interpretative maps to minimize duplication of effort. All drawings, tables, and appendices in the report are numbered consecutively, regardless of whether they first appear in the Christiansen report or in the overall report. All of the larger plans and cross-sections are included at the back of the report. A second master copy of the complete report text and reproducible copies of all drawings have been submitted in acordance with the terms of the contract.

Geological information was compiled from a number of sources including oil and gas exploration testholes, Saskatchewan Research Council groundwater exploration testholes, and Saskatchewan Power Corporation and Department of Mineral Resources coal exploration testholes. Groundwater exploration testholes for which geophysical logs are available through the Family Farm Assistance Branch test drilling assistance program were also used. These sources provided the bulk of the first order geological information that was used by Christiansen to establish the geological framework for this study. The information was compiled and presented on plans (Fig. 2-5) and cross-sections (Fig. 10-22).

Water well information compiled in a microfiche format by the Water Rights Branch, Environment Saskatchewan was used extensively to compile the preliminary hydraulic head maps in the study area (Fig. 6-9). The format in which this information is now available makes it possible to use this source of data for hydrogeological studies. Wells completed in the Eastend to Ravenscrag Formations were selected on the basis of the information reported together with the information provided by Christiansen. Ground elevations were checked against the 1:50,000 topographic maps and the hydraulic head maps were compiled by contouring the reported water level elevations.

The meteorological information at a few selected stations in the study area was compiled into our computer file from microfiche records provided by the Atmospheric Environment Service, Environment Canada. Files and output graphics were generated to obtain a "first look" at the climatology of the study area.

Hydrographs from selected observation wells which form part of the Saskatchewan Research Council observation well network are included in Appendix C.

Water analyses from the Saskatchewan Reseach Council water chemistry data file and from published sources (Rutherford, 1967) were also compiled into our computer file. Tables and output graphics were generated to characterize the water chemistry of the Eastend to Ravenscrag Formations in the study area.

Preliminary yield predictions were based on the anticipated natural recharge over the area of the aquifer.

1.3

Terminology

1.3.1 <u>Eastend to Ravenscrag Formations:</u>

Early in the investigation it became apparent that the Ravenscrag Formation could not be separated from the underlying sand and silt beds which are present throughout the study area. Furthermore, the Ravenscrag Formation alone does not comprise a valid hydrostratigraphic unit. Accordingly, all of the strata present between the upper contact of the Bearpaw and Pierre Formations and the Tertiary gravels [or glacial deposits] were considered as a single rock unit. (Christiansen, this report).

1.3.2 Aquifers and Aquifer Systems:

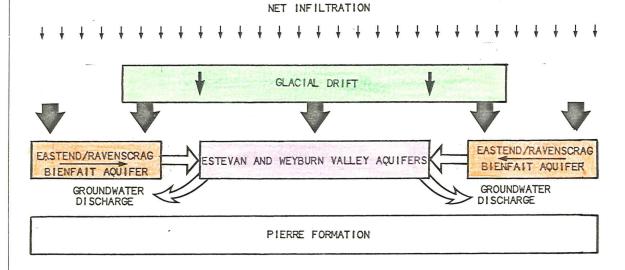
An <u>aquifer</u> is a rock unit which is saturated and which is capable of <u>delivering</u> sufficient water to a properly-constructed well completed in it to satisfy the intended need for water.

An <u>aquitard</u> is a rock unit which may be saturated or unsaturated. Although it is sufficiently permeable to permit some water to move through it under the prevailing hydraulic gradient, an aquitard will typically yield only a small amount of water to a well. For example, a bored well may be completed in till which forms the aquitard overlying an intertill aquifer. Although pumping a well in an adjacent aquifer may alter the hydraulic head within an aquitard, pumping a well completed in an aquitard will have no measurable effect on the hydraulic head in an adjacent aquifer.

An <u>aquifer system</u> is an assemblage of one or more aquifers and their associated aquitards which together function as a single hydrogeologic unit within an area that can be defined physically on the basis of topography and/or geology. An aquifer system is the basic unit for groundwater resources management. The schematic diagram of the aquifers and aquifer systems in the study area (Fig. 28) demonstrates how the nomenclature is applied.

Note that the name Bienfait Aquifer is applied to the Eastend to Ravenscrag Formations in the Estevan area because this unit is a subordinate component of the Estevan Valley Aquifer System and not an aquifer system in its own right.

SHAUNAYON, CORONACH, BENGOUGH AND ORMISTON AQUIFER SYSTEMS. In all of these aquifer systems the Eastend toRavenscrag Formations are the dominant element. That is, they are the most pervious and continuous rock units through which lateral groundwater flow occurs.



ESTEVAN VALLEY AQUIFER SYSTEM. In this aquifer system the Estevan and Weyburn Valley Aquifers are the dominant elements through which most of the lateral groundwater flow occurs. Although lateral flow also occurs through the Eastend to Ravenscrag Formations, the hydraulic head in the Bienfait Aquifer is controlled by the hydraulic head in the Estevan and Weyburn Valley Aquifers.

Fig. 28 Schematic diagrams of aquifers and aquifer systems in the study area.

1.3.3 Hydraulic Head:

Hydraulic head is used in the manner defined by Freeze and Cherry (1979, p.18-22). In the context of this study, it is the elevation at which water stands in a well completed in the Eastend to Ravenscrag Formations (Fig. 29). It is made up of two components, the elevation head or elevation of the mid-point of the completion zone, and the pressure head which is the height that the water rises in the well above the mid-point of the completion zone.

In this study no correction was applied for the density of the actual fluid column in the well. This was unnecessary because the water in the Eastend to Ravenscrag Formations is comparatively fresh, that is, the density of the water is very close to unity, and because the length of the water column is relatively short.

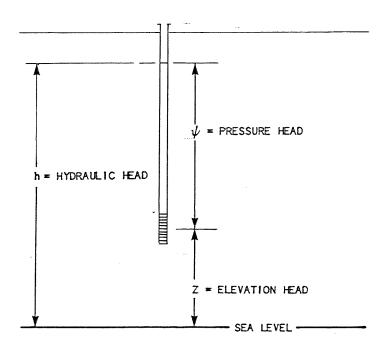


Fig. 29 Schematic definition of hydraulic head

2.0

HYDROGEOLOGY

2.1

Introduction

Groundwater obtained from the Eastend to Ravenscrag Formations in southern Saskatchewan constitutes a major source of water supply for domestic and municipal users within the study area. Several aquifer systems, which constitute discrete water management units, have been identified and delineated. The potential utilization of groundwater from this source is governed by the quantity and quality of groundwater available and the impact of groundwater extraction on the existing groundwater users.

No attempt has been made to re-state the geological interpretations made by Christiansen. It is presumed that the reader has studied his report which is appended. The following discussion deals with the hydrogeology in the context of the geological framework.

2.2

Well Yields

The yield of a well is governed by the hydraulic conductivity of the formation in the immediate vicinity of a well. In the study area, wells completed in the blanket sand near the base of the unit and those completed in channel sands may be expected to have the highest specific capacity. Throughout the study area, the blanket sands and channel sands range from fine to medium grained sand. Only a few values of hydraulic conductivity have been documented. In the Shaunavon Aquifer System, at SRC Shaunavon and SRC Garden Head the hydraulic conductivity calculated from short-duration pumping tests (Meneley, et.al, 1979) was found to range from:

1.3E-05m/s to 7.3E-05m/s

According to well reports 53647 and 54746 (SE8-8-18-W3) wells constructed for the Town of Shaunavon had reported transmissivities ranging from 5100 to 5190 Igpd/ft. The corresponding range in hydraulic conductivity expressed in SI units is:

6.7E-05m/s to 7.0E-05m/s

Other wells in the Shaunavon and Coronach Aquifer Systems typically have specific capacities ranging from:

0.1 to 2.5 Igpm/ft

Allowing for differences in the length of the completion zones in these wells the equivalent hydraulic conductivity is still in the same range, that is:

1E-05 to 7E-05m/s

At SRC Coronach the hydraulic conductivity determined from a response test (Meneley, et.al., 1979) is:

3.0E - 05m/s

In the Coronach area Whitaker (personal communication) considered that the coal beds were fractured and that the more lithified sandstones were brittle and had significant secondary fracture permeability. For the present it is considered that the hydraulic conductivity of the Bengough and Ormiston Aquifer Systems is similar to that of the Coronach Aquifer system.

In the Bienfait Aquifer, the specific capacity reported in the Water Rights Branch records for 50 wells were selected for analysis. These were adjusted for the reported length of the completion zone and the resulting hydraulic conductivity values were calculated. The values range from:

2.3E-07 to 2.0E-05m/s

Walton (1970, p.549-550) used well records to estimate the transmissivity of the Ravenscrag Formation. He used a hydraulic conductivity value of:

9.4E - 07m/s

which is approximately the median value determined from the present sampling. This is not surprising considering that he started from essentially the same type of information.

This information suggests that the probable yield of wells completed in the Eastend to Ravenscrag Formations should be expected to range from:

6.3E-05 to 6.3E-03 m^3 /s [1-100 USgpm]

with wells yields in the western part of the study area biased toward the upper part of the range and well yields in the Bienfait Aquifer biased toward the low end of the range.

The estimated well yields are consistent with the geological environment of the Eastend to Ravenscrag Formations. Individual wells are generally completed in a 1-10m interval in which the driller encountered the most favorable material. Inspection of the geophysical logs from FFIB wells confirms that drillers are able to identify these zones.

Examination of the geophysical logs on the cross-sections (Fig. 10-22) indicates that channel sands and/or blanket sands are encountered in virtually all testholes. It is considered that the hydraulic conductivity values computed above reflect the hydraulic conductivity of the blanket and channel sands in the Eastend to Ravenscrag Formations.

The sand beds encountered in these formations are commonly friable so that wells must be screened and filter packed to minimize sand production with the water. Even so, construction of wells capable of yielding $>1E-03m^3/s$ [about 20 USgpm] requires special care and attention.

Some of the sand beds are cemented and are quite competent. Coal beds also constitute competent layers which tend to have fracture permeability. Wells in these materials can be completed openhole.

The hydraulic conductivity distribution of the deltaic deposits will be anisotropic, with the maximum permeability axis oriented parallel to the axis of the channel. Pumping tests carried out on wells that are correctly situated (in channel fill deposits) will display barrier boundary effects due to the presence of the channel walls.

In summary, both the texture of the sands and their hydraulic conductivity may be expected to limit the yield of wells completed in the Eastend to Ravenscrag Formations. Wells completed in fracture zones may be more productive, but may produce sand unless they are filter-packed.

2.3

Recharge

The Eastend to Ravenscrag Formations in the Cypress, Wood Mountain and Willowbunch Lake areas are present beneath the inter-stream divide between the Missouri River Basin to the south and the Saskatchewan-Nelson Basin to the north. The hydraulic head maps of these areas (Fig. 6,7, and 8) show that the hydraulic head is a subdued replica of the present topography. They confirm that a simple gravitational flow system (Hubbert, 1940) exists in these aquifer systems. Thus, the only source of natural recharge to these aguifer systems is from precipitation which falls on the land surface above the aquifer and infiltrates through the zone of aeration and through any overlying aquitards which may be present before entering the aquifer. It is also evident from the topographic position and stratigraphy of these aquifers as shown in cross-sections (Fig. 10-22) that virtually the entire area of the aquifer will be a recharge area, with discharge limited to the peripheral outcrop area.

The Bienfait Aquifer (Fig. 9) is more complex. Recharge to the Bienfait Aquifer occurs by vertical infiltration of water through the overlying aquitards. Groundwater discharges laterally from the Bienfait Aquifer into the Estevan Valley Aquifer and Weyburn Valley Aquifer. These function as major groundwater drains which intercept groundwater from the Weyburn and Virden area and discharge it to the Souris River. Discharge from the valley aquifers is concentrated at two locations where the Estevan Valley passes beneath the Souris River north of Outram, and south of Oxbow. Discharge from the Bienfait Aquifer also occurs directly to the Souris River Valley in the vicinity of Estevan. Fig. 9 shows that recharge occurs over substantially the entire sub-crop area of the aquifer.

The amount of recharge to these aquifer systems must be known if the groundwater resources of these aquifer systems are to be administered effectively. The hydraulic head maps clearly indicate that recharge can only originate from precipitation which falls on the land surface above the aquifers. Thus, recharge must be related to the climate of southern Saskatchewan. Fig. 30, 31, 32, and 33 show the total precipitation records at a few selected meteorological stations within the study area. All stations show that the precipitation is highly-variable from year to year. Fig. 35 shows the cumulative departure of annual precipitation from the mean at the stations included. The trend of the Garden Head/Shaunavon record is most diagnostic because the meteorological record there has the longest duration. The shorter records at the other stations diverge from the trend of the Garden Head/ Shaunavon record during their early years but the trends converge toward a similar pattern toward the present.

The hydrograph of SRC Garden Head (Fig. 35) shows the same trend as the cumulative departure trend of Garden Head/Shaunavon. The hydrograph of SRC Shaunavon [not shown] is considered to be influenced by production from the Town of Shaunavon well field. Similarly, the hydrograph of SRC Coronach is dominated by the effect of dewatering the SPC Coronach mine. SRC Forget is completed in the surficial deposits adjacent to Moose Mountain Creek in the Weyburn/Virden area (Fig. 9). Its hydrograph [not shown] also has the same form as the cumulative departure from mean precipitation at Estevan Airport. Note that these hydrographs are plotted on a dimensionless relative scale for trend comparison only. The actual hydrographs are presented in Meneley et.al, (1979) with updated hydrograph information available on request from the Saskatchewan Research Council.

The evidence from the observation well network hydrographs demonstrates that the aquifer systems are being replenished by recharge from precipitation.

Therefore, the water from these aquifer systems can be allocated as a renewable resource.

However, it must be recognized that the rate of renewal may be slow, and certainly there will be periods of several years duration during which there will be no recharge at all. Any allocation policy must permit drawing to some degree on the water in storage in the groundwater reservoir. As Bredehoeft and Young (1970) pointed out, lowering the groundwater level in an aquifer system will tend to increase the amount of recharge into the system and to diminish the amount of discharge. Development of the maximum groundwater resource potential requires that some groundwater mining must occur. They considered that most aquifer systems would have to be considered on a non-steady state basis because it would probably take at least 100 years for an aquifer system to approach equilibrium under developed conditions.

Meneley (1972,p. 682-689) estimated the net groundwater yield of the Estevan Valley Aquifer System would be about 1.5 E07 m³/yr under conditions of full development of the Estevan Valley Aquifer. Because the Bienfait Aquifer is a subordinate component of the Estevan Valley Aquifer System, the net groundwater yield of the Bienfait Aquifer would be some fraction of the net groundwater yield assigned to the Estevan Valley Aquifer System. This will be discussed in more detail in a later section of this report.

2.4 <u>Water Chemistry</u>

The water chemistry in the Eastend to Ravenscrag Formations was compiled from existing sources of information and is summarized by aquifer systems in Table 1 and in Fig. 36, 37 and 38. Only those samples for which all of the major constituents were measured were included. Many of the analyses from the Public Health lab in Regina were not included because only partial analyses were carried out.

The water from the Shaunavon, Coronach, Bengough, and Ormiston Aquifer systems meet all of the guidelines for rural water supplies in Saskatchewan according to the Pollution Control Branch Water Quality Objectives (1975). However, water from Bienfait Aquifer does not meet the objectives principally due to excess total solids and excess chlorides. The water analyses that do not meet the guidelines are noted in Table 1.

Water from the Eastend to Ravenscrag Formations is not suitable for irrigation due to excess sodium and high salinity (Fig. 39). The only possible exception may be in the Shaunavon Aquifer System which will be discussed in detail in a later chapter.

There is a systematic change both in the composition and concentration of groundwater in these aquifer systems across the study area. In the Shaunavon aquifer System the mean concentration is about 1100 mg/l. The water is of the sodium-bicarbonate type. Moving eastward, the concentration increases to about 1800 mg/l, the total hardness decreases, but the water type remains the same in the Coronach Aquifer. However, further eastward in the Bienfait Aquifer, the total concentration is about 2,600 mg/l and the water is a sodium-bicarbonate chloride type water either with no sulphate, or with a significant sulphate component as well. Further investigation of the water chemistry would be required to get a better understanding of the origin and alteration of the water within the flow system.

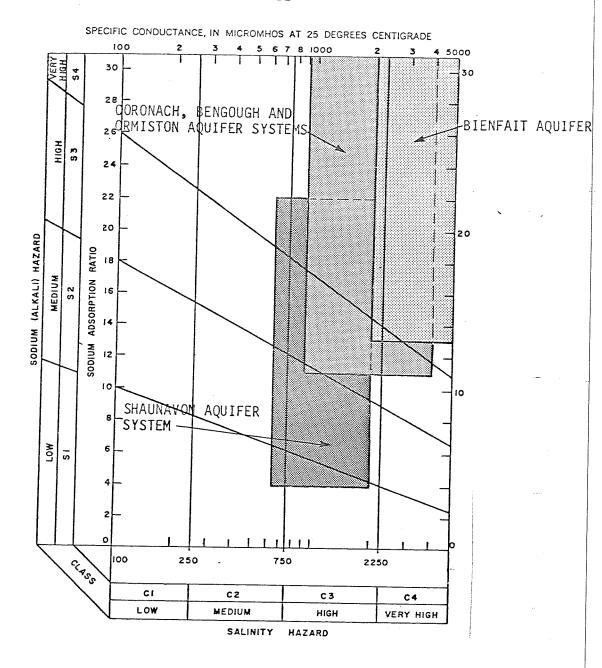


Fig. 39 Suitability of water from the Eastend to Ravenscrag Formations for irrigation purposes (modifified from Hem, 1959,p.251).

The specific conductivity was calculated by dividing the sum of ions reported in Table 1 by 0.75 because it was not measured for many of the samples reported.

3.0 DISCUSSION OF INDIVIDUAL AQUIFERS AND AQUIFER SYSTEMS

3.1 <u>Shaunavon Aquifer System</u>

The Shaunavon Aquifer System is the most important bedrock aquifer system in the study area in terms of its probable yield and the quality of groundwater that may be obtained from it. The Shaunavon Aquifer underlies about $2,600~\rm{km^2}$ in the Cypress area. Fig. 2, and 6 show the thickness and hydraulic head distribution and cross-sections (Fig. 10, 20 and 21) show the stratigraphy. The aquifer system is bounded on the south by the Frenchman River (Fig. 20), on the west by Swiftcurrent Creek (Fig. 10,21), and on the north and east by glacial erosion of the Eastend to Ravenscrag Formations.

The Shaunavon Aquifer is a tabular mass of poorly-consolidated sandstone and interbedded silt and silty clay beds. The observed water level (Fig. 6) is sustained only by precipitation. Given a period of sufficiently long duration with no recharge this aquifer would drain at a diminishing rate until it was empty. The present average saturated thickness of the Shaunavon Aquifer is about 50m. Because the water table is within the Shaunavon Aquifer it must be considered as an anisotropic unconfined aquifer. If it is assumed that the storage coefficient of the aquifer is about 20%, then the volume of water in storage in the aquifer is about 2 E10 m³.

There is little information about the absolute rate of annual recharge. Certainly the SRC Shaunavon and SRC Garden Head observation wells show pronounced seasonal fluctuations indicative of seasonal recharge. If it is assumed that the annual recharge is about 10% of the 5 yr moving mean precipitation (Fig. 31), then the annual recharge probably ranges from about 25-50 mm, or:

$60 - 120 E06 m^3/yr$

The annual recharge is small compared with the volume of water in storage in the aquifer. On the basis of the 1981 census figures (Statistics Canada, 1982) the rural population density in the area underlain by the Shaunavon Aquifer is about 0.5persons/km² and the total rural population is about 1,400 (Table 2). The only significant population centre is Shaunavon which had a population of about 2,100 in 1981. A number of wells completed in the Shaunavon Aquifer supply the needs of the Town of Shaunavon with excellent quality water (Table 1). The characteristics of the water are summarized in Fig. 36. Production performance evaluation of the town well field is beyond the scope of this investigation.

The yield of individual wells in the Shaunavon Aquifer System probably ranges from about:

16.3 $E-04m^3/s$ to 3.8 $E-03m^3/s$ [10 - 60 USgpm]

The water in the Shaunavon Aquifer meets the Rural Water Quality Objectives (Environment Saskatchewan, 1975). the water used by the Town of Shaunavon is less mineralized than the aquifer average. [see wells in 17-08-18-3, Table 1] and it meets the municipal drinking water objectives. The difference in water chemistry is significant but the reason for the difference is not known. Perhaps pumping from the well field has induced additional recharge of very fresh water into the aquifer. This hypothesis could be tested by measuring stable isotope ratios and tritium dating the water in the aquifer.

The water in the vicinity of the Town of Shaunavon well field is the only water that would be even marginally acceptable for irrigation according to Fig. 39. Water from the Shaunavon Aquifer System would pose a high salinity hazard and a low to high sodium alkali hazard. The water quality, the low unit yield of wells and the limited areal extent of the aquifer system preclude its use for large scale irrigation in the Shaunavon district.

In the late Fifties, some water was produced from the Shaunavon Aquifer for secondary recovery of petroleum. This was halted in the early Sixties when deeper water source wells were constructed to utilize brackish and saline water that was of no value for domestic use and stock watering.

It appears that the Town of Shaunavon will continue to be the major water user in this aquifer system. Although the rural population is continuing to decline, there will be an increase in water use for intensive livestock operations. Such uses may in the future offer real competition to the existing municipal and domestic users.

SRC Shaunavon and SRC Garden Head will continue to provide valuable information to monitor water level trends in the Shaunavon Aquifer System. They will also continue to provide information on the relative recharge to the system. Additional studies are required to evaluate the production performance of the Town of Shaunavon well field and to assess its impact on the overall aquifer system.

Groundwater pollution is the greatest threat to this aquifer system. The system is totally dependent on infiltration of local precipitation to the aquifer, and this aquifer is the sole source of water supply both for the town and the surrounding rural area. Special effort should be directed toward obtaining carefully collected water samples for trace pesticide and herbicide analysis on a regular basis from specially-constructed wells. These could also be used to supplement the existing monitoring network. These

wells should also be utilized to monitor nutrient migration from the solum to the aquifer.

The Shaunavon Aquifer System should be established as a ground-water management unit within which, regulations necessary for the protection and allocation of this valuable resource can be applied. Because the groundwaer in this area is vital to the future prosperity of the Shaunavon district, research studies on the mechanics of recharge and the rate of infiltration and migration of contaminants would be a valuable investment.

3.2

Coronach Aquifer System

The isopach map of the Coronach Aquifer System is shown in Fig. 3 and 4 and the hydraulic head is shown in Fig. 7 and 8. Cross-sections (Fig. 10, 17, 18) show the stratigraphic and topographic position of the Eastend to Ravenscrag Formations. The Coronach Aquifer System is an anisotropic unconfined aquifer system. Glacial deposits locally cover the aquifer, but are generally to thin to show on the cross-sections. According to Whitaker (personal communication) the upper part of the aquifer may be expected to be disturbed and fractured by glacial thrusting. He feels that secondary permeability due to fracturing of the more brittle sandstone beds constributes significantly to the hydraulic conductivity of the Eastend to Ravenscrag Formations in the Coronach area.

The hydraulic head maps show that the hydraulic head in the aquifer conforms with the surface topography, that is, a simple gravitational flow system is present in the Coronach Aquifer System. Strong downward hydraulic gradients should be expected beneath the upland areas. That is, the pressure head will remain approximately the same regardless of how deep a well is completed beneath the upland.

The average saturated thickness of the aquifer is about 40m and the aquifer is present over about 6600 km^2 . Assuming a porosity of 20% the volume of water in storage in the aquifer is about:

5.3 E10m³

The 5yr moving mean annual precipitation at Coronach is about 450mm. Assuming that up to 10% of this is available for infiltration, then the total seasonal recharge to the aquifer would be about:

$$3.0 E08^3 m3/yr$$

or about 1% of the storage volume.

The best sand beds in which to complete wells are the channel sands and the basal blanket sands. Although individual channel fill units cannot be correlated, one or more such units are almost always encountered in every drillhole. Fractured coal beds also constitute significant aquifers in the Coronach Aquifer System.

Individual well yields may be expected to range from:

6.3 E-04 to 6.3 E-03 m^3/s [10-100 USgpm]

depending upon the degree of fracturing.

Water from the Coronach Aquifer System is significantly more mineralized than in the Shaunavon Aquifer System (Fig. 37). Two types of water are present in the aquifer. Most of the samples indicate that the water is of the sodium-bicarbonate sulphate type with no chloride present. A few samples are of the sodium-bicarbonate/chloride type with sulphates absent.

Water from this aquifer system is unusable for irrigation due to the moderate to high sodium alkali hazard and the high salinity hazard (Fig. 39).

Dewatering the SPC Coronach coal mine has created a significant cone of influence in the Coronach Aquifer System. The cone is not readily evident on Fig. 8 because most of the hydraulic head data was obtained from water wells completed before dewatering started. SRC Coronach (Appendix C), situated about 3 miles northwest of the mine, has been drawn down about 1.4m since 1976 and there is no indication that the rate of drawdown is decreasing. Although it is not certain that SRC Fife Lake has been affected by dewatering, the water level-trend in the well is downward. Early spring water levels in 1981 declined below the top of the well screen.

Dewatering the mine has had a significant effect on the water resources of this aquifer system already, and it appears that the cone of depression will get larger and deeper before any equilibrium is established.

The Coronach Aquifer System extends into the United States. Presumably the monitoring system for the mine development is sufficient to monitor the effects of this and other developments on water levels in the vicinity of the border.

Groundwater from this aquifer system is used by most of the rural population as a source of water supply. The population density is extremely low (0.5 persons/km 2 : Table 2) and has decreased by about 7% since 1976. It appears unlikely that any forseeable rural water supply development would have a significant effect on the groundwater availability compared with the imnpact of mine dewatering

3.3 Ormiston and Bengough Aquifer Systems

These units were classified as separate aquifer systems because they are hydraulically separate from each other and from the Coronach Aquifer System. Thus, each constitutes a separate administrative unit. These aquifer systems are isolated remnants of bedrock separated by glacially-eroded troughs. It is probable that much of the remaining bedrock has been sheared and fractured by glacial thrusting. The Ormiston and Bengough Aquifer Systems are typically overlain be continuous glacial deposits (Fig. 10, 15, 16, and 22).

No information has been obtained to date regarding aquifer coefficients determined in these systems. Presumably, they are not greatly different than those determined for the Coronach Aquifer System. The chemistry was considered together with that from the Coronach Aquifer system (Fig. 37).

3.4 Bienfait Aquifer

The Bienfait Aquifer reaches a maximum thickness of 304m in T1, R6, W2 (Fig. 5). The hydraulic head map (Fig. 9) shows that the Estevan Valley functions as a drain which controls the hydraulic head in the Bienfait Aquifer. Cross-sections (Fig. 10, 11, 12, 13, 14) show that structural thinning and glacial erosion control the northern boundary of this aquifer. The Bienfait Aquifer extends southward across the Canadian-USA border in the Weyburn and Virden map areas. The Bienfait Aquifer is is overlain by relatively thick glacial deposits which will tend to impede recharge to the aquifer, except in the vicinity of Estevan and Bienfait (Fig. 5).

The average saturated thickness of the Bienfait Aquifer is about 100m and the aquifer extends over an area of about 10,000 $\rm km^2$. Assuming a porosity of about 20% the storage volume is about:

2.0 E11m³

The 5yr moving mean precipitation at Estevan Airport has ranged from 325 to 500 mm/yr during the period of record (Fig. 35). If it is considered that the recharge to the Bienfait Aquifer will be less than the aquifer systems found beneath a thinner drift cover, then the recharge to the Bienfait Aquifer is probably 1-5% of the annual precipitation for a total annual recharge input to the Bienfait Aquifer of about:

3.2 E07 to 2.5 $E08m^3/yr$

<0.1% of the storage volume in the aquifer.

As calculated earlier the probable yield of wells completed in the channel sands in the Bienfait Aquifer will probably range from:

6.3 E-05 to 6.3 E-04
$$m^3$$
/s [1-10 USgpm]

Wells completed in fractured coal or the hard fractured sandstone may yield as much as:

3.1 E-
$$03m^3/s$$
 [50 USgpm]

The hydraulic head in the Bienfait Aquifer is governed by the hydraulic head in the Estevan Valley (Fig. 9). Intensive development of the Estevan Valley Aquifer System as proposed by Walton (1970) would affect water levels over much of the Bienfait Aquifer. However, because of the permeability difference, development of wells in the Bienfait Aquifer could not significantly alter the hydraulic head in the Estevan Valley Aquifer.

The groundwater resources of the Bienfait Aquifer must be administered as a component part of the groundwater resources of the Estevan Valley Aquifer system.

The water in the Bienfait Aquifer is highly-mineralized (Table 1; Fig. 38). Many of the wells sampled yield sodium-chloride/bicarbonate water or sodium-bicarbonate/chloride water which is relatively soft but highly-mineralized. It is unusable for irrigation purposes due to the high to very high sodium alkali hazard and very high salinity hazard (Fig. 39).

4.0 CONCLUSIONS AND RECOMMENDATIONS

- 1. Water wells capable of yielding 10 to 100 USgpm can be constructed in sands and fractured coal seams in the Eastend to Ravenscrag Formations in the study area. Although individual sand units for the most part cannot be traced for any distance, one or more sand units will generally be encountered in a properly drilled and geophysically-logged testhole.
- 2. The existing FFIB test drilling Assistance program provides adequate incentive to ensure that proper testholes are drilled and logged. The information from that program greatly improved the resolution of the present study.
- 3. Similarly, the PFRA well assistance grant program provides assistance and incentive for good well construction.
- 4. Any information gaps in the geological framework will be filled in with time with information generated as a by-product of the above programs.
- The major information gap is in the area of water chemistry. This could be eliminated by providing some sort of water sampling program to ensure that those wells for which testhole logs and well construction records are available are sampled. Good quality analyses should be carried out on these samples, and the results incorporated into the Water Rights Branch well inventory records.
- 6. Having the water well records available on microfiche enabled that information to be utilized in this study. In the past, that information was very cumbersome because the well records for each year were filed separately.
- 7. Research type studies to learn how bedrock aquifers are recharged should be concentrated on the Shaunavon Aquifer System because it will be one of the critical areas for groundwater resource development.
- 8. Recording observation wells should be installed in the Ormiston and Bengough Aquifer Systems and in the Bienfait Aquifer. Where these aquifer systems abut the Canada-USA boundary, the recording observation wells should be constructed near the boundary. Supplementary non-recording observation wells should be completed in the Bienfait Aquifer along the Canada-USA border to establish what water level changes are occurring along the border.

- 9. The monitor well network in the Coronach Aquifer System should be reviewed to ensure that it is providing a realistic assessment of the extent of the cone of influence due to mine dewatering.
- 10. The groundwater resources in the Eastend to Ravenscrag Formations cannot be used for irrigation purposes due to the high degree of mineralization of the water and the high sodium content of the water.

5.0

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W. A. MENELEY CONSULTANTS LTD. W.A. Meneley, P.Eng.

Fig. 31 ANNUAL PRECIPITATION SHAUNAVON/GARDEN HEAD

ANNUAL PRE-CIPITATION 5 YEAR MEAN PREC.

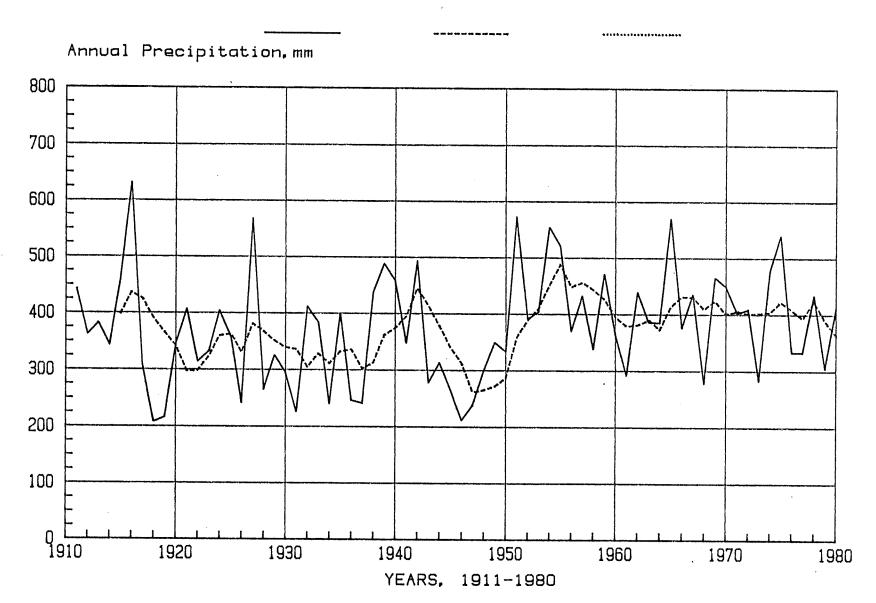


Fig. 32 ANNUAL PRECIPITATION

CORONACH

ANNUAL PRE-CIPITATION 5 YEAR MEAN PREC.

Annual Precipitation, mm

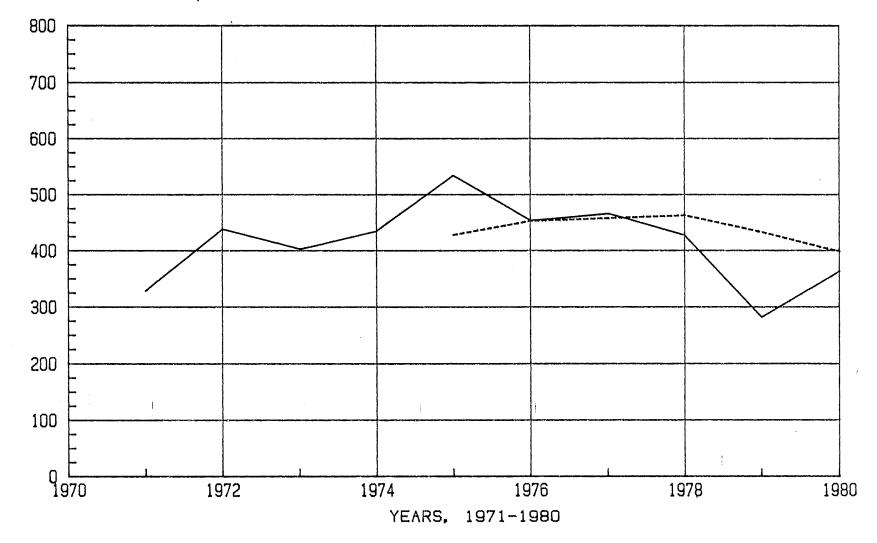


Fig. 33 ANNUAL PRECIPITATION

WEYBURN

ANNUAL PRE-CIPITATION 5 YEAR MEAN PREC.

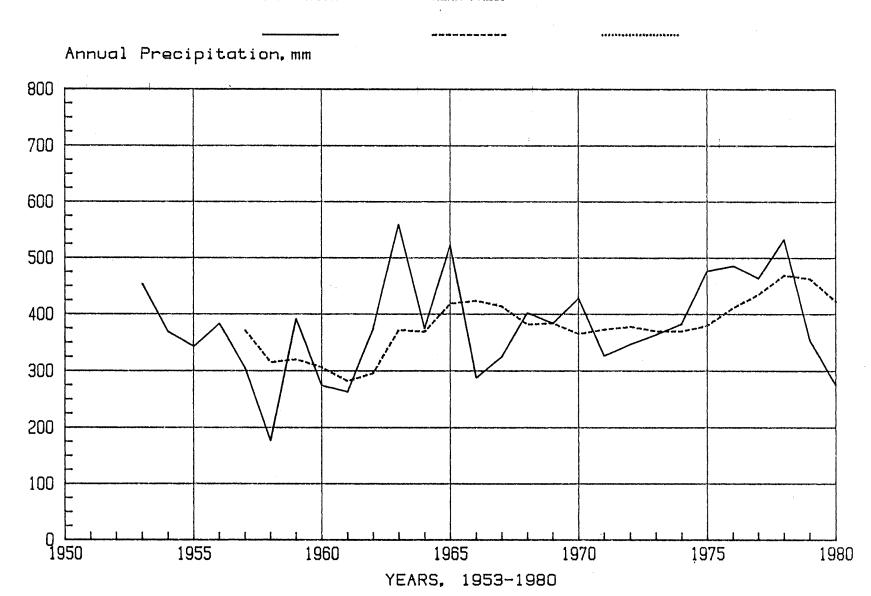


Fig. 34 ANNUAL PRECIPITATION ESTEVAN AIRPORT

ANNUAL PRE-CIPITATION 5 YEAR MEAN PREC.

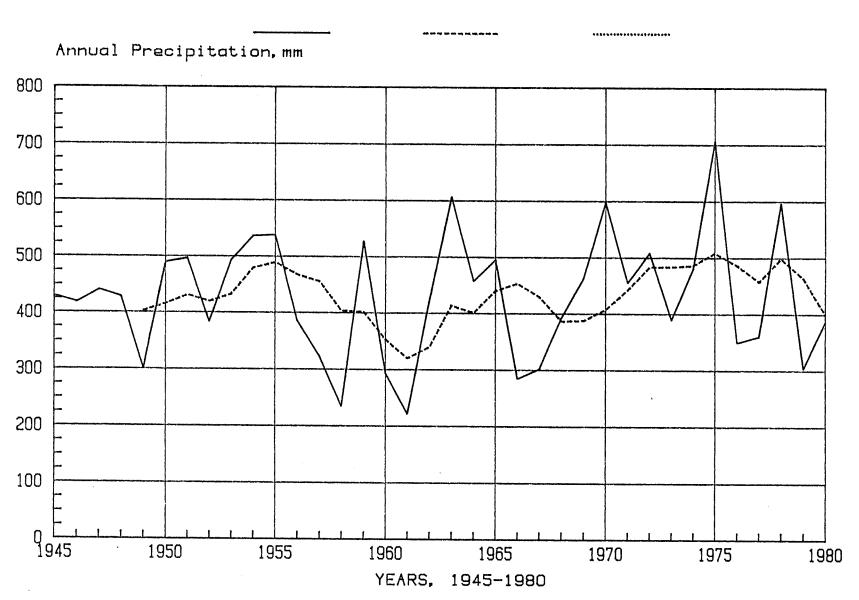
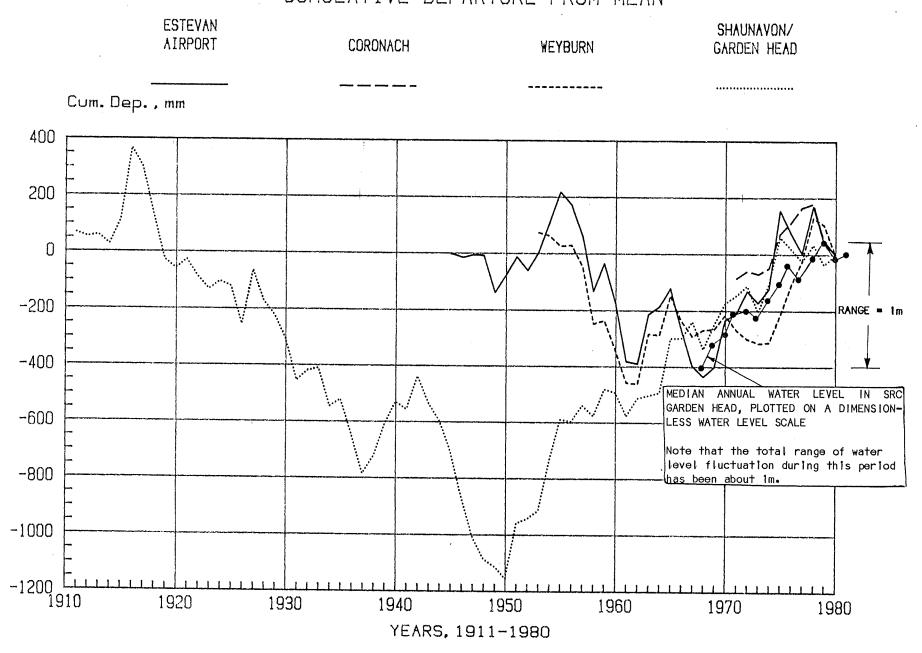
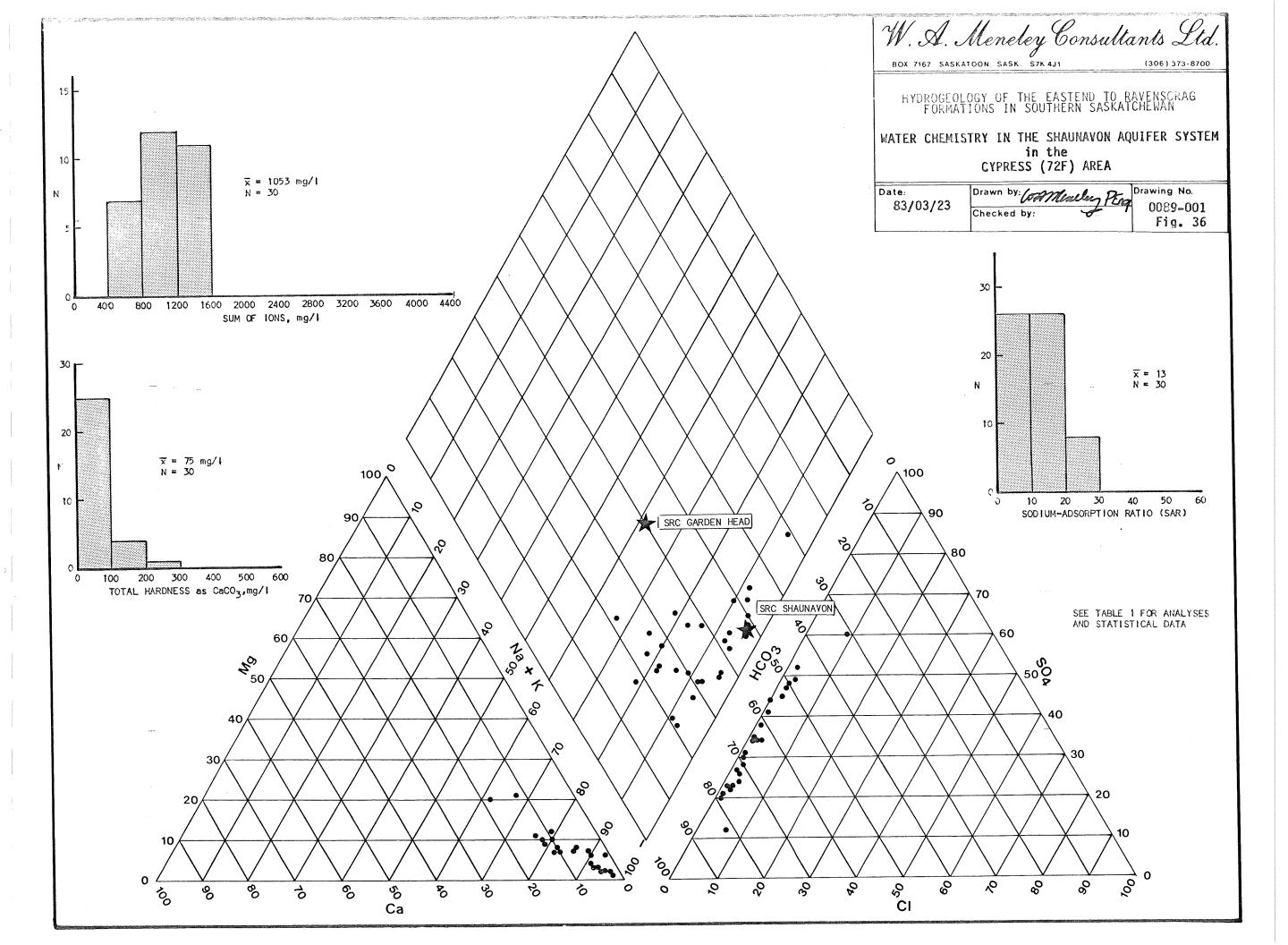
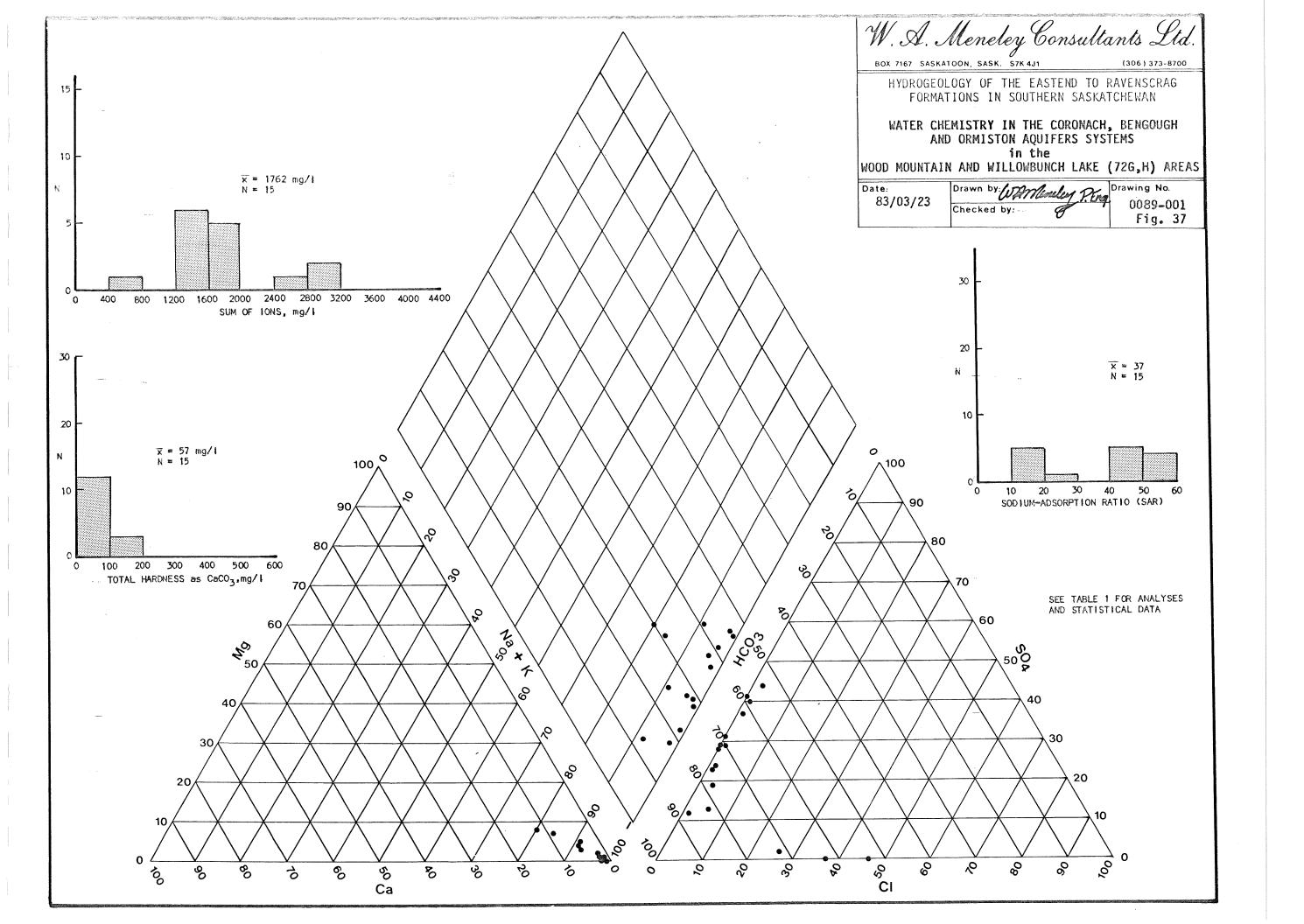
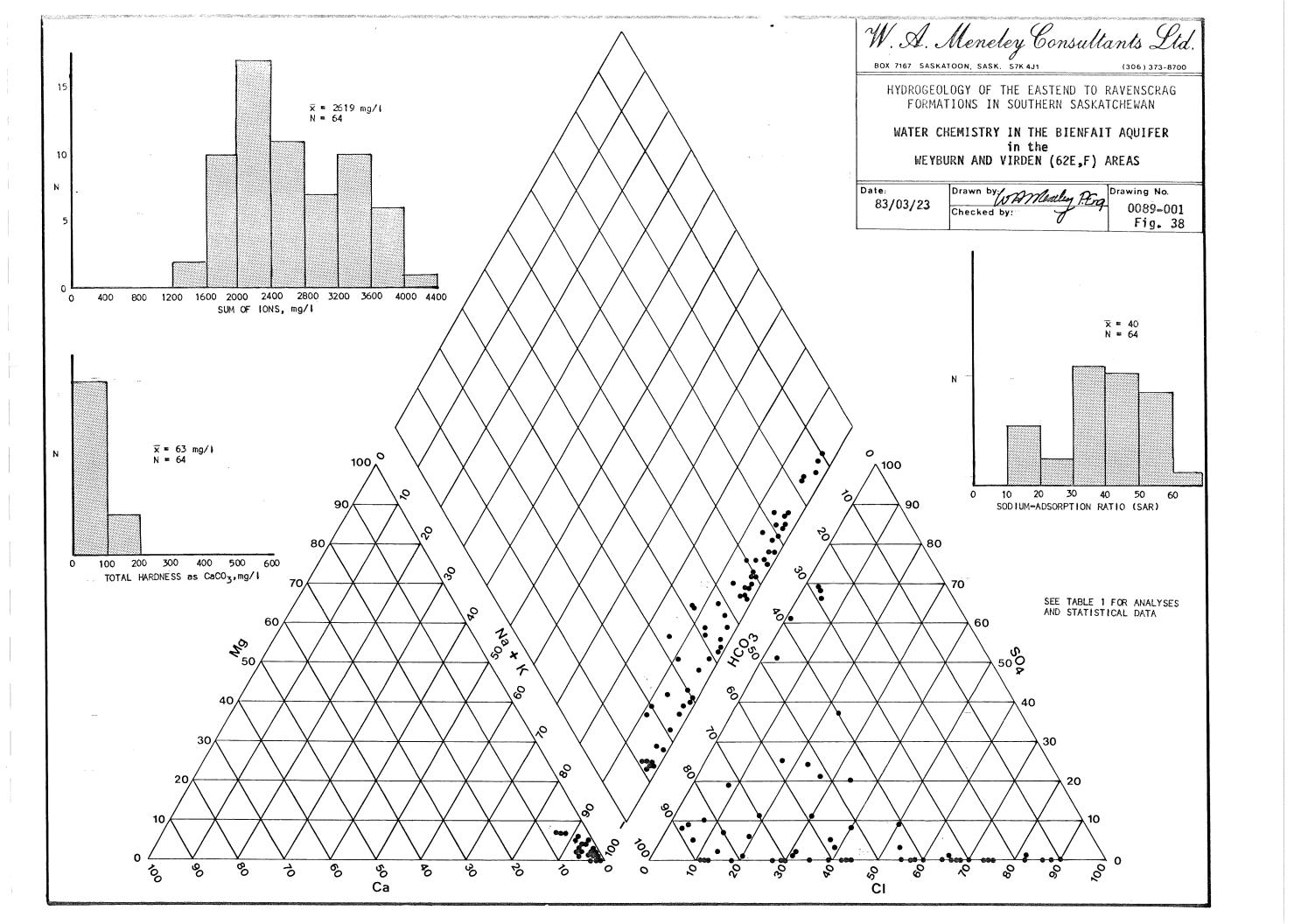


Fig. 35 ANNUAL PRECIPITATION CUMULATIVE DEPARTURE FROM MEAN









Water analyses in the Eastend to Ravenscrag Formations in southern Saskatchewan Table 1

											 CL		 PECIFIC S		TOTAL			SUM OF	I ON				HLU3+	
LAND LOCATION LSD S T R M XXXX XX XXX XX X	DEPTH m	DATE YYMMDD	PH	CA mg/l .0499	MG mg/l .08224	NA mg/l .0435	κ mg/l .02558	HCO3 mg/l .01639	CO3 mg/l .03333	SO4 mg/l .02082	mg/l .0282	mg/l .01613	COND. uS/cm	IONS H	ARDNESS 5 CaCO2	SAR CA ⁻ epm	TIONS	ANIONS	BALANCE	CA= 		NA+K= 	 Co3=	S04=
SW-12-02-17-2	126	 *R	8.35	12	 1	745	 2	 922	108	722	 22	0	ND	2534	34	56	33.14	34.36	-1.81	2	0	98 96	54 62	44 37
SE-13-04-23-2	69	*F:	NA	14	8	828	ō	1403	0	664	19	O	ИD	2936	68		37.37	37.36	0.03	∠ 1	1	76 98	71	29
NE-05-02-24-2	30	*F:	8.15	4	3	448	3	844	O	277	0	O	ND	1579	22		20.01	19.60 15.53	1.04 -1.63	=	4	91	75	24
W-13-19-03-26-2	110	740920	8.04	16	7	311	5	712	O	177	4	3.8	1450	1236 2842	69 62		15.03 35.93	36.44	-0.71	2	1	97	59	40
NE-03-05-26-2	81	*R	8.10	15	6	795	4	1310	0	692	20 336	0	ND ND	1917	23		25.88	25.67	0.40	1	1	98	63	O
SE-16-05-26-2	104	*R	8.15	6	2	583	2	988 886	0	0	440	Ö	ND	1945	24		27.02	26.93	0.16	1	0	98	54	0
NE-18-05-26-2 SE-03-14-02-27-2	79 81	*R 740918	8.20 8.09	8 8	1 4	610 420	5	841	Ö	261	1	. 1	1870	1540	36	30	19.12	19.25	-0.34	2	2	96	72	28 31
6W-04-14-02-27-2	55	750925	7.75	37	18	390	7	885	ó	310	2	. 45	1680	1649	166	= -	20.47	21.02	-1.33	9	/	84 98	69 72	2
W-08-02-05-27-2	77	740820	8.19	6	1	464	4	914	O	25	188	4.2	1710	1606	19		20.67	20.87	-0.49 1.34	1	0	76 77	7 <u>2</u> 78	19
SW-08-35-01-28-2	87	740918	8.69	2	0	402	3	716	50	156	21	. 4	1760	1351	8		17.72 17.55	17.25 17.80	-0.69	12	8	81	70	29
6W-13-28-05-28-2	130	730710	8.00	41	17	320	9	761	О	251	3	.8	1480	1402	170 109		22.56	22.83	-0.59	4	5	90	59	41
SW-11-09-03-29-2	49	720612	7.85	19	15	465	6	817	0	448	3	1.8	1920 ND	1775 1469	16		18.33	18.56	-0.63	1	1	98	82	13
SE-21-05-29-2	114	*R	8.35	3	2	413	2	875	29 0	113 47	32	0	886	652	33	13	8.02	7.92	0.63	5	3	92	87	12
NE-06-28-04-02-3 		730724	8.30	8	3	167	4	422		4/ 									<u>-</u>	 15	 15	 15	 15	<u>1</u> 5
NO.SAMPLES	15	8	14	15	15	15	15	15	15	15	15 0	14 0	8	15 652	15 8	15 11	15 8.02	15 7.92	-1.81	1	0	81F	I	Ō
1IN RANGE MAX RANGE	30		0.70	2	0	167	0	422 1403	0 108	0 722	440	4.2	1920	2936	170	63	37.37	37.36	1.34	12	8	99	87	44
TEAN	130 83		8.69 8.16	41 13	18	828 491	9 4	886	12	276	73	1	1567	1762	57	37	22.59	22.76	-0.31	3	2	94	68	23 15
ST. DEV.	29		0.23	12	6	188	2	233	30	250	138	1	399	610	52	18	8.02	8.17	0.92	ن	ٽ	6	10	
<u>W</u> £	ATER ANA	LYSES SH	AUNAVON	AQUIFER	SYSTEM	· *	=RUTHERF	ORD (196	 7)															
SW-18-08-16-3	20	*F:	ND	15	7	310	o	75 7	0	149	7	o	ND	1245	66		14.81	15.71	-2.94	5 9	4 12	91 79	79 82	20 12
NE-13-09-07-17-3	122	721005	7.76	19	15	184	13	505	0	60	19	4.3	940	819	109		10.52	10.13 16.99	1.87 -0.17	7	6	93	79	20
NW-12-07-17-3	42	*R	ND	3	12	359	7	787	15	163	7	О	ND	1353	57 64	19 16	16.93 16.76	18.00	-3.58	4	3	92	72	27
NW-09-09-17-3	32	*F:	ND	14	7	356	O	793	0	231	7	0	ND	1408	78	6	8.69	8.94	-1.45	10	8	82	75	23
IE-14-07-08-18-3	39	771021	8.30	18	8	161	5	334	38	97	2	7.8 3.8	790 1375	671 1247	67	14	15.82	16.31	-1.52	5	3	92	69	30
NW-06-17-08-18-3	ND	771021	8.38	17	6	330 333	5 5	605 629	38 0	238 226	4	4	1300	1221	58	15	15.78	15.19	1.89	4	3	93	68	31
NW-06-17-08-18-3 SW-07-17-08-18-3	ND 36	740221 771021	8.20 - 7.85	14 35	6 15	333 259	6	586	Ö	240	6	2.5	1261	1150	149	7	14.40	14.81	-1.41 _	_ 12	9 7	79	65 72	34 27
SW-07-17-08-18-3	36	740221	8.44	14	8	193	5	344	36	123	1	2.7	816	726	66	8	9.84	9.47	1.93	7	4	87 88	72 70	28
SE-09-17-08-18-3	43	771021	8.35	19	7	261	5	477	50	184	4	3.4	1181	1010	76	10	13.01	13.48	-1.80 2.39	12	21	67	78	21
SE-09-17-08-18-3	43	670210	8.21	16	17	98	6	298	0	62	3	3	535	499	10B 70	4 =	6.57 6.51	6.26 6.37	1.10	12	10	78	76	23
SE-09-17-08-18-3	43	740221	7.80	16	8	115	4	296	0	69	1	3.1	564	511 521	76 76	4	6.53	6.60	-0.49	13	11	77	73	24
NE-14-17-08-18-3	39	670210	8.03	17	8	111	7	294	0	76 77	6	1.1 3.5	575 627	569	66	6	7.38	7.02	2.52	11	7	82	76	22
NE-14-17-08-18-3	ND	740221	7.78	16	6	137	4	325 423	O 64	73 227	4	5.9	1211	1034	113	9	13.89	14.06	-0.60	10	7	84	64	34
NE-15-17-08-18-3 NE-15-17-08-18-3	ND ND	771021 740221	8.31 8.09	27 16	11 11	264 150	6 5	365	0	105	4	2.2	721	658	83	6	8.31	8.32	-0.01	10	10	80	72	26
SW-02-09-18-3	61	740221 *R	ND	11	4	331	5	268	6	427	50	0	ND	1102	44	17	15.40	14.89	1.69	4	2	94 96	31 64	60 35
SW-04-09-18-3	47	*R	ND	Ê	4	379	3	592	30	279	7	. 0	ND	1302	36	22	17.29	16.71	1.71 2.30	Δ	<u>∠</u> ₹	70 93	58	41
SE-01-19-09-18-3	40	740221	8.25	16	6	415	5	662	О	366	4	. 9	1600	1475	6 5	18 19	19.47 18.49	18.60 18.89	-1.07		2	95	58	41
01-27-09-18-3	72	771021	8.36	12	5	399	5	604	32	. 374	5	.04	1667	1436	51 68	16	18.29	18.76	-1.26	4	3	93	56	44
01-27-09-18-3	72	670208	8.36	15	7	384	9	575	30	396	2 7	1.8	1670 1413	1421 1171	35	19	15.24	15.49	-0.81	3	2	95	50	48
15-33-09-18-3		771021	8.47	9	3	332	4	437	19	360 341	7	<.01 1.3	1370	1143	75	13	14.94		-0.78	4	6	90	51	47
15-33-09-18-3 09-05-10-18-3	95 49	670208 670208	8.83 8.72	11 17	12 6	305 328	7 8	439 418	18 18	407	11	1.3	1500	1213	65	14	15.77	16.25	-1.47	5	3	92	46	52
5E-01-07-10-18-3	52	740221	8.40	12	5	300	4	392	6	322	11	3.1	1230	1055	51	15	14.16		1.70	4	3	93	48 63	49 34
6W-04-15-07-19-3		721004	7.67	8	3	338	8	586	ō	251	15	2.6	1400	1211	31	21	15.53		0.75	2	8	96 86		38
11-14-08-19-3	91	670208	7.90.	17	13	270	8	520	O	253	6	1.1	1240	1088	98	10	13.90		-0.22 -1.09	2	1	96		45
NE-13-34-08-19-3	16	661107	8.32	7	2	310	6	39 3	37	314	9	ND	1290	1077	25	21 22	14.13			2	2	97	51	47
NE-13-34-08-19-3		700717	7.45	5	3	312	4	460	0	334	7	2	1520 1130	1127 1115	24 276	4	14.31			18	20		60	40
SW-13-21-09-19-3 		710825	7.00	5 3	35 	195	12	538 		280										30	30			. 30
10.SAMFLES	25	25	25	30	30	30.	30	30	30	30	30	28 0	25 0	30 499	24	4	6.51			1	1	61	31	12
				3	1.9	98	0	268	0	60	i	U	J	7 / /						• • •	7.1	07	82	60
	,		~	_						477	50	Ω	1.470	1475	276	22	19.47	18.89	2.52	18	21	97		
1IN RANGE 1AX RANGE 1EAN	122 53		8.83 8.18	53 16	35 9	415 274	13 6	793 490	64 15	427 234	50 8	8 2	1670 1157	1475 1053	276 75	13	19.4/ 13.56 3.76	13.64		7 4	41 6 5	97 87 9	64	34

											Table 1	(conti	nued)										
		YSES BI				*:	=RUTHERF	DRD (196)	7)														
LAND LOCATION LSD S T R M XXXX XX XXX X	m m	YYMMDD	ГRI	CA mg/1 ,0499	MG mg/1 .08224	NA mg/1 .0435	K mg/l .02558	HCO3 mg/l .01639	CO3 mg/l .03333	SO4 mg/l .02082	CL mg/l .0282	NO3 Si mg/l .01613	PECIFIC S COND. uS/cm	SUM OF IONS mg/l	TOTAL HARDNESS as CaCO2	SUM OF SAR CATIONS epm	SUM OF		CA=	MG=	NA+K=	HC03+ C03=	S04= N
NE-08-01-31-1•	139	*R	ND	7	6	999	0	543	0	11	1250	o	ND	2816	42	56 44.30			 1	 1	 98	20	
NE-36-02-31-1 NW-05-01-33-1	110 77	*R • *R	ND ND	14 7	12 7	481 773	0	1251 946	0	84 160	186 660	0	ND ND	2028 2553	84 46	19 22.61 42 34.55			3	4	93	75	6
NW-16-01-33-1	102	*R	DA T	14	2	839	ō	879	ő	4	774	Ö	ND	2512	43	41 37.36			2	0	97 98	41 40	9 0
NW-14-02-33-1● NE-16-02-33-1	96 99	*₽ *₽	7.80 8.05	34 17	9 5	1201 970	6 र	594 1080	0	0	1600 925	0	ND ND	3444	122 63	36 54.83 41 43.53			3	1	96	18	ŏ
SE-14-02-34-1	140	*R	ND	14	2	1038	Ō	769	0	4	1177	0	ND	3000 3004	43	41 43.53 51 46.02			2 2	1	97 98	40 27	0 0
NW-01-01-01-2 NE-04-12-01-01-2 ●	81 ND	*R 760226	ND 8.10	14 13	7 र	868 1015	0 3	769 811	0	0	936	0	ND	2594	64 45	38 39.03		0.04	2	1	97	32	. 0
NW-10-03-01-2	125	*R	ND	14	5	672	ő	1348	0	4	1118 338	.02 0	3180 ND	2963 2381	56	50 45.12 31 30.34		0.34 -2.20	1 2	1	98 96	30 70	0 0
NE-10-04-01-2 NE-19-05-01-2	91 120	*R *R	ND 8.30	14	13 4	629 715	0	824 674	0	279	348	0	ND	2107	88	25 29.13		0.00	2	4	94	46	20
SE-25-06-01-2	96	*R	ND	21	7	552	Õ	915	0	0 139	755 272	0	ND ND	2156 1906	31 81	46 31.78 21 25.64			1 4	1 2	98 94	34 59	O 11
SE-02-02-02-2 NW-02-02-02-2	94 73	*F:	ND 8.10	14 6	0 5	622 525	0	1080 1281	0	0	33 6	0	ND	2052	35 34	32 27.76		1.05	3	õ	97	65	0
NE-02-02-02-2	104	*R	8.20	34	4	750	4	845	0	55 625	58 287	0	ND ND	1930 2549	36 101	32 23.55 24 34.75			1 5	2	97 94	88 40	5 37
SW-13-02-02-2 • NE-14-02-02-2	134 136	*R *R	7.60 8.85	29 4	5 2	1251 700	4 0	591	0	17	1621	0	ND	3518	93	42 56.38		0.56	3	1	97	17	1
NE-29-03-03-2	142	*F:	ND	29	8	606	0	815 1001	99 0	358 336	254 180	0	ND ND	2234 2160	23 105	49 30.91 20 28.47		-0.58 -0.02	1 5	1 2	98 93	53 58	24
SW-25-05-03-2 NE-15-06-03-2 ●	85 110	*R *R	7.90 ND	13 14	. 7 26	720	3	1070	0	333	317	0	ND	2463	61	32 32.62	33.41	-1.19	2	2	96	52	25 21
NW-13-18-08-04-2	75	760323	8.49	5	20 3	1021 523	0 2	793 744	0 41	1542 .01	76 371	.09	ND 2100	3472 1689	142 25	33 47.25 37 23.30		0.01 -1.54	1	5	94 98	28	68
SW-06-05-05-2 ● SW-10-02-06-2	110 58	*R *R	7.75 ND	29	7	960 700	4	760	0	1390	76	0	ND	3226	101	32 43.89	43.54	0.40	3	1	76 95	56 29	0 66
NW-09-19-06-06-2		760304	8.45	8	1	782 740	0 2	815 537	0 56	1020 0	13 761	.71	ND 2920	2647 2106	60 24	39 35.22 49 32.72		0.37 0.90	1	3 0	97	38	61
SW-04-01-07-2 NE-32-01-07-2 ●	85 135	*R *R	ND 8.00	14	4	748	0	1727	0	37	159	0	ND	2689	51	3 5 33.57	33.56	0.01	2	1	99 97	33 84	0 2
NE-04-02-07-2 •	156	*F:	8.10	10	ن 4	1101 1080	3 3	1260 1229	0	0	993 960	0 0	ND ND	3368 3286	32 41	66 48.62 58 47.88		-0.04 0.70	1	1	99	42	o
SW-12-02-07-2 SW-14-05-07-2	69 113	*R *R	ND ND	14	4	687	0	866	Ō	759	31	Ó	ND	2361	51	32 30.91	30.87	0.07	2	1	98 97	43 46	0 51
NE-05-02-08-2		631111	8.40	14 5	19 1	503 492	O ND	1171 1015	0 32	86 100	112 56	O ND	ND 1780	1905 1701	113 17	18 24.14 40 21.73		0.00 0.86	3	6	91	80	7
NE-17-02-08-2 ● SW-18-02-08-2 ●		631217 631209	8.00 7.95	11	3	1115	ND	1105	O	O	1140	ND	4600	3374	40	59 49.30	50.26	-0.97	1	1	98 98	83 36	10 0
SW-18-02-08-2 ●	- 114	*R	7.95	13 14	6 37	1230 1210	DN 3	1130 1140	0	0	1258 1320	ND O	5000 ND	3637 3724	57 187	57 54.65 35 56.45		0.60 0.48	1	1	98 97	34	o
NE-20-02-08-2 NE-20-02-08-2	67 67	631213 *R	8.15 7.80	8 11	4 2	937	ИD	1200	Ö	Ō	860	ND	3900	3009	36	54 41.49	43.92	-2.85	1	1	93 98	33 45	0
NE-32-02-08-2	37	*R	8.49	3	2	1020 400	3 0	1200 902	0 115	0 93	860 34	0	ND ND	3096 1549	36 16	56 45.16 36 17.71	43.92 21.51	1.39 -9.68	1	0	98 88	45	0
SE-35-02-08-2 SE-35-02-08-2	105 91	631217 *R	8.35 7.90	4	3	600 400	ND	1180	47	O	250	ND	2350	2084	22	46 26.55	27.96	-2.59	1	1	98 98	87 75	9 0
NW-22-03-08-2	131	631217	8.50	5	2	600 597	ND	1180 1400	0 18	0	252 100	O QN	ND 2100	2049 2122	26 21	40 26.82 45 26.38		0.70 0.03	1	1	98 98	73 00	0
SE-06-04-08-2 ● SE-18-05-08-2 ●	72 133	*R *R	ND 7.80	7	8 8	1113	0	854	0	1644	40	O	ND	3666	50	59 49.42	49.35	0.07	1	1	78 98	89 28	0 69
NE-22-05-08-2	98	*R	8.00	25 21	8	1431 527	4 7	367 780	0	0 98	2020 349	0	ND ND	3855 1790	95 85	50 64.26 20 24.81	62.98 24.67	1.00 0.29	2	1 -	97	10	0
NW-24-02-09-2 SE-16-24-02-09-2 ●		631217 631217	8.10 8.10	11	3	925	ND	1780	O.	370	114	ND	3250	3203	40	49 41.03	40.09	1.16	1	1	93 98	52 73	8 19
SE-02-14-03-09-2		631116	7.90	13 6	د 1	1115 607	DM 3	1136 1205	0	0	1150 290	ND ND	4700 2450	3417 2111	45 15	55 49.40 48 26.78		-1.64 -2.10	. 1	0	98 ⁻ 99	" 36	0
SE-22-03-09-2 NE-26-01-10-2	77 32	631216 *R	8.90	6	2	550	ND	1185	84	Ō	107	ND	2000	1934	23	39 24.39	25.24	-1.71	1	1	77 98	71 88	0 0
SE-02-02-10-2	123	*R	ND ND	14 14	7 19	680 537	0	1599 1281	0	119	32 164	0	ND ND	2451 2015	64 113	30 30.85 19 25.62		2.10 0.00	2	2 6	96	89	8
SW-04-02-10-2 NE-19-02-10-2	116 111	631209 *R	8.20 ND	5	2	770	ND	1815	0	ō	163	ND	2700	2755	21	58 33.91	34.34	-0.64	1	Ö	91 99	82 87	0 0
SE-32-03-10-2●	107	631119	7.65	14 18	13 4	408 1445	O ND	811 549	0	8	215 1935	O ND	DN 0086	1469 3951	88 61	16 19.52 61 64.08		-0.02 0.41	4	5	91 98	68	1
SE-09-19-02-11-2 NE-32-02-11-2	65 138	760312 *R	7.95 8.15	37	20 5	500	6	1020	0	20	273	.15	2290	1876	175	13 25.39	24.84	1.11	7	6	86	14 67	0 2
SE-02-28-04-11-2	91	760313	8.00	6 34	20	975 535	3 4	1580 927	0	0 43	598 354	0 1 9. 7	ND 2510	3167 1937	36 167	60 43.20 15 26.72		0.51 0.62	1	1 6	- 98 87	61 50	O
SE-02-28-04-11-2 NW-34-04-11-2	91 104	631211	7.32 7.80	25 20	22	553	6	970	Ö	64	369	0	2750	2009	153	16 27.27	27.64	-0.68	5	7	87 89	58 58	3 5
NE-03-03-12-2 ●	110	*R	ND	28 21	8 7	1495 1270	ND O	486 903	0	15 4	2120 1484	ND O	6700 ND	4152 3689	103 81	49 67.09 48 56.87	68.06 56.73	-0.72 0.12	2	1	97 97	12	0
SE-34-03-13-2 NW-22-02-14-2	122 61	*F: *F:	7.80 8.37	6 4	2	750	O	1130	0	Ó	501	Ō	ND	2389	23	53 33.09	32.65	0.67	1	O	97 99	26 57	0 0
SE-28-04-14-2	50	*R	8.48	4 6	1	607 687	2 0	916 837	97 124	142 0	176 466	0	ND ND	1945 2121	14 19	54 26.74 51 30.27	26.17 30.99	1.08 -1.19	1	0	99 99	70	11
SW-04-02-04-15-2 • NW-18-04-15-2 •	ND 132	670717 *F:	8.12	16	6	790	8	969	O	48	689	3.5	4400	2530	65	34 35.86	36.37	-0.70	2	1	99 96	58 44	3 0
SW-04-15-05-16-2		720802	ND 8.60	21 9	4	1122 833	0 13	763 652	0 76	0 20	1340 882	0 2.7	ND 3780	3253 2492	81 39	42 50.43 46 37.35	50.29 38.55	0.14 -1.59	2	1	97	25	0
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2 3 8.11 0.33 275 9 • One or more of the constituents in this water sample exceed the Water Quality Objectives (1975) value for a useable rural water supply.

Table 2. Rural Population in the Area Underlain by the Shaunavon, Coronach, Bengough and Ormiston Aquifer Systems and the Bienfait Aquifer. (From Statistics Canada, 1982).

NAME	RM NUMBER	FRORATION FAC.	POP. 1976	FOP: 1981	% CHANGE	SQ. KM	POP./SQ.KM
				32	-11	154	0.20
VAL MARIE	17	5	249	3 <u>2</u> 219	-12	602	0.40
WHITE VALLEY	49	30	488	461	-6	795	0.60
GRASSY CREEK	78	95		173	-6	335	0.50
ARLINGTON	79	4 <u>0</u>	184	29	-13	42	0.70
LAC PELLETIER		5	34	453	-11	713	0.60
BONE CREEK	108	85	511	400		, dr ,	
			TOTAL 1501	TOTAL 1367	MEAN -10	TOTAL 2641	MEAN 0.50
	TON CONTONIACIO	AQUIFER SYSTEM cre	ated by y allen				
NAME	TOM COUDINACU	PRORATION FAC.	GCED by Argiten	Control of		SQ. KM	POP./SQ.KM
14(711).		THE TOTAL THE PARTY OF THE PART	, compa groups across arous admin groups and a profit design across across design around groups around			,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	
HAPPY VALLEY	10	80	252	265	5	642	0.41
HART BUTTE	11	100	497	470	-5	837	0.56
POPLAR VALLEY	12	100	420	347	-17	764	0.45
OLD FOST	43	70	634	587	-7	2210	0.27
BENGOUGH	40	10	·64	57	-10	105	0.54
WILLOWBUNCH	42	100	736	629	-15	1019	0.62
WAVERLEY	44	40	209	199	-5	326	0.61
LAKEoftheRIVE	RS 72	50	258	253	-2	345	0.73
STONEHENGE	73	20	159	140	-12	202	0.69
LAKE JOHNSTON	102	30	99	94	-6	170	0.55
			TOTAL	TOTAL	MEAN	TOTAL	MEAN
			3327	3041	-7	6620	0.54
RURAL POPULAT	ION BENGOUGH	AQUIFER SYSTEM cre				SQ. KM	
		100	472	423	-10	836	0.50
LAKE ALMA	8	100	426	3 8 3	-10	803	0.50
SURPRISE VALL		20	420 63	66	5	161	0.40
HAPPY VALLEY	10	20 100	679	582	-14	837	0.70
LAURIER	38		453	422	-7	838	0.50
THE GAP	3 9	100 70	446	- 402	-1O	737	0.50
BENGOUGH	40		196	171	-13	336	0.50
BROKENSHELL	68	40		92	-13	168	0.60
NORTON	69	20	106 80	47 67	-16	84	0.8
KEY WEST	70	10	80	U/	also benef		
make state their senie hand desire deals some state and			TOTAL	TOTAL	MEAN	TOTAL	MEAI
			2920	2608	-10	4799	0.5
			エフエ リ	2000			

RURAL POPULATI	ON ORMISTON	AQUIFER SYSTEM cr	eated by v.allen	1 83/03/26 (por	orm)		
NAME	RM NUMBER	PRORATION FAC.	POP. 1976	POF. 1981	% CHANGE	SQ. KM	POP./SQ.KM
WILLOWBUNCH	42		147	126	-15	204	0.60
KEY WEST	70	70	560	471	-16	586	0.80
EXCEL	71	100	975	838	-14	1142	0.70
LAKEoftheRIVER	RS 72	20	103	101	-2	138	0.70
ELMSTHORPE	100	50	297	248	-16	419	0.60
TERRELL	101	70	388	320	-18	612	0.50
LAKE JOHNSTON	102	40	132	125	-6	226	0.60
		and the case and the comments are the case and the case and the case and the case and the best told	TOTAL	TOTAL	MEAN	TOTAL	MEAN
			2602	2229	-12	3328	0.64

NAME	RM NUMBER	PRORATION FAC.	POP. 1976	POP. 1981	% CHANGE	SQ. KM	POP./SQ.KM
ARGYLE	1		89	82	-8	112	0.70
MOUNT PLEASANT	2	20	89	99	-6	153	0.60
ENNISKILLEN	3	100	686	657	4	834	0.80
COALFIELDS	4	100	549	494	-10	830	0.40
ESTEVAN	5	100	1100	1185	8	814	1.50
CAMBRIA	6	100	482	456	-5	838	0.50
SOURIS VALLEY	7	100	585	 546-	-7	838	0.70
RECIPROCITY	32	40	248	243	-2	280	0.90
MOOSE CREEK	33	100	595	544	-9	837	0.70
BROWNING	34	100	801	687	-14	837	0.80
BENSON	35	90	601	586	-3	755	0.80
CYMRI	36	60	418	361	-1.4	501	0.70
LOMOND	37	90	469	444	-5	754	0.60
MOOSE MOUNTAIN	6 3	60	461	454	1.	441	1.00
BROCK	64	100	457	400	-13	829	0.50
TECUMSEH	45	60	344	306	1 1	501	0.60
WEYBURN	67	10	1.22	107	-12	82	1.30
			TOTAL	TOTAL	MEAN	TOTAL	MEAN
			8096	7650	- 7	10234	0.78

The population statistics were obtained by summing the reported population in rural municipalities. Where only a portion of the municipality is underlain by an aquifer system the population and area of the muncipality were prorated on the basis that the population is uniformly distributed within the municipality. The populations of villages and hamlets were excluded from this tabulation and no attempt was made to assess the percentage of rural residents who rely on the Eastend to Ravenscrag Formations for their water supply. The total areas computed for the aquifer systems were checked by planimetry of the actual subcrop area determined by Christiansen. The values correspond with an uncertainty of $\frac{1}{2}$ 10%.

W.A. MENELEY CONSULTANTS LTD.

GEOLOGY OF THE EASTEND TO RAVENSCRAG FORMATIONS, SASKATCHEWAN

Report 0088-001 March 14, 1983



E. A. Christiansen Consulting Ltd.

CONSULTING GEOLOGIST

BOX 3087 SASKATOON, SASKATCHEWAN, CANADA S7K 3S9

PHONE 374-6700

March 24, 1983

W.A. Meneley Consultants Ltd. Box 7167 Saskatoon, Saskatchewan S7K 4J1

Attention: Dr. W.A. Meneley

Dear Dr. Meneley:

Enclosed are six copies of Report 0088-001 on the "Geology of the Eastend to Ravenscrag Formations, Saskatchewan". All the geological objectives set forth in Contract No. 46 (8283) with Environment Saskatchewan with the exception of identifying geological gaps have been dealt with.

It is my understanding that you will identify the geological information gaps, if any, in the context of the hydrogeology of the Eastend to Ravenscrag aquifer system.

Sincerely yours,

E.A. Christiansen

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INTRODUCTION

1.1 Objective

The objective of this investigation is to provide the following as set forth in Contract No. 46(8283) with Environment Saskatchewan.

- (1) Compile and correlate relevant existing data on the geology of the Ravenscrag System for an area bounded by the Saskatchewan Manitoba Border on the east, the Canada United States of America Border on the south, Township II on the north, and Range I7 west of the Third Meridian on the west. This area was extended north to 50° 00' North Latitude and to the Swiftcurrent Creek valley on the west which is a natural hyrologic boundary (Fig. 1).
- (2) Analyse and evaluate the data to determine the stratigraphy of the Ravenscrag System. This system was extended to the top of the Bearpaw Pierre formations which form the base of the aquifer system.
- (3) Construct preliminary isopach maps of the Ravenscrag System.
- (4) Construct two separate east-west geological cross sections and six north-south separate geological cross sections. An additional five cross sections were drawn to more precisely define the aquifer system.
- (5) Identify, where possible, individual significant aquifer units in the Ravenscrag System.
- (6) Identify geological information gaps.

1.2 Previous Work

Geology and groundwater maps, which include the Eastend to Ravenscrag

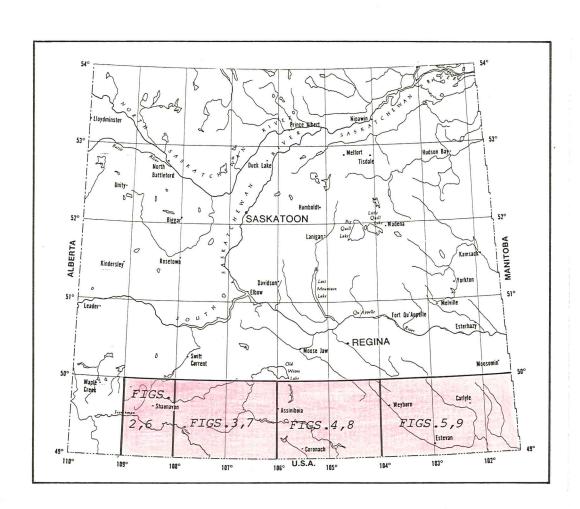


Figure 1. Location of the study-area.

formations, were published by the Saskatchewan Research Council (Whitaker, 1967; 1974,a,b; 1976). The geology of the Ravenscrag Formation was further studied to evaluate the coal resources of southern Saskatchewan (Whitaker et al., 1978).

1.3 <u>Present Study</u>

Because the Eastend to Ravenscrag formations belong to one aquifer system, this investigation dealt primarily with the sediments lying between the Bearpaw and Pierre formations and the Tertiary gravels or drift. From geological and geophysical logs, four isopach maps of the Eastend to Ravenscrag formations unit (Figs. 2-5, in back of report), and 13 geological cross sections were drawn (Figs. 10-22, in back of report). Figures 6 to 9 are in the W.A. Meneley Consultants Ltd. report. Where the surface relief is too great to permit accurate isopaching, only data values are shown. Wells in the Eastend to Ravenscrag formations unit within two kilometres of the cross sections were plotted on them.

1.4 Acknowledgements

Testhole information was made available by the Saskatchewan Research Council, Saskatchewan Power Corporation, and Saskatchewan Institute of Pedology. Water well information was supplied by Environment Saskatchewan.

2. GEOLOGY

2.1 General Setting

To provide a geological framework for the Eastend to Ravenscrag formations unit, the cross sections were extended from the present-day surface to the top of the Eagle Formation (Eagle shoulder) (Figs. 10-22). The nomenclature for the bedrock geology was taken from

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Whitaker et al. (1978) (Fig. 23).

The Eastend to Ravenscrag formations unit is underlain in ascending order by the Claggett, Judith River, and Bearpaw formations. East of the depositional "pinch-out" of the Judith River Formation (Fig. 10), these three formations become the Pierre Formation (McNeil and Caldwell, 1981).

The Eastend to Ravenscrag formations unit is overlain locally by Tertiary sands and gravels (Cypress Hills and Wood Mountain formations, Figs.18,19), most of which is too thin to be shown in the cross sections. Most of the remainder of the unit is covered with till. In the Estevan Valley (Fig. 10), the Empress Group separates the underlying Eastend to Ravenscrag formations unit from the overlying till.

2.2 <u>Eastend to Ravenscrag Formations Unit</u>

Because, for the most part, it is impossible to separate this unit into its component formations in geophysical logs, the Eastend to Ravenscrag formations are considered as one unit in this report. In the Cypress Hills, this unit in ascending order is composed of Eastend, Whitemud, Battle, Frenchman and Ravenscrag formations (Kupsch, 1956).

The Eastend Formation is composed of grayish and greenish sand, silt, and clay with thin coal seams in the upper part. The Whitemud is composed of kaolinitized, white sand and clay separated by a carbonaceous zone and overlain by a purplish shale of the Battle Formation. The Frenchman Formation is composed of sand and clay facies, and the Ravenscrag is composed of sands, silts, clays, and coals. These formations, which were defined from exposures, are impossible, for the most part, to identify in the subsurface. The lower part of the Eastend Formation is indistinguishable from

ERA	PER.	EPOCH	SOUTHERN ALBERTA	NORTHEASTERN MONTANA	SOUTHER! SASKATCHE		NORTHWESTERN NORTH DAKOTA	SOUTHWESTERN MANITOBA
	QUAT.	PLEISTOCENE	GLACIAL DRIFT	GLACIAL DRIFT	GLACIAL DE	IIFT	GLACIAL DRIFT	GLACIAL DRIFT
	0				EMPRESS	3		的 质,还是多数
		PLIOCENE		FLAXVILLE				
		MIOCENE			WOOD MOUN			
ZOIC	ARY	OLIGOCENE			CYPRESS HI	LLS	WHITE RIVER	
CENOZOIC	TERTIARY	EOCENE			SWIFT CURRENT	CREEK	GOLDEN VALLEY	
				SENTINEL BUTTE			SENTINEL BUTTE	
		PALEOCENE	PORCUPINE HILLS	TONGUE RIVER			TONGUE RIVER	
				LEBO	RAVENSCR	AG		
			WILLOW CDEEK	TULLOCK	A STATE		LUDLOW CANNONBALL	TURTLE MOUNTAIN
			BATTLE (KNEEHILLS)	HELL CREEK	FRENCHM	AN	HELL CREEK	
			WHITEMUD	COLGATE	WHITEMU	0	COLGATE	BOISSEVAIN
ပ	Sno		ST. MARY RIVER	FOX HILLS	EASTEN		FOX HILLS	
ZOI	SEC	UPPER	BLOOD RESERVE			-		
MESOZOIC	CHETACEOUS	CRETACEOUS	BEARPAW	BEARPAW	BEARPAW	1¥		
Σ	CR		JUDITH RIVER (BELLY RIVER)	JUDITH RIVER	JUDITH RIVER	3 MOUNTAIN	PIERRE	RIDING MOUNTAIN
			CLAGGETT (PAKOWKI)	CLAGGETT	LEA PARK	RIDING		

Figure 23. Correlation chart of uppermost Cretaceous and Tertiary formations in southern Saskatchewan and adjacent areas. From Whitaker et al. (1978).

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the Frenchman Formation unless the Whitemud Formation is present. In outcrop the Frenchman Formation may be indistinguishable from the Ravenscrag Formation where the latter does not contain coal.

Because of this difficulty, Whitaker et al. (1978) lumped the Eastend, Whitemud, Battle, and Frenchman formations into one unit which he called the "Frenchman Formation". During the present study an attempt was made to separate the "Frenchman Formation" of Whitaker et al. (1978) from the Ravenscrag Formation. Although in many places the lower part of the Eastend to Ravenscrag formations unit is more sandy and contains less coal, a credible contact was not found.

The Eastend to Ravenscrag formations unit in the study area is composed of deltaic sand blankets in the Eastend Formation and channel sands in the Frenchman and Ravenscrag formations. The deltaic sands are interbedded with silt, clay, and thin coal seams in their upper part, whereas the overlying channel sands are intercalated with silts and clays with commercial seams of coal. The Eastend to Ravenscrag formations unit in the studyarea ranges from 0 to 304 m (Figs. 2-5).

The lower contact of the Eastend to Ravenscrag formations unit is conformable, whereas the upper contact is unconformable. The lower contact was affected by Tertiary tectonism either during or after the deposition of the Ravenscrag Formation (Whitaker et al., 1978) The lower contact ranges in altitude from 269 m in the north flank of the Williston Basin south of Bienfait (Husky Roche Percee 3-8-1-6-W1, Fig. 5) to 973 m in the northeast flank of the Bowdoin Dome in the Wood Mountain area (DME-SRC-WMR SW4-28-2-9-W3, Fig. 3). Locally, the lower contact is downwarped (Figs. 15, testhole 157; 22, testhole 280) which is attributed to collapse as a result of the dissolution of salt from the Prairie Evaporite Formation (Whitaker, 1974a).

The upper contact of the Eastend to Ravenscrag formations unit was formed by fluvial and glacial erosion. In the eastern part of Figure 3 and the southwestern part of Figure 4 where the surface is too irregular to be isopached, the surface of the unit was severely eroded by glacial meltwater (Christiansen, 1979). In this area a local relief of up to 100 m is not uncommon (Figs. 3, 17,18). According to Christiansen (1979), this erosion took place when the melting glacier stood north of Wood Mountain (Fig. 24).

In the remainder of the study area, the top of the Eastend to Ravenscrag formations unit was glacially eroded to varying degrees. According to Christiansen and Whitaker (1976), The Dirt Hills (Figs. 4,17, between testholes 203 and 204) were formed by glacial stacking of drift and bedrock derived by glacial erosion (Fig. 25). The absence of the Eastend to Ravenscrag formations unit in the re-entrant between the Ormiston and Bengough aquifer systems (Figs. 4, 16,22) and the upward-facing concave surfaces on this unit are attributed to glacial erosion.

In the Wood Mountain area (Fig. 3) much of the formerly mapped Eastend to Ravenscrag formations (Whitaker, 1967) was removed by glacial erosion (Figs. 10,19). The interbedded till and bedrock in testhole 18 (Fig. 10) and the abrupt changes in lithology between testholes 27 and 29 (Fig. 10) and testholes 223 to 29 (Fig. 19) along with deep jointing and oxidation in testhole 227 are the evidence for this interpretation.

2.3 <u>Environmental Conditions during Deposition of the Eastend to</u> Ravenscrag Formations Unit

The regression of the Bearpaw sea marked the end of marine influences in southern Saskatchewan. According to Whitaker et al.

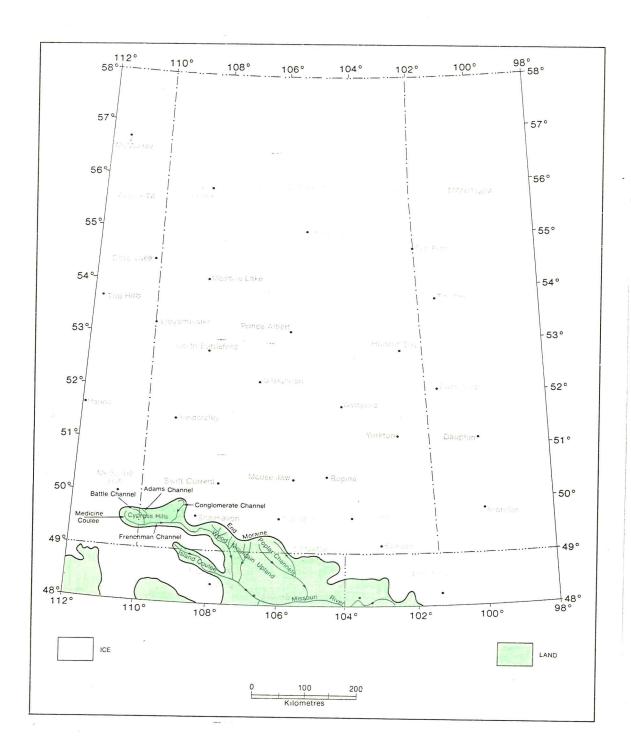


Figure 24. Phase I of the history of deglaciation of southern Saskatchewan and adjacent areas showing the formation of the "badlands on the south slope of the Wood Mountain. From Christiansen (1979).

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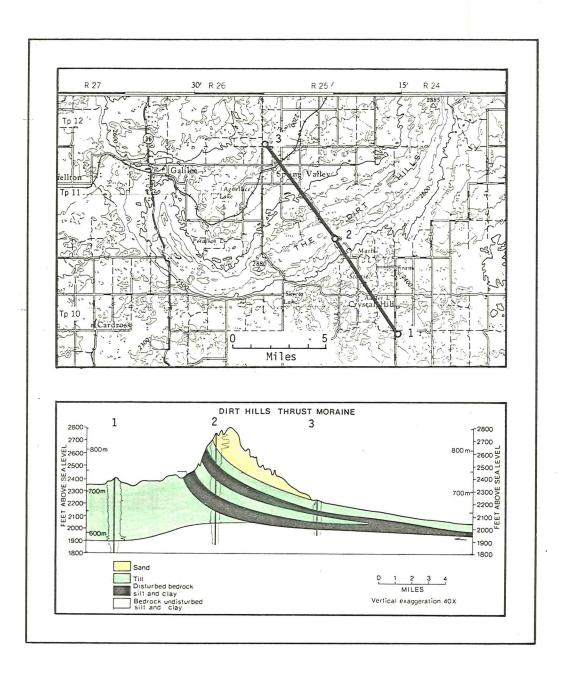


Figure 25. The Dirt Hills formed by stacking of drift and bedrock derived from glacial erosion. From Whitaker and Christiansen (1976).

(1978), the sediments in the Eastend, Frenchman, and Ravenscrag formations were deposited in an advancing delta or in the following alluvial deltaic plain (Fig. 26). Fluctuations of the Late Cretaceous epicontinental sea resulted in an intertonguing of marine (Bearpaw and Claggett formations) and nonmarine (Judith River Formation) sediments (Fig. 26). In southern Saskatchewan, the general sequence of events were slow regressions of the seas followed by rapid marine trangressions (Fig. 26) to form wedges of nonmarine (Judith River Formation) and marine (Demaine Member of the Bearpaw Formation) sands.

Based on work in northeastern Montana, Archibald and Clemens (1982) concluded the Fox Hills Sandstone (Eastend Formation) was deposited in beaches and barrier islands that migrated eastward as the sea regressed. This would account for the conformable contact between the Bearpaw and Eastend formations and for the blanket shape of sands in the later formation. They further concluded the Hell Creek and Tullock formations (Frenchman and Ravenscrag formations) were laid down by streams that meandered across a swampy flood plain which would account for the common occurrence of "shoestring" sands in the Frenchman and Ravenscrag formations and the origin of Ravenscrag coal deposits (Fig. 27).

GROUNDWATER GEOLOGY

3.1 Aquifer Systems

3.1.1 Introduction

The Shaunavon, Coronach, Ormiston, and Bengough aquifer systems and the Beinfait Aquifer occur in the Eastend to Ravenscrag formations unit of southern Saskatchewan (Figs. 2-5). In these figures, the point thicknesses are shown along with isopach lines where the

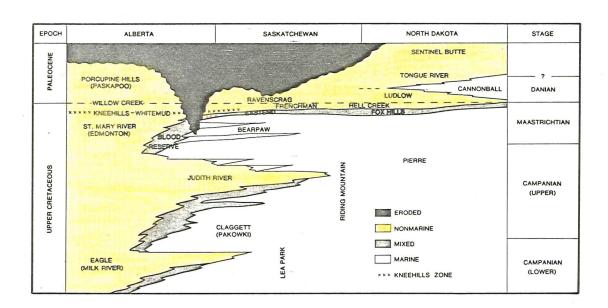


Figure 26. Schematic cross section showing intertonguing marine and nonmarine strata characteristics of the Upper Cretaceous in the Western Interior and their relationship to overlying Paleocene strata. From Whitaker et al. (1978).

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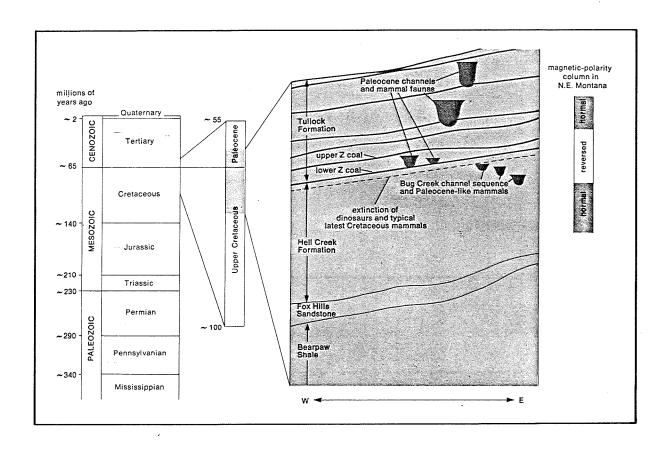


Figure 27. Rock sequence in northeastern Montana showing the blanket-shaped Fox Hills Sandstone (Eastend Formation) and the shoestring channel sands in the Hell Creek and Tullock formations (Frenchman and Ravenscrag formations). From Archibald and Clemens, (1982).

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surfaces of the aquifer systems were sufficiently regular to be isopached.

3.1.2 Shaunavon Aquifer System

The Shaunavon Aquifer System is about 70 km long, 55 km wide, and at least 143 m thick (Fig. 2). It is bounded on the north and west by the Swiftcurrent Creek valley and on the south by the Frenchman River valley into both of which the system drains. The eastern boundary was formed by glacial erosion.

The Shaunavon Aquifer System is composed of blanket and channel sands (Figs. 10,20,21). The basal sand, which appears in many of the testholes in cross sections A-A', K-K' and L-L', (Figs. 10,20,21) is probably a blanket sand laid down in the Eastend Formation. The discontinous sands in the upper part of the Eastend to Ravenscrag formations unit is interpreted as shoestring sands deposited in alluvial channels. Both the blanket and shoestring sands are typically fine to medium grained.

3.1.3 Coronach Aquifer System

The Coronach Aquifer System is about 150 km long, 65 km wide with a narrow appendage extending 50 km northward, and is at least 237 m thick (Figs.3,4). It is bounded to the south by the Canada - U.S.A. Border and to the east by The Lake of the Rivers, Willow Bunch Lake, and Big Muddy valleys. The western and northern boundaries were formed by glacial erosion (Figs. 3,4,17,18,22). Most of the surface of the Coronach Aquifer System was extensively eroded by glacial meltwater which issued from the glacier as it stood north of the Wood Mountain (Fig. 24). Because of the excessive relief of the

surface of most of the Coronach Aquifer System in the Wood Mountain area (Fig. 3) and south of the Big Muddy Valley in the Willow Bunch Lake area (Fig. 4), these parts of the system were not isopached.

Except in the northern appendage of the Coronach Aquifer System (Fig. 4) where the sand beds are thin and interbedded with silt (Fig. 17), the system is composed of a basal sand blanket and shoestring sands scattered throughout the upper part of the system (Figs. 4,10,16-18). Most of these blanket and shoestring sands are fine grained.

3.1.4 Ormiston Aquifer System

The Ormiston Aquifer System is about 80 km long, 70 km wide, and at least 159 m thick (Fig. 4). It is bounded to the west by The Lake of the Rivers and Willow Bunch Lake valleys and the remainder of the boundaries were formed by glacial and fluvial erosion.

If blanket sands occur in the Ormiston Aquifer System, they are much thinner than in the Shaunavon and Coronach aquifer systems. The shoestring channel sands are also thinner, and the system appears to be generally more silty (Figs. 16,22).

3.1.5 Bengough Aquifer System

The Bengough Aquifer System is about 85 km long, 80 km wide, and at least 210 km thick (Fig. 4). It is bounded to the south by the Big Muddy Valley and the Canada - U.S.A. Border and to the east by an arbitrary line along the boundary between Ranges 16 and 17 (Fig.4). The remainder of the boundaries were formed by glacial erosion.

Sands in the Bengough Aquifer System appear to have formed mainly in channels or in overbank environments where they are intercalated with silt, clay, and coal (Figs. 10,15,22). The channel sands are fine and medium grained, whereas the overbank, interbedded sands are fine grained.

3.1.6 Bienfait Aquifer

The Beinfait Aquifer is about 195 km long, 100 km wide, and at least 304 m thick (Fig. 5). It is bounded to the south by the Canada - U.S.A Border and to the west by the Bengough Aquifer System (Fig. 4). The remainder of the boundaries were formed by glacial erosion.

The Bienfait Aquifer thickens rapidly southward toward the center of the Williston Basin in North Dakota. The other noticeable characteristic in the isopach map (Fig. 5) is the Estevan Valley which was eroded into the Bienfait Aquifer in preglacial time.

The sands appear to be mainly channel and overbank deposits interspersed with alluvial silt, clay, and coal (Figs. 10-14). The channel sands are commonly fine and medium grained, whereas the overbank deposits are very fined and fine grained.

4. REVIEW OF OBJECTIVE

The following is a review of the "Objective" cited in the beginning of the report.

(1) All relevant existing information was compiled and correlated for an area bounded by the Saskatchewan-Manitoba Border to the east, the Canada-U.S.A. Border to the south, Latitude 50°00' North Latitude to the

- north, and Range 17, West of the Third Meridian on the west (Fig. 1). The study-area requested by Environment Saskatchewan was extended to Swiftcurrent Creek on the west which is a natural hydrologic boundary.
- (2) The existing information was analysed and evaluated to determine the stratigraphy of the Eastend to Ravenscrag formations unit. This unit was extended to the top of the Bearpaw and Pierre formations which forms the natural base of the aquifer system.
- (3) Isopach maps were constructed for the Cypress (72-F), Wood Mountain (72-G), Willow Bunch Lake (72-H), and Weyburn and Virden area (62-E,F). The large amount of information required the production of four maps at 1:250,000 instead of one at 1:500,000 which was the basis for the proposal.
- (4) Thirteen cross sections instead of the eight requested were drawn. The larger number of cross sections were drawn in order to prepare more accurate isopach maps.
- (5) It was not possible to identify individual significant aquifers in the Eastend to Ravenscrag formations unit. Such identification would require considerably more information. It was recognized, however, that discontinuous blankets of sands occur near the base of the unit, particularly in the western part of the study-area, and shoestring channel sands are interspersed with alluvial silts, clays and coals in the upper part of the unit.
- (6) Geological information gaps will be addressed by W.A.

 Meneley Consultants Ltd. based on their hydrogeological
 assessment of the Eastend to Ravenscrag formations aquifer
 systems.

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APPENDIX A. Name and locations of logs in cross sections

Log No.	Name	Location
j	GDHPR Pine Coulee 1	11-17-8-21-W3
2	SP et al.Dollard	15-10-8-21-W3
3	DMR-SRC-EMR Cypress 16	CTR5-2-8-21-W3
4	MGM Fork	13-35-7-21-W3
5	SOCONY STH 75-108	SW4-19-7-20-W3
6	TW Dollard Crown	15-9-7-20-W3
7	DMR-SRC-EMR Cypress 61	NW5-12-7-20-W3
8	CNE Eastend SX-234	SW4-6-7-19-W3
9	CNE Eastend SX-251	SW4-4-7-19-W3
10	GAGE GARVEY E- Dolard	5-4-7-19-W3
11	CNE Eastend SX-257	SW4-3-7-19-W3
12	SPC Shaunavon 13	NW13-35-6-19-W3
13	SPC Shaunavon 1	SE1-2-7-18-W3
14	SRC Gunn Creek	NW14-36-6-17-W3
15	SPC Shaunavon 22	NW16-22-6-16-W3
16 .	OGFI Frenchville	3-25-6-16-W3
17	CNE Shaunavon SX-493	SW4-26-6-15-W3
18	SRC Driscol Lake	SW4-14-7-13-W3
19	CNE Mankato SX-522	SW4-16-6-12-W3
20	CNE Mankato SX-527	SW4-2-6-12-W3
21	CNE Mankato SX-538	SW4-24-5-12-W3
22	DNR-ARC-EMR Wood Mtn. 29	SW4-17-5-11-W3
23	CNE Mankato SX-548	SW4-10-5-11-W3
24	CNE Mankato SX-571	SW4-6-5-10-W3
25	DMR-SRC-EMR Wood Mtn. 30	SE1-28-4-10-W3
26	AS Crown S-K	16-12-4-10-W3
27	DMR-SRC-EMR Wood Mtn. 31	SE8-1-4-10-W3
28	CNE Mankato SX-595	SW4-4-4-9-W3
29	DMR-SRC-EMR Wood Mtn. 16	SW4-15-3-9-W3
30	SHELL Wood Mtn. 5	10-11-3-9-W3
31	CNE Mankato SX-702	SW3-10-3-8-W3
32	SRC Horse Creek	NE1-1-3-8-W3
33	CNE Mankato SX-646	SW4-15-3-7-W3

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Log No.	Name	Location
34	DMR SRC-EMR Wood Mtn. 15	S1-24-3-7-W3
35	SHELL Wood Mtn. 11	16-15-3-6-W3
36	DMR-SRC-EMR Wood Mtn. 13	NW13-14-3-6-W3
37	DMR-SRC-EMR Wood Mtn. 34	SW1-29-3-5-W3
38	DMR-SRC-EMR Wood Mtn. 73	SE1-36-3-5-W3
39	DMR-SRC-EMR Wood Mtn. 35	NW13-35-3-4-W3
40	DMR-SRC-EMR Wood Mtn. 83	NW13-19-3-3-W3
41	SSR Wood Mtn.	9-18-3-3-W3
42	DMR-SRC-EMR Wood Mtn. 93	SE3-13-3-3-W3
43	DMR-SRC-EMR Wood Mtn. 27	SE1-16-3-2-W3
44	SRC Quantock	NE13-35-2-1-W3
45	SRC Fife Lake 001	SE14-9-3-29-W2
46	IMP Constance	8-36-3-29-W2
47	SPC Rockglen 2	NW13-34-3-28-W2
48	DMR-SRC-EMR Willow Bunch 67	NW13-16-4-27-W2
49	MOBIL Harptree	6-21-4-26-W2
50	FFIB Lawrence Bros.	NW4-22-4-26-W2
51	SPC Bengough 3	NE16-23-4-25-W2
52	SPC Bengough 4	SW13-14-4-24-W2
53	SPC Bengough 1	SW4-18-4-22-W2
54	DMR-SRC-EMR Willow Bunch 33	SW4-14-4-22-W2
55	DMR-SRC-EMR Willow Bunch 34	SW2-3-4-21-W2
56	TENN CAN SUP Salt Lake	11-3-4-20-W2
57	DMR SRC EMR Willow Bunch 13	SW4-7-4-19-W2
58	DMR-SRC-EMR Willow Bunch 12	SE1-30-3-18-W2
59	DMR-SRC-EMR Willow Bunch 2	SW4-29-3-17-W2
60	PURE MOBIL Mather Lake	8-18-3-16-W2
61	DMR-SRC-EMR Willow Bunch 5	W12-35-2-16-W2
62	SOCONY N. Ratcliffe	5-30-2-15-W2
63	MOBIL Ratcliffe	5-33-2-15-W2
64	DMR-SRC-EMR Estevan 66	SW12-2-3-14-W2
65	SUPTST Oungre	9-17-2-13-W2
66	DMR-SRC-EMR Estevan 67	NW13-21-2-12-W2
67	CFP Torquay	12-20-2-11-W2

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Log No).	Name	Location
68		HALL Estevan 14	SW3-28-2-11-W2
69		DMR-SRC-EMR Estevan 65	SW4-14-2-11-W2
70		GSC Outram 2	NE15-22-2-10-W2
71		DMR-SRC-EMR Estevan 16	NW16-7-2-9-W2
72		DMR-SRC-EMR Estevan 164	SE1-15-2-9-W2
73		WHITE ROSE et al. Tableland	8-22-2-9-W2
74		DMR-SRC-EMR Estevan 194	NE16-31-2-8-W2
75		DMR-SRC-EMR Estevan 57	NW13-34-2-8-W2
76		DMR-SRC-EMR Estevan 13	SW4-33-2-7-W2
77		KISSINGER Estevan "B"	15-35-2-7-W2
78		DMR-SRC-EMR Estevan 19	SW4-28-2-5-W2
79		DMR-SRC-EMR Estevan 20	SE1-28-2-4-W2
80		GSC Frobisher 65-10	SE9-2-3-4-W2
81		QUASAR et al. Frobisher	3-19-3-3-W2
82		FFIB D. Odgers	SW11-36-3-2-W2
83		DMR-SRC-EMR Estevan 30	SW4-4-4-1-W2
84		DMR-SRC-EMR Estevan 32	SW4-16-4-33-W1
85		SOCONY Nottingham	6-10-5-32-W1
86		SRC Fertile	SW4-6-5-30-W1
87		Outram	SW4-21-2-10-W2
88		GSC Frobisher 65-16	SW4-36-2-4-W2
89	* =	GSC Frobisher 65-8	SW13-13-3-4-W2
90		GSC 13-61	NE16-23-3-3-W2
91		GSC Frobisher 65-15	NW13-36-2-4-W3
92		GSC Frobisher 65-9	SE1-11-3-4-W2
93		GSC Frobisher 65-14	NE9-11-3-4-W2
94		Deleted	
95		GSC Outram	NE15-21-2-10-W2
96		GSC Outram	NE14-23-2-10-W2
97		HALL Estevan 15	SW2-29-2-11-W2
98		Hall Estevan 13	SW4-27-2-11-W2
99		Hall Estevan 12	SW1-27-2-11-W2

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Log No.	Name	Location
100	DMR-SRC-EMR Estevan 25	NW13-3-1-6-W2
101	DMR-SRC-EMR Estevan 130	NW13-15-1-6-W2
102	CANDEL Percee	8-27-1-6-W2
103	DMR-SRC-EMR Estevan 14	NE14-3-2-6-W2
104	KISSINGER et al. Taylorton	9-15-2-6-W2
105	DMR-SRC-EMR Estevan 119	SW2-29-2-6-W2
106	DMR-SRC-EMR Estevan 18	SE1-26-3-6-W2
107	LEACH FELMONT KOPP	15-8-4-6-W2
108	DOME Steelman	12-21-4-6-W2
109	CAN OIL et al. Kingsford	7-1-5-7-W2
110	DMR-SRC-EMR Estevan 45	SW4-27-5-7-W2
111	DMR-SRC-EMR Estevan 46	SW4-27-6-7-W2
112	FFIB Ken Rehm	SE16-10-7-7-W2
113	DMR-SRC-EMR Estevan 53	W4-26-7-7-W2
114	SRC Forget	SW12-2-9-7-W2
115	DMR-SRC-EMR Estevan 52	SW4-17-9-8-W2
116	DMR-SRC-EMR Estevan 58	SE16-3-1-8-W2
117	CAN OIL et al. Boundary	16-4-1-8-W2
118	DMR-SRC-EMR Estevan 17	SW4-14-1-9-W2
119	DMR-SRC-EMR Estevan 198	SW4-22-1-9-W2
120	DMR-SRC-EMR Estevan 90	SE1-29-1-9-W2
121	CFP Tableland l	10-29-1-9-W2
122	DMR-SRC-EMR Estevan 15	SW4-16-3-9-W2
123	Hall Estevan 5	SE16-32-3-9-W2
124	EPD Estevan 32	SW6-5-4-9-W2
125	HALL Estevan 1	SW12-5-4-9-W2
126	HALL EStevan 4	SW2-7-4-9-W2
127	HALL Estevan 26	SW2-13-4-10-W2
128	DMR-SRC-EMR Estevan 55	S2-26-4-10-W2
129	DMR-SRC-EMR Estevan 49	SW4-28-5-10-W2
130	SRC Marienthal	NE9-4-1-12-W2
131	SRC Marienthal	SW4-9-1-12-W2

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Log No.	Name	Location
132	SHELL Mount Green	5-29-1-12-W2
133	SHELL Torquay	1-5-2-12-W2
134	FFIB Clem Marcotte	NE8-3-3-12-W2
135	DMR-SRC-EMR Estevan 70	SW4-30-3-12-W2-
136	DMR-SRC-EMR Estevan 73	SW4-28-4-12-W2
137	SRC Goodwater	SW4-15-5-13-W2
138	SRC Goodwater	SW4-27-5-13-W2
139	CDR Flat Lake East	13-3-1-15-W2
140	SOCONY et al. S.E. Ratcliffe 1	15-15-1-15-W2
141	CDR Ratcliffe	11-25-1-15-W2
142	DMR-SRC-EMR Estevan 71	NW4-1-2-15-W2
143	CDR Hoffer	7-12-2-15-W2
144	FFIB C.Hansen	SE23-2-15-W2
145	SUPTST Oungre	3-16-3-15-W2
146	SRC Maxim	SW4-2-4-15-W2
147	DMR-SRC-EMR Estevan 75	SW4-27-5-15-W2
148	CAN OIL Colgate	2-35-5-15-W2
149	SRC Weyburn 03	NW13-7-8-14-W2
150	DMR-SRC-EMR Willow Bunch 16	SW1-16-1-21-W2
151	DMR-SRC-EMR Willow Bunch 13	SE1-13-2-22-W2
152	SOCONY STH 6	NW16-14-2-22-W2
153	SOCONY STH 1	SW4-34-2-22-W2
154	SOCONY STH 7	SW4-11-3-22-W2
155	SPC Minton 3	NE16-14-3-22-W2
156	SOCONY STH 3	NW12-23-3-22-W2
157	SOCONY STH 2	SE9-34-3-22-W2
158	DMR-SRC-EMR Willow Bunch 42	SW4-15-5-22-W2
159	MONSANTO Green L.	8-10-6-22-W2
160	FFIB Art Peterson	7-23-6-22-W2
161	DMR-SRC-EMR Willow Bunch 37	E8-31-6-21-W2
162	SOCONY STH 3	NW13-10-7-21-W2
163	DMR-SRC-EMR Willow Bunch 38	NE16-22-7-21-W2

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Log No.	Name	Location
164	SRC Amulet	NE9-2-8-21-W2
165	SRC Moreland	SW4-13-9-20-W2
166	SOCONY East Poplar	1-15-1-25-W2
167	SPC Big Beaver 1	SE9-21-1-25-W2
168	IMP Velocity hole 3	NE16-16-2-25-W2
169	DMR-SRC-EMR Willow Bunch 69	SW15-33-2-25-W2
170	SOHIO STANDARD Gap 1	16-10-3-25-W2
171	DMR-SRC-EMR Willow Bunch 39	NW13-21-5-24-W2
172	MOBIL East Viceroy	5-4-6-24-W2
173	SOCONY STH 4	SE1-35-6-24-W2
174	SRC Glasnevin	NW4-17-7-23-W2
175	FFIB Blair Knudson	SW2-26-7-24-W2
176	DMR-SRC-EMR Willow Bunch 52	SE3-3-8-24-W2
177	DMR-SRC-EMR Willow Bunch 48	NW13-10-9-24-W2
178	FFIB Stan Ursu	NE11-23-9-24-W2
179	DMR-SRC-EMR Willow Bunch 51	NW13-6-11-23-W2
180	FFIB Eldon Miller	SE3-13-11-24-W2
181	SOCONY STH 6	SW4-7-12-23-W2
182	FFIB Dave Holland	SE14-7-12-23-W2
183	SOCONY STH 4	SW4-19-12-23-W2
184	SRC Borderland	SW4-16-1-1-W3
185	SOCONY Willowvale	12-18-2-1-W3
186	DMR-SRC-EMR Wood Mtn. 26	W5-19-2-1-W3
187	DMR-SRC-EMR Wood Mtn. 122	NW5-21-3-1-W3
188	SOCONY Canopus	12-25-3-2-W3
189	DMR-SRC-EMR Wood Mtn. 124	SW2-6-4-1-W3
190	DMR-SRC-EMR Wood Mtn. 39	NW73-28-4-1-W3
1913	DMR-SRC-EMR Wood Mtn. 21	SW4-18-5-1-W3
192	FFIB Valley View Farms Ltd.	NW4-17-6-1-W3
193	DMR-SRC-EMR Wood Mtn. 19	E16-20-6-1-W3
194	SRC Maxstone	NE15-32-6-30-W2
195	FFIB Joseph Gosselin	SE1-24-7-30-W2

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Log No.	Narrie	Location
196	SOCONY STH 4	NW12-29-7-29-W2
197	SOCONY Willows	14-29-7-29-W2
198	FFIB Medard Huys	NE14-34-7-30-W2
199	DMR-SRC-EMR Willow Bunch 57	SW4-4-9-29-W2
200	FFIB Kelly Johnson	SE13-20-9-29-W2
201	SRC Vantage	NE16-10-10-29-W2
202	DMR-SRC-EMR Willow Bunch 55	SW4-29-10-28-W2
203	DMR-SRC-EMR Willow Bunch 54	NW13-34-10-27-W2
204	SRC Spring Valley	SE4-6-12-25-W2
205	DMR-SRC-EMR Wood Mtn. 1	SW4-8-1-4-W3
206	SRC Lonesome Butte	NW12-16-1-4-W3
207	DMR-SRC-EMR Wood Mtn. 2	SE3-5-2-4-W3
208	DMR-SRC-EMR Wood Mtn. 6	SW4-26-2-5-W3
209	DMR-SRC-EMR Wood Mtn. 8	NW4-34-2-5-W3
210	DMR-SRC-EMR Wood Mtn. 10	NW4-5-3-5-W3
211	DMR-SRC-EMR Wood Mtn. 133	SW4-21-3-5-W3
212	DMR-SRC-EMR Wood Mtn. 129	SE3-2-4-5-W3
213	SRC Fir Mountain	SE1-12-4-5-W3
214	DMR-SRC-EMR Wood Mtn. 128	SW4-28-4-4-W3
215	DMR-SRC-EMR Wood Mtn. 25	NW13-33-4-4-W3
216	DMR-SRC-EMR Wood Mtn. 23	SW4-26-5-4-W3
217	Deleted	
218	BA Baciu	15-36-6-4-W3
219	FFIB Leo Palmier	NE16-12-7-4-W3
220	SRC Limerick	SE4-28-8-3-W3
221	SOCONY Limerick	6-35-8-3-W3
222	AMERADA SHELL Crown	5-29-1-9-W3
223	DMR-SRC-EMR Wood Mtn. 18	SW4-28-2-9-W3
224	CNE Mankato SX-614	SW4-23-3-9-W3
225	CNE Mankato SX-615	SW4-25-3-9-W3
226	CNE Mankato SX-612	SW4-35-3-9-W3
227	SRC Wideview	SE1-3-4-9-W3

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Log No.	· Name	Location
228	CNE Mankato SX-596	SW4-10-4-9-W3
229	AMERADA SHELL Crown	4-35-4-9-W3
230	SRC Frontier	NE1-35-1-20-W3
231	FFIB Nelson Farms	NW13-25-2-20-W3
232	Deleted	
233	TW Rapan Crown	8-5-4-19-W3
234	SRC Climax	NW13-16-4-19-W3
235	DMR-SRC-EMR Cypress 8	SE1-16-5-18-W3
236	DMR-SRC-EMR Cypress 5	SW4-2-6-19-W3
237	SPC Shaunavon 2	SW4-30-6-18-W3
238	DMR-SRC-EMR Cypress 51	NW13-12-7-19-W3
239	DMR-SRC-EMR Cypress 67	SW12-19-7-18-W3
240	ALTANA PLAZA et al. Leon Lake	8-31-7-18-W3
241	DMR-SRC-EMR Cypress 1	SW12-32-7-18-W3
242	Town of Shaunavon 1	SE9-17-8-18-W3
243	SPC Shaunavon 35	SW4-27-8-18-W3
244	DMR-SRC-EMR Cypress 64	NW13-1-9-18-W3
245	DMR-SRC-EMR Cypress 2	SW4-14-9-18-W3
246	CANSO PRENALTA Instow	3-6-10-17-W3
247	DMR-SRC-EMR Cypress 6	SW4-16-10-17-W3
248	SOCONY Instow	10-22-10-17-W3
249	FFIB John Bolton	13-26-10-17-W3
250	DMR-SRC-EMR Cypress 3	SW4-11-11-17-W3
251	Deleted	
252	WHITEALL CAN STH 23	NE14-28-11-17-W3
253	MARATHON Illerbrun	2-4-12-17-W3
254	CAN DELHI et al. Jones	6-18-9-20-W3
255	FFIB Bench Colony	NW12-17-9-20-W3
256	DELHI HUSKY Jones 1	1-9-9-20-W3
257	FFIB G Bellefeville	NE1-25-8-20-W3
258	TW Lawrence L. CR.	1-25-8-20-W3
259	SRC Shaunavon	NW13-34-8-19-W3

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Log No.	Name	Location
260	DMR-SRC-EMR Cypress 35	SW13-3-8-18-W3
261	SPC Shaunavon 5	NW13-31-7-17-W3
262	SOCONY Mossbank STH 6	NE16-4-12-29-W2
263	SOCONY Ardill STH 2	SW4-26-11-29-W2
264	SOCONY Ardill STH 4	SW4-14-11-29-W2
265	SOCONY Ardill	14-11-11-29-W2
266	FFIB G.C. McKechnie	SE7-1-10-28-W2
267	FFIB Ross McNutt	SE13-28-9-27-W2
268	DMR-SRC-EMR Willow Bunch 59	SW4-25-9-27-W2
269	FFIB G. Montgomery	SW7-9-26-W2
270	FFIB E. Schneikart	SW4-4-9-26-W2
271	MOBIL Burn Lake	14-27-8-26-W2
272	DMR-SRC-EMR Willow Bunch 56	NW13-14-8-26-W2
273	DMR-SRC-EMR Willow Bunch 53	SW4-28-7-25-W2
274	FFIB Tom Mead	NE16-36-6-23-W2
275	DMR-SRC-EMR Willow Bunch 44	SE1-19-6-22-W2
276 -	DMR-SRC-EMR Willow Bunch 21	NE16-15-6-20-W2
277	DMR-SRC-EMR Willow Bunch 20	NE15-9-6-19-W2
278	FRONTIER Ogema	NW13-6-6-18-W2
279	DMR-SRC-EMR Willow Bunch 35	SW4-10-6-18-W2
280	IMP	NW13-9-6-17-W2
281	DMR-SRC-EMR Willow Bunch 4	SW4-14-6-17-W2
282	DMR-SRC-EMR Willow Bunch 24	SW4-26-6-16-W2
283	SPC Shaunavon 12	NW13-33-7-17-W3
284	SUPTST Westburne Climax	10-34-7-17-W3
285	ASHLAND Leon Lake	1-25-8-19-W3
286	Exposure	NW14-9-9-20-W3
287	FFIB Ed Huss	SE5-2-8-17-W3

APPENDIX B. Name and location of wells in cross sections

Well No.	Name	Location
1001	DNR	SE33-1-6-W2
1002	Tom Hesheth	NE33-1-6-W2
1003	Don Electric Power	SW3-2-6-W2
1004	Pete Dillman	NW22-2-6-W2
1005	R.Hassard	SE32-2-6-W2
1006	Deleted	
1007	R.M. Browning	SW4-3-6-W2
1008	Deleted	
1009	Deleted	
1010	Deleted	
1011	Deleted	
1012	Bill Maintte	NW12-1-9-W2
1013	Ron Fiest	NE21-3-9-W2
1014	Edward Willie	NW28-3-9-W2
1015	Deleted	
1016	N. Halverson	SW35-2-12-W2
1017	Ron Peaterson	NE4-4-12-W2
1018	N. Singer	SW27-2-15-W2
1019	PFRA Maxim	NW14-4-15-W2
1020	PFRA Maxim	SE28-4-15-W2
1021	Ken Walker	SE27-4-22-W2
1022	John Bartol	NW10-1-25-W2
1023	Wm Wagner	NE28-1-25-W2
1024	Albert Rolke	SW4-2-25-W2
1025	Felix Warken	NW9-2-25-W2
1026	L. Hicks	NE21-2-25-W2
1027	Deleted	
1028	Deleted	
1029	Deleted	
1030	Deleted	

Well No.	Name	Location	un.
1031	Deleted	•	
1032	George Khoss	SE30-1-1-W3	
1033	Arnold Keller	NE31-1-1-W3	
1034	Nick Yorga	NE29-2-1-W3	
1035	Deleted		
1036	Grant Ching	NE36-3-2-W3	
1037	Daniel Prefontaine	NW.8-4-1-W3	
1038	C. Martina	SE29-4-1-W3	
1039	A. Waslenko	NW32-4-1-W3	
1040	George Gieni	SE6-6-1-W3	
1041	Deleted		
1042	Deleted		
1043	A Evenson	NW21-4-19-W3	
1044	A.H. Malone	NW13-6-19-W3	
1045	Consol Pipelin	SE35-6-19-W3	
1046	Deleted		,
1047	V.R. International	NW8-8-18-W3	
1048	Town of Shaunavon	NE17-8-18-W3	
1049	Deleted		
1050	J. Schikowsky	SE23-9-18-W3	
1051	John Bolton	NW26-10-17-W3	
1052	Richard Belleuille	NW26-8-20-W3	
1053	Amber Truman	NE19-8-18-W3	
1054	A.W. Burgess	NE9-8-18-W3	
1055	Ralph Oberle	SW32-7-17-W3	
1056	Geo. Ecklund	SE36-9-28-W2	
1057	Deleted		
1058	Charles Holmes	SE36-6-20-W3	
1059	Northern Natural Gas	SE33-6-19-W3	
1060	George Gagnon	SW3-7-17-W3	

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Well No.	Name		Location
1061	A. Peterson		NW16-3-6-W3
1062	Mel Monea		SE19-3-3-W3
1063	Deleted		
1064	Deleted		
1065	Deleted	w	
1066	J. Stevenson		SW10-3-2-W3
1067	Peter Jacobs		SW6-3-1-W3
1068	Ray Heagy		NE33-2-1-W3
1069	Deleted		
1070	Thor Spagrud	•	SE8-3-30-W2
1071	Rockglen School		SE3-3-30-W2
1072	SRC Fife Lake 001		SE14-9-3-29-W2
1073	Lorne Kimball		SW15-3-29-W2
1074	Wifred Burnay		NE30-3-28-W2
1075	Larry Deblois		NW12-4-28-W2
1076	Deleted		
1077	A. Gibson		NW16-4-27-W2
1078	Lawrence Bros.		SW22-4-26-W2
1079	Paul Hauges		SW13-4-26-W2
1080	Mike Corolvick		NE18-4-25-W2
1081	L. Blackmore		SW3-4-20-W2
1082	K. Tunet	* #	SW30-2-12-W2
1083	Lawrence Dove		NW21-2-12-W2
1084	Campbell Forester		NW22-2-12-W2
1085	Deleted		
1086	Deleted		
1087	Deleted		
1088	M. Marcotte		SE30-2-11-W2
1089	B. Bjorndalen		SW20-2-11-W2
1090	Allen Soudie		NE19-2-10-W2
1091	W. Brokenshire		NW8-2-9-W2

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Well No.	Name	Location	
1092	R. Asbenlieder	SW14-2-9-W2	
1093	Alfred Garneau	NW24-2-9-W2	
1094	Erwin Kroeger	SE6-3-8-W2	
1095	H.G. Gallaway	SE32-2-8-W2	
1096	V. McClement	SE34-2-8-W2	
1097	Ken Beggs	SW35-2-8-W2	
1098	H. Horrocks	NW25-2-8-W2	
1099	Ewaski Farm	NE25-2-7-W2	
1/100	P.K. Christenson	SE34-2-6-W2	
1101	Deleted		
1102	Robert Collins	NE19-3-2-W2	
1103	Les Lazar	SE27-3-2-W2	
1104	Unknown	NE31-3-1-W2	
1105	Unknown	NE3-4-1-W2	
1106	Unknown	SE12-4-1-W2	
1107 -	R.W. Beatty	SE10-4-34-W1	
1108	SRC Shaunavon	NE13-34-8-19-W3	
1109	FFIB Ed Huss	SE5-2-8-17-W3	
1110	FFIB Valley View Farms	NW4-17-6-1-W3	
וווו	FFIB J. Gosselin	SE1-24-7-30-W2	
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