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LIMITED REPORT

Geology and Groundwater Resources of the Pasquia Hills Area (62E-F), Saskatchewan

by

M.J. Millard

Resources and Environment Group

SRC Publication No. R-1510-2-E-97

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INTRODUCTION

Geological mapping, test drilling, and groundwater observation well measurements have been conducted for the entire settled area of Saskatchewan during the past 30 years. These data provide a basis for the evaluation of the groundwater resources in the province. The objective is to continuously improve the understanding of provincial groundwater resources in terms of occurrence, quality, and behaviour, in order to support the development, management, and protection of these water supplies.

With this need in mind, the Saskatchewan Research Council (SRC) has worked co-operatively with Sask Water to complete a new Geology and Groundwater Resources map series corresponding to the 1:250,000 NTS areas of southern Saskatchewan.

The present report accompanies the preliminary maps and cross sections that depict the geology and groundwater resources in the Pasquia Hills area (63E-F). This work, which is an update of maps published during the late 1960's and 1970's, indicates the location, extent, and depth of major aquifers throughout the area. It also demonstrates the close relationship of soil salinity to geology and groundwater conditions and assists in evaluating irrigation potential and contamination hazards.

Compilation for the current work was completed at a scale of 1:250,000. Control was provided by stratigraphic cross sections that are spaced 14 to 19 kilometres apart; ideally, one cross section every one and one-half townships, which results in about 15 sections per map. The original cross sections (horizontal scale = 1:125,000; vertical exaggeration = 50X) were constructed by fixing photographically-reduced copies of testhole logs to the topographic section. The testhole logs used were obtained from records stored at SRC and include records with electrical logs only (oil and potash exploration holes), testholes drilled by SRC (comprised of electrical logs, driller's logs, and geologist's descriptions), and farm or municipal water-well testholes (comprised of electrical logs and driller's logs) which were drilled with the assistance of Sask Water, or formerly, the Family Farm Improvement Branch of the Saskatchewan Department of Agriculture.

Separate map sheets were compiled, on paper copies of the original topographic sheet, for each stratigraphic level at which aquifers, or potential aquifers (*i.e.*, sands and gravels) are known to occur. Information included on the aquifer maps consists of the surface elevation of the site, depth to and thickness of the deposit, and static water level, when known. In addition to these maps, a separate map showing the bedrock surface geology and topography was prepared.

Upon completion of the map compilations, the line work (maps and cross sections) was digitized and the point data were compiled into a database. A digital base map, obtained by Sask Water from the Central Survey and Mapping Agency (CSMA) was utilized to produce the final output in AutoCAD. The maps, which are archived as AutoCAD drawing files, were plotted at a scale of 1:250,000. The cross sections, also archived as AutoCAD drawing files, are plotted at a horizontal scale of 1:250,000 with a vertical exaggeration of 50X. Map 1 shows the location of the testhole logs that were used in this compilation.

GEOLOGY

General

All sediments between the bedrock surface and the present surface are considered to be "glacial drift." The drift in the Pasquia Hills area ranges in thickness from 12 meters, along the northwest flank of the Pasquia Hills (FFIB C. Asborne, 5-31-49-7W2; log # 55), to 220 metres in the Pasquia Hills (SRC Pasquia Hills, SE 6-14-52-2W2; log # 18). The bedrock surface (Map 2) slopes generally towards the north and east, away from the Pasquia Hills Upland, which is a part of the Manitoba Escarpment. Bedrock-surface elevations range from 551 to 242 metres ASL.

The glacial ice eroded pre-existing sediments, but also deposited material, mainly till, which is an unsorted mixture of sand, silt, clay, pebbles, and boulders accumulated by the glacier. As the ice retreated from the area, much meltwater was released resulting in the deposition of stratified gravels, sands, silts, and clays. This process of erosion and deposition of till and stratified deposits occurred several times as the ice repeatedly advanced and retreated over the area. This sequence of events resulted in the drift stratigraphy that presently exists.

For most of the NTS areas mapped to date, the drift has been subdivided into three groups where the information makes it possible to do so. However, because of the sparsity of reliable testhole data throughout most of the Pasquia Hills area, this practice has not been followed here, except to separate the Surficial Stratified Deposits from the underlying, undifferentiated till units. The description of the typical drift units forming the stratigraphy elsewhere in the province are provided by Christiansen (1992) and Whitaker and Christiansen (1972).

Glaciotectonic Structures

A compressive ice-flow regime, caused by glacial ice flowing upward over the Manitoba Escarpment provides mechanisms whereby bedrock, or previously deposited drift sediments, can be displaced to a higher elevation or a higher (*i.e.*, younger) stratigraphic level. McNeil and Caldwell (1981) document examples of reverse faults observed in measured bedrock sections. These they attribute to glaciotectonic (ice-thrust) processes.

Bedrock

Fine-grained marine sediments deposited in epeiric seas during the Cretaceous Period form the bedrock surface throughout most of the southern half of the Pasquia Hills area. These dominantly marine sediments include, in descending order, the Pierre Shale, Niobrara Formation, Morden Shale, Favel Formation, and Ashville Formation. Below the Ashville Formation, the basal-Cretaceous Swan River Formation includes marine and non-marine, locally cemented, fine- to medium-grained sand, silt, and clay. Comprehensive descriptions of the Cretaceous units found in the Hudson Bay area are provided by McNeil and Caldwell (1981), as are the locations of measured sections that are exposed along some creeks flowing from the Pasquia Hills.

Rocks that do not belong to the Cretaceous System form the bedrock surface in two areas. A small outlier of noncalcareous sand, believed to be Tertiary in age, overlies the Pierre Shale in the southern part of the Pasquia Hills Upland. Paleozoic rocks, primarily carbonates, form the bedrock surface in the northeast part of the Pasquia Hills area.

Undifferentiated Paleozoic Rocks

Carbonate rocks of Paleozoic age form the bedrock surface in the northeast part of the Pasquia Hills area. As the precise position of the Paleozoic - Cretaceous unconformity is rather poorly defined in this area, its location has been adopted from Whitaker and Pearson (1972). The carbonate rocks that are found in this area belong to the Interlake Formation (Silurian).

Swan River Formation

The Swan River Formation, consisting of locally cemented, fine- to medium-grained sand, silt, and clay, is considered to be the lithostratigraphic equivalent of the Mannville Group of western Saskatchewan. The basal Jurassic-Cretaceous sands that disconformably overlie Paleozoic sediments have been included in this unit following the practice of Christopher (1984). The Swan River Formation attains a maximum thickness of about 140 metres in the southwest corner of the Pasquia Hills area (SRC Armley, NW 12-14-47-14W2; log # 56).

Ashville Formation

The Ashville Formation is comprised primarily of noncalcareous dark grey or black silt and clay. It is the lithostratigraphic equivalent of the lower Colorado Group of western Saskatchewan. This unit attains a maximum thickness of about 70 metres in the southwestern corner of the Pasquia Hills area (SRC Armley, NW 12-14-47-14W2; log # 56).

Favel Formation

The Favel Formation consists of dark gray, calcareous shale with thin beds of clayey limestone. It is the lithostratigraphic equivalent of the Second White Speckled Shale that marks the base of the upper Colorado Group farther west. This unit attains a maximum thickness of about 20 metres near the southeast corner of the Pasquia Hills area (UofS Eagle No. 135 Ceba, SW 06-22-47-03W2, log # 62).

Morden Shale and Niobrara Formation

The Morden Shale and Niobrara Formation are, for the purposes of the present report, considered as a single unit. Formerly known as the Vermillion River Formation (Moran and Whitaker, 1969), the lower part of this unit (Morden Shale) is comprised of uniform, black, noncalcareous shale with occasional thin bentonite beds, while the upper part (Niobrara Formation) consists of chalky or chalk-speckled shale. The Niobrara Formation is the lithostratigraphic equivalent of the First White Speckled Shale of western Saskatchewan; however, the Morden Shale, or its equivalent, pinches out to the west (McNeil and Caldwell, 1981). This unit attains a maximum thickness of about 25 metres near the southeast corner of the Pasquia Hills area (UofS Eagle No. 135, Ceba, SW 06-22-47-03W2, log # 62).

Pierre Shale

The Pierre Shale is the lithostratigraphic equivalent of the Bearpaw, Judith River, and Lea Park formations of western Saskatchewan. The noncalcareous silts and clays are mainly indistinguishable from those of the Bearpaw and Lea Park formations. The Pierre Shale forms the bedrock surface at higher elevations of the Pasquia Hills.

Tertiary Sediments

The youngest bedrock deposits encountered in the Pasquia Hills area consist of about 3 metres of yellowish brown, noncalcareous sand that lies upon the Pierre Shale and grades upward to about 1 metre of well rounded, black chert gravel. These sediments have been found at one location only: UofS Eagle No. 134 Fir River (CE 01-05-48-05W2 log # 61); where they occur as erosional remnants of Tertiary to earliest Quaternary(?) fluvial bedrock deposits.

Drift

Due to the sparsity of reliable testhole information throughout most of the Pasquia Hills area, the drift deposits have not been subdivided into stratigraphic units beyond the differentiation of the Surficial Stratified Deposits from the underlying glacial deposits.

The Surficial Stratified Deposits occur primarily as lacustrine deposits northwest of the Pasquia Hills in the basins of glacial Lake Saskatchewan and Lake Agassiz. This lacustrine complex includes a series of progressively lower, and therefore younger, deltaic deposits that occur along the Saskatchewan River. Christiansen *et al.* (1995) discuss the geology of the deltaic sediments that occur in the southwestern part of the Pasquia Hills area. These include the Nipawin, Torch River, and Mosseyvale deltas.

GROUNDWATER RESOURCES

General

Groundwater originates from precipitation that infiltrates to the water table, moves downward and laterally under the influence of gravity, and eventually discharges back to the ground surface at some point of lower elevation (Meneley, 1977).

An aquifer is a layer in which a well can be constructed yielding sufficient water for production. Aquifers are separated by aquitards which are layers sufficiently permeable to transmit water, but not sufficiently permeable to allow completion of a production well. The inter-relationships between aquifers, aquitards, and aquifer systems are discussed by Meneley (1983). The Paleozoic rocks, Swan River Formation, and surficial sands and silts form the major aquifers in the Pasquia Hills area. Till units and bedrock and surficial clays form aquitards.

Groundwater moves through inter-granular openings and fractures in the sediments. The water moves under the influence of gravity from regions of higher hydraulic head to regions of lower hydraulic head. The hydraulic head generally is expressed as the elevation above sea level of the static water level in a well. If the layers are vertical and of large areal extent, the water tends to move vertically in aquitards while in aquifers it moves horizontally. The distribution of the hydraulic head, which is controlled by factors such as topography, stratigraphic setting, and the type of material forming the aquifers and aquitards, determines the direction of flow.

Surficial Aquifers

Surficial sands and silts form an important aquifer along the western boundary of the Pasquia Hills area (Map 5). This aquifer, which is drained by the Saskatchewan River, attains thicknesses in excess of 50 metres (*i.e.*, UofS Eagle No. 155 Nipawin, SW 12-03-52-13W2, log # 79).

Intertill Aquifers

Intertill aquifers are defined stratigraphically rather than topographically. Thus, in some areas the depth to the same intertill aquifer can vary from relatively shallow to deep. Where intertill aquifers are reasonably well defined by the till units that occur above and below them (which is not the case in the Pasquia Hills area) they are shown on the cross sections and maps. Intertill aquifers can be quite variable in thickness, and where these stratified deposits are interbedded with till or where insufficient data exist to define them stratigraphically (which is the case in the Pasquia hills area), aquifers are not shown on the maps and cross sections. In the Pasquia Hills area, intertill aquifers occur northwest of the Pasquia Hills primarily between this upland and the Saskatchewan River (Map 4). Depths to the tops of these water-bearing sands varies between 16 metres and 79 metres while thicknesses range between 2 meters and 21 metres.

Bedrock Aquifers

Bedrock aquifers in the Pasquia Hills area occur at two stratigraphic positions: the Swan River Formation and the undifferentiated Paleozoic carbonate rocks. The Tertiary(?) fluvial sediments are not considered to be an aquifer as they are thin (about 4 metres thick) and are known to occur at one testhole site only. The aquifer system that is comprised of Paleozoic carbonate rocks while important regionally, particularly in Manitoba, is used little in Saskatchewan as a source of domestic water supply. Only one domestic well is known to be completed into the Paleozoic rocks (SWC Sask. Dept. Of Agriculture, NE 29-56-06W2, log # 112).

The aquifer that is comprised of the Swan River Formation is found throughout the Pasquia Hills area, except in the northeastern part, where it has been removed by erosion (Map 3). This aquifer provides domestic water supplies primarily in those areas where shallower aquifers, such as the surficial or intertill sands, are absent. Static water level data indicate that the piezometric elevation for this aquifer varies between 300 meters and 347 metres.

Flowing Wells

Flowing wells, where the static water level is above the ground surface, generally indicate an upward groundwater flow. Appendix I lists the flowing wells in the Pasquia Hills area that are archived in SRC's testhole record database.

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APPENDIX I

Flowing Wells in the Pasquia Hills Area (63E-F)

LOCATION	AQUIFER CLASS./STRAT. POSITION	COMPLETION DEPTH
NE 29-56-6W2	Bedrock/Paleozoic	32m
SW 19-52-10W2	Bedrock/Swan River	49m
NE 14-52-11W2	Bedrock/Swan River	40m
NW5-36-46-13W2	Intertill	37m

APPENDIX II

Index of Cross Section Logs

The following types of logs and records have been used for the compilation of this work.

1. The SRC file contains logs that include E-logs, driller's logs, geologist's description of the cutting samples, and often analytical results. These logs are listed as SRC, SHT, SDH, UOFS, HAYTER, and DTRR.

2. The Oil - Potash logs consist of geophysical logs only. These logs are listed as OIL.

3. The SWC file contains records consisting of E-logs, driller's logs, and information pertaining to well completion. Collection of this type of data was initiated under the Family Farm Improvement Branch (FFIB) Testhole Assistance Program, which was the forerunner of a program later administered under the SWC. These logs are listed as SWC.

	QLSD	LSD	QSEC	SEC	TWNN	RNGN	MER	NAME	ACQNO
1	SE	13		10	53	14	2	SWC NOWLIN VIC	7152
2		0	NE	10	53	14	2	SWC THORSON ELDON	15679
3		1		12	53	14	2	SWC LIDSTER DON NANCY	10830
4	SW	12		5	53	13	2	SWC STUDER BERNARD F.	15681
5	SW	4		18	53	11	2	UOFS EAGLE NO.154 NIPAWIN	2897
6	NW	13		11	53	10	2	SWC CRAGE DAVE	13591
7	NE	16		19	51	13	2	SWC FYFE LEN	11677
8		11		20	51	13	2	SWC EBERLE DALE	6203
9		0	SW	21	51	13	2	SWC FYFE DOUG	10981
10		0	SE	21	51	13	2	SWC WILLIAMS GAR	15651
11		0	SW	21	51	12	2	SWC PAIDEL ARNOLD	15655
12	SE	4		22	51	12	2	SWC WARNOCK WILFORD	0
13	NE	16		20	51	11	2	UOFS EAGLE NO.153 NIPAWIN	2896
14		5		24	51	11	2	SWC BLABER AL	9914
15		0	NE	32	51	10	2	SWC CRAGG JIM	7879
16	NE	8		20	51	8	2	SWC DERRY TOM	9927
17		2		8	51	6	2	OIL CAL STD PASQUIA HILLS	71588
18	SE	6		14	52	2	2	SRC PASQUIA HILLS	415
19	NE	9		21	50	14	2	PFRA TOWN OF NIPAWIN	2394
20		16		10	50	14	2	SWC SHALTEN GENE	0
21	NE	16		12	50	14	2	UOFS EAGLE NO.158 NIPAWIN	2901
22	NW	13		23	50	13	2	UOFS EAGLE NO.157 NIPAWIN	2900
23	NE	14		24	50	13	2	SWC KOZUN GEORGE M	12592
24	NE	15		32	50	12	2	SWC SCOTT RALPH	13229
25	SE	4		5	51	11	2	SWC HOLOWKA WALTER	12123
26	SE	1		4	51	11	2	SWC SCHELLENBERG JOHN	11674
27		0	SE	2	51	11	2	SWC DOERKSEN FRANK F	7189
28	NW	15		34	50	10	2	SWC ROWAN GORDON	15674
29		0	NE	35	50	10	2	SWC SAUDER ALFRED	7811
30		0	NW	36	50	10	2	SWC PARKER CHARLIE	7570
31	NW	15		36	50	10	2	SWC WILSON DON	6119
32	SE	4		4	51	9	2	SHT SMOKY BURN NO. 5-85	2793
33	SE	3		4	51	9	2	SHT SMOKY BURN NO. 6-85	2792
34	SW	2		4	51	9	2	SHT SMOKY BURN NO. 4-85	2791
35	SE	1		4	51	9	2	SHT SMOKY BURN NO. 1-85	2787
36		0	NE	35	50	9	2	SWC HAUGHIAN RYAN	6980
37	NE	14		32	50	8	2	SRC SMOKEY BURN	416
38	SW	15		32	50	8	2	SWC BERGEN BILL	6327
39	NE	16		34	50	8	2	SWC BITTNER ERNEST MARY	10669
40		0	NW	35	50	8	2	SWC CHARKO WALTER	6264
41	SE	4		1	51	8	2	SRC SMOKY BURN	418
42	SW	4		28	48	14	2	SWC BOXALL JACK	13234
43	SW	12		30	48	13	2	UOFS EAGLE NO.159 NIPAWIN	2902
44	SW	12		2	49	13	2	SWC FREEMAN CECIL	15646
45	NW	13		8	49	12	2	SRC NIPAWIN NO.18	2395

	QLSD	LSD	QSEC	SEC	TWNN	RNGN	MER	NAME	ACQNO
46	NE	16		11	49	12	2	SWC RUDY MERVIN	8059
47	SE	0		31	48	11	2	SDH CARROT RIVER	421
48	NW	13		29	48	11	2	SHT CARROT R. BRIDGE NO.1016	3031
49		0	NE	24	48	11	2	SWC BLACK JACK	6947
50		0	NW	26	48	10	2	SWC MILLER HARVEY	6112
51		0	SE	2	49	10	2	SWC GORDON BILL	7397
52		0	NW	12	49	10	2	SWC STAGMAN LLOYD	6912
53	SW	4		20	49	9	2	SWC BASKEY FRANCIS	11338
54		0	NW	19	49	8	2	SWC CROSS NORMAN	13226
55		0	SW	31	49	7	2	SWC CRAIG OSBORNE	6114
56	NW	12		14	47	14	2	SRC ARMLEY	425
57		0	SW	12	47	13	2	SWC VILLAGE OF ZENON PARK	13232
58		0	SE	12	47	13	2	SWC VILLAGE OF ZENON PARK	13231
59	SW	5		7	47	12	2	SWC LEBLANC LEO	12591
60		0	SE	25	47	11	2	SWC PERRIN MARK	6976
61	CE	1		5	48	5	2	UOFS EAGLE NO.134 FIR RIVER	2860
62	SW	6		22	47	3	2	UOFS EAGLE NO.135 CEBA	2859
63		12		20	47	2	2	OIL PHILLIPS HUDSON BAY CH 1	71587
64	SW	13		11	47	14	2	SDH LEATHER RIVER NO. 2	2795
65	SW	4		1	48	14	2	SHT LEATHER RIVER NO. 1	2796
66	NW	13		6	48	13	2	SHT LEATHER RIVER NO. 1	2794
67	SE	1		18	49	13	2	SWC MONTGOMERY DON	10550
68	NE	14		36	49	14	2	SRC NIPAWIN NO.24	2459
69	SW	2		1	50	14	2	SWC HARRIS DAVID	9915
70	NW	13		1	50	14	2	SWC HAMILTON JOHN	0
71	NW	15		24	50	14	2	SWC SILVERTHORN BRIAN	15666
72	SW	4		25	50	14	2	SRC NIPAWIN NO.218	2401
73	SW	4		1	51	14	2	HAYTER NIPAWIN TH & WELL	428
74	SE	1		7	51	13	2	SWC HORNSETH ELMER	0
75	NE	14		8	51	13	2	SWC WILLIAMS GAR	15654
76	SW	2		17	51	13	2	SWC ARNST LARRY	15652
77	NE	16		16	51	13	2	SWC BROWN GERALD	6204
78		0		34	51	13	2	SWC REIN ED	13233
79	SW	12		3	52	13	2	UOFS EAGLE NO.155 NIPAWIN	2898
80		13		18	52	13	2	OIL TRIAD WHITEFOX	71589
81	SE	12		19	52	13	2	SWC EULER CLARKE	15682
82	SW	4		30	52	13	2	SWC WATSON GARLAND	12127
83	SW	4		36	52	14	2	UOFS EAGLE NO.162 NIPAWIN	2905
84	NW	5		36	46	13	2	SWC VALOIS RICHARD	13230
85	NW	13		7	47	12	2	SWC MCCREA CLEMENT	15649
86	SW	4		18	47	12	2	SWC LALONDE LUCIEN	9751
87	NE	1		17	48	12	2	SWC FORBES MARK	9752
88		0	SW	35	49	12	2	SWC DIGNESS ALBERT	9916
89		0	NE	34	49	12	2	SWC SWATZKY ALLAN	7891
90		0	SE	10	50	12	2	SWC GENTNER BRIAN	6126

	QLSD	LSD	QSEC	SEC	TWNN	RNGN	MER	NAME	ACQNO
91	NE	15		36	50	12	2	SWC DERKSEN DAVE	10665
92	NW	16		7	51	11	2	SWC SCOTT RALPH	9922
93	NE	16		32	51	11	2	SWC LALKOWSKI ALEX	15671
94	SW	2		6	52	11	2	SWC FEHR JAKE	7051
95	NW	12		6	52	11	2	SWC FLOWERDAY DONALD	15670
96	NW	13		12	52	12	2	SWC FORBES ROY	9923
97	NE	1		13	48	11	2	SWC JOHANSEN MORRIS	6528
98	SW	4		18	48	10	2	SWC HACKETT IVAN	6973
99	SW	2		5	49	10	2	SWC MEYERS MURRAY	10558
100	NW	12		9	49	10	2	SWC STEWART D M	8061
101		0	SE	3	50	10	2	SWC GINTER GEORGE	7875
102	NE	8		10	50	10	2	SWC MEGLI WAYNE	12590
103	SE	9		15	50	10	2	SWC MEGLI IRVIN	15675
104	SE	16		22	50	10	2	SWC LITTLE LORNE	9930
105	NE	16		27	50	10	2	SWC MILLER RAY	10829
106	NW	3		2	51	10	2	SWC FRIESEN LAURENCE	11341
107	SW	13		16	52	10	2	SWC FORSBERG GLEN	6329
108	NE	13		28	52	10	2	SWC BOUEY LYLE	15677
109		8		33	52	10	2	SWC SINCLAIR KEITH	7817
110	SW	4		3	53	10	2	SWC RATZLAFF KENNETH D	6900
111	SW	4		24	54	10	2	UOFS EAGLE NO.137 SQUAW RAPI	2861
112		0	NE	29	56	6	2	SWC SASK. DEPT. OF AGRICULTURE	13225
113		0	SW	12	50	8	2	SWC JOHNSON RAY G	6812
114		0	SE	26	50	8	2	SWC FEHR JOHN	7797
115	SE	8		17	51	8	2	SWC ISAAC JERRY	9926
116	NE	10		5	53	1	2	SRC BAINBRIDGE RIVER	414