PRELIMINARY REPORT

FLUCTUATIONS IN THE GROUND WATER LEVELS IN BONANZA VALLEY

Agricultural Extension Service

University of Minnesota

February 1977

PRELIMINARY REPORT

FLUCTUATIONS IN THE GROUND WATER LEVELS IN BONANZA VALLEY[1]

By Orville M. Gunderson and John E. Morris[2]

Bonanza Valley is a glacial outwash area of about 320 square miles (205,000 acres) in west central Minnesota. It is located in eastern Pope, southwestern Stearns, and northern Kandiyohi counties. Minnesota Highway Number 55 traverses the valley from Glenwood on the northwest to Paynesville on the southeast.

Soils of Bonanza Valley

The soils of Bonanza Valley were formed in glacial outwash. They consist of relatively shallow layers of loam to sandy loam over coarse sand and gravel. Thus their plant available water capacity is low and drought periods prevail during almost every growing season unless irrigation is used.

The Estherville soil series are the most predominant irrigable soils in the valley. They are found on 57 percent of the area (117,000 acres).[3] The Estherville series are shallow with a loamy mantle of 12-24 inches overlying coarse sand and gravel. The calculated plant available water capacity is 2.52 inches. The water intake rate of these soils is estimated to be 1.5 inches per hour.[4] The Estherville soil series are classified as having moderate permeability with rates of 0.2 to 2.0 inches per hour.

The other soils in Bonanza Valley have some limitations for irrigation. The Salida soil series, found on rolling and sloping topography, are extremely droughty with an available water capacity of less than two inches. Soil series such as Mayer, Biscay, and Muck are limited for irrigation because of wetness. The United States Department of Agriculture (USDA) - Soil Conservation Service has completed a generalized soil capability map of the valley.

Ground Water Investigation

In 1965 local leaders and the directors of the West Central Minnesota Resource Conservation and Development Committee (now Wes Min R C & D) requested assistance from the United States Geological Survey (USGS) and the Division of Waters, Soils, and Minerals of the Minnesota Department of Conservation (now DNR) to determine if there was sufficient water in the valley to support irrigation.

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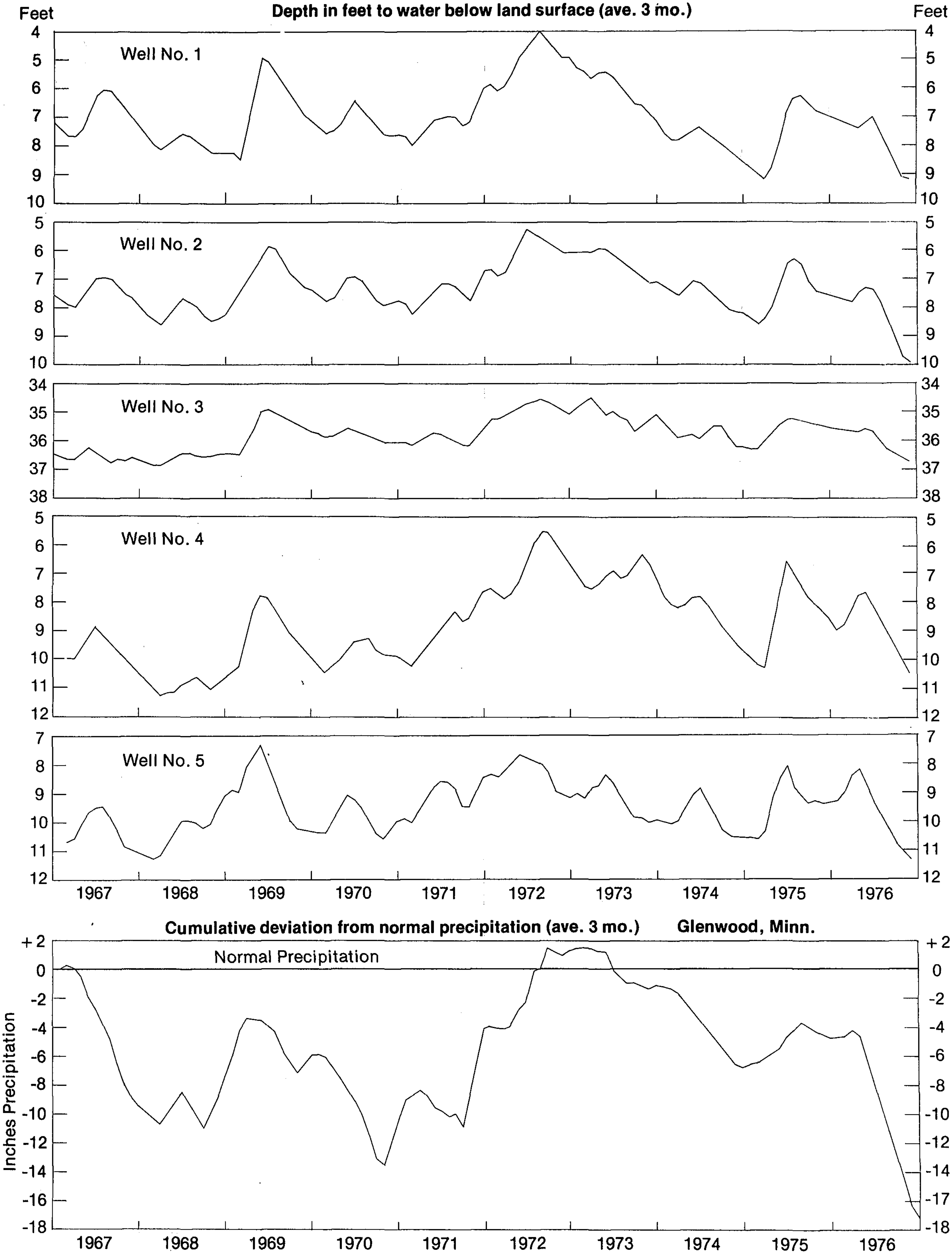
1. Cooperative observations by the University of Minnesota, Agricultural Extension Service and the United States Geological Survey.
2. Professor and Area Extension Agent - Soils; Pope County Extension Director and Associate Professor.
3. Ross, L.M. 1971. An Evaluation of Irrigation Potential in the Bonanza Valley. Agricultural Extension, University of Minnesota.
4. Irrigation Guide for Minnesota. USDA, Soil Conservation Service.


Depth in feet to water below land surface (ave. 3 mo.)
Feet
Well No. 1
Well No. 2
Well No. 3
Well No. 4
Well No. 5
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
Cumulative deviation from normal precipitation (ave. 3 mo.)
Glenwood, Minn.
Normal Precipitation
Inches Precipitation

The ground water report delineated areas of potential water supplies, however, test drilling is necessary to locate water supplies for specific wells throughout the valley.

The total cost of the ground-water survey was $41,600. Half of the cost came from Federal funds through the USGS; one fourth from a state appropriation to DNR; and one fourth from local contributions.

Growth of Irrigation and Water Use

In 1966 there were 23 known irrigation wells and approximately 1,000 acres were irrigated. The use of irrigation expanded to 5,000 acres in 1969, and to 12,000 in 1973.

A survey of township officers in the fall of 1976 showed about 23,000 acres under irrigation. The land under irrigation in 1976 is shown on the map on page five.

Field corn is the major crop under irrigation, followed by potatoes and dry beans. In years of normal precipitation, 10 to 14 inches of gross irrigation water are needed to produce field corn.

In 1976 the Minnesota DNR permitted irrigators to use up to 16 inches of water because of the abnormally dry growing season. Most irrigators growing full season crops used that amount.

Withdrawals from the aquifer for irrigation can be estimated by multiplying the irrigated acres by the permitted water use. These are shown in the following table.

Maximum Water Withdrawal Under Permits for Irrigation
from the Surficial Aquifer in Bonanza Valley

Year	Acres Irrigated	Maximum Inches per Acre	Acre Feet Withdrawn
1966	1,000	12	1,000
1969	5,000	12	5,000
1973	12,000	12	12,000
1976	23,000	16	31,000

Monitoring Aquifer Water Levels

Monthly measurements of aquifer water levels have been continued in the observation wells established during the ground-water study. The USGS monitored the wells until July, 1972 under a program financed by 50% Federal, 25% State, and 25% Local funds. Since 1972 local persons have made monthly measurements. John Morris, Pope County Extension Director, Dean Eisenhauer and Jerry Wright, Extension Irrigation Engineers have been responsible for wells 1, 2, and 3. Carl Anderson, retired Belgrade farmer, is responsible for wells 4 and 5.

Field work for a ground water survey began in 1966 and was completed in 1968. Hydrologists from the USGS collected data from over 300 existing domestic and irrigation wells and studied the geology and hydrology data pertaining to the area. More than 250 power auger test holes were drilled in the surficial aquifer. Pumping tests to determine aquifer characteristics such as transmissivity and storage coefficient were conducted at four locations.

Water samples from 12 wells were collected for laboratory chemical analysis to determine the suitability of the water for irrigation.

Five observation wells were established and continuous water-table fluctuations were collected for two years. The locations of the wells are shown on the map on page five. Precipitation during the 1967 growing season was recorded at seven locations for comparisons with the water-level fluctuations in the observation wells. Base flow in all streams was measured in August, 1967.

A comprehensive report on the quantity and quality of ground water in Bonanza Valley was published by the USGS in 1971.[5] The report showed that the surficial-outwash aquifer underlies most of the valley. The upper limit of the aquifer is the water table and its base is glacial till. The water saturated thickness ranges from 10 feet along the North Fork of the Crow River to more than 60 feet along the East Branch of the Chippewa River. In most parts of the valley the water table is less than 20 feet below land surface.

Recharge to the surficial aquifer was found to be almost entirely from precipitation. The physical condition of the soils in the valley are conducive to moderate to rapid infiltration of water. Most recharge occurs during the spring from snowmelt and rainfall. Water discharges from the aquifer by underflow (lateral underground movement), by seepage to streams, and by evapotranspiration.

The conclusions listed in the USGS report on the ground water resources in Bonanza Valley are as follows.

1. In parts of Bonanza Valley there are adequate ground water resources in the surficial aquifer for anticipated irrigation requirements. Additional potential sources of water are buried at places in the glacial drift and must be located by test drilling.

2. The aquifer is capable of yielding 300 gallons per minute (gmp) or more of water to wells in the northern and southwestern parts of the valley.

3. The quality of water is suitable for irrigation of most crops. The surficial and buried aquifers contain water of the calcium magnesium bicarbonate type that has low sodium and salinity hazzards. Boron concentrations are within acceptable limits even for sensitive crops.

4. Water level changes predicted by the analog model indicate that the surficial aquifer will support withdrawals of about 20,000 acre feet for at least 20 consecutive, abnormally dry years.

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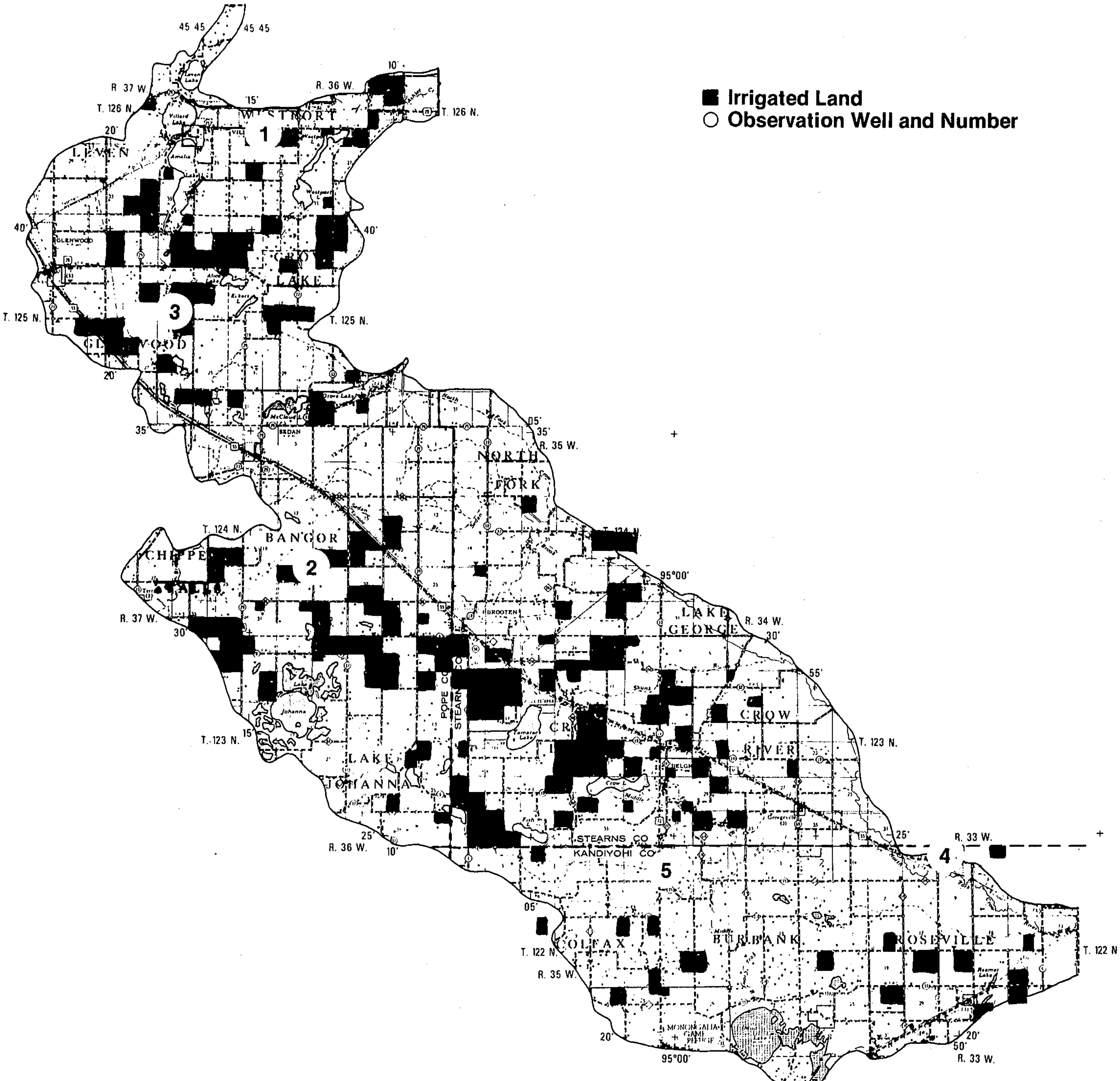
5. Van Voast, W.A. 1971. Ground Water for Irrigation in the Brooten-Belgrade Area, West-Central Minnesota. United States Geological Survey.

Bonanza Valley



UNIVERSITY OF MINNESOTA

Area Extension Office-Irrigation
Public School District 737
Brooten, Minnesota 56315

June 23, 1980

Mr. George Blake, Director
Water Resources Research Center
866 Biological Sciences Center
1445 Gortner Avenue
St. Paul, Mn. 55108

Dear Mr. Blake:

Please find enclosed copies of the five Bonanza Valley observations well's water level records.

For your information, last spring USGS put all of the water level records for Bonanza Valley and other areas into their computer and are now updating these levels monthly from the field observations. According to one USGS personnel I talked to last spring, they will be printing hydrographys periodically for each of the wells.

If you are still issuing reports of your sponsored projects, I would appreciate receiving any that would relate to irrigation.

Thank you for your interest in water levels and I hope that the enclosed information is helpful.

Sincerely yours,

Jerry Wright

Jerry Wright
Area Extension Irrigation Engineer

JW:mh
Enc.

FORM 9-148

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

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Report Page No. ________
GROUND WATER BRANCH

WATER RESOURCES DIVISION

COUNTY POPE

STATE ________

WATER LEVELS IN OBSERVATION WELLS

VILLARD
126-36-20-bcc1

Highest water level ________ 19____; lowest ________ 19____
Records available ________ Water level ________

Date	Water level	Date	Water level	Date	Water level	Date	Water level
1-29-79	8.88						
2-26	9.10						
3-30	9.13						
4-27	7.12						
5-30	6.93						
6-29	5.80						
7-31	6.23						
8-31	6.72						
9-28	7.21						
10-30	7.56						
11-29	6.97						
12-31	7.30						
1980							
Feb 1	7.75						
2-28	7.85						
3-31	7.62						

GPO 935799

VILLARD

Water Levels in Observation Wells

*- Turned measuring over to Pope Co SCSD

126-36-20 BCC1

Date	Water level	Date	Water level	Date	Water level
1973 Jan. 12	4.50	Jan. 23	8.98	MAY 25-77	9.61
Feb. 9	6.00	Mar. 4	9.22	June 22	9.59
Mar. 20	5.23	Apr. 3	9.18	July 27*	9.80
Apr. 27	5.42	Apr. 25	7.88	Aug 31	10.05
May 29	5.55	May 30	6.59	Oct 4	10.10
June 25	5.82	June 30	6.18	Oct 31	9.93
July 23	6.23	July 31	6.25	Nov 30	9.30
Aug. 22	6.57	Aug. 27	6.39	Dec 28	10.07
Sept. 24	6.85	Oct. 13	6.87	1978	
Oct. 7	6.28	Nov. 6	7.04	1-31	9.20
Dec. 12	7.30	1976		2-27	9.44
1974		Feb. 23	7.90	3-30	8.05
Jan. 9	7.54	Mar. 17	7.67	4-27	7.89
Feb. 8	7.79	Apr. 26	6.50	5-30	7.40
Mar. 8	7.99	May 28	7.15	6-30	7.31
Apr. 10	7.59	Jun 21	7.52	7-26	7.42
May 7	7.50	Jul 22	8.09	8-31	7.97
June 12	7.31	Aug 27	8.99	9-28	7.60
July 12	7.52	Sept 17	9.06	10-30	8.05
Aug. 12	7.74	Oct 25	9.40	11-29	8.36
Sept. 16	8.09	Nov 30	9.63	12-29	8.63
Oct. 11	8.27	Jan 24, 77	9.90	1979	
Nov. 8	8.47	FEB 22	10.05	1-29	8.88
Dec. 17	8.79	Mar 23	9.47		
1975		APR 29	9.63		

* Turned measuring over to Pope Co SCSD

Water Levels in Observation Wells

Sedan - 124-36-20 dddl

Date	Water level	Date	Water level	Date	Water level
1915 Oct. 13	7.58	Nov 30	8.29	Nov 29	6.82
Nov. 4	7.61	Dec 28	8.10	DEC 31	7.05
1976		1978		1980	
Feb. 2	8.05	Jan 31	8.50	Feb 1	7.37
Mar. 17	7.55	Feb 27	8.75	2-28	7.67
Apr. 26	7.05	Mar 30	7.70	3-31	7.36
May 28	7.33	APR 27	7.05		
June 21	7.84	MAY 30	6.92		
July 22	8.50	June 30	6.77		
Aug 27	9.50	July 26	6.48		
9-17	9.80	AUG 31	7.31		
Oct 25	10.04	SEPT 28	6.60		
Nov 30	10.05	Oct 30	6.98		
JAN 3/77	10.15	NOV 29	7.15		
JAN 24	10.25	DEC 29	7.49		
FEB 22	10.33	1979 JAN 29	7.72		
Mar 23	9.77	FEB 26	7.85		
APR 22	9.12	MAR 30	7.31		
MAY 26	8.95	APR 27	5.55		
June 22	8.35	MAY 30	5.95		
July 27*	8.74	June 29	5.62		
Aug 31	8.50	July 31	6.25		
Oct 4	9.42	Aug 31	6.96		
Oct 12	9.20	Sept 28	7.35		
Oct 31	9.03	Oct 30	7.45		

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UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Report Page No. ____

WATER RESOURCES DIVISION

GROUND WATER BRANCH

COUNTY POPE

STATE ____

WATER LEVELS IN OBSERVATION WELLS

Glenwood Well #3
125-37-14-dbb1

Highest water level ____ 19 ____; lowest ____ 19 ____
Records available ____ Water level ____

Date	Water level	Date	Water level	Date	Water level	Date	Water level
1-29-79	36.94						
2-26	37.06						
3-30	36.89						
4-27	36.05						
5-30	36.09						
6-29	36.17						
7-31	36.39						
8-31	36.59						
9-28	36.75						
10-30	36.73						
11-29	36.65						
12-31	36.70						
1980							
2-1	36.78						
2-28	36.87						
3-31	36.77						

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Water Levels in Observation Wells

Glenwood - *- Turned measuring over to Pope Co SCSD

125-37-14-dbb1

Date	Water level	Date	Water level	Date	Water level
1972					
Nov. 9	35.89	Nov. 8	37.16	FEB 22	37.85
Dec. 6	36.08	Dec. 17	37.18	Mar 23	37.58
1973		1975		APR 19	37.52
Jan. 12	36.15	Jan. 23	37.24	MAY 25	37.15
Feb. 9	35.10	Mar. 4	37.27	June 22	37.29
Mar. 20	35.90	Apr. 3	36.63	July 27*	37.59
Apr. 27	36.12	Apr. 26	36.34	Aug 31	37.58
May 29	36.26	May 29	36.20	Oct 4	37.45
June 25	35.60	June 30	36.12	Oct 31	37.45
July 23	36.58	July 31	36.26	Nov 30	37.28
Aug. 27	36.60	Aug. 26	36.34	Dec 28	36.85
Sept. 24	36.68	Oct. 13	36.24	1978	
Oct. 7	36.78	Nov. 4	36.56	Jan 31	37.08
Dec. 12	35.80	1976		Feb 27	37.09
1974		Feb. 23	36.89	Mar 30	36.72
Jan. 9	36.19	Mar. 17	36.72	APR 27	36.40
Feb. 8	36.95	Apr. 26	36.36	MAY 30	36.30
Mar. 8	36.96	May 28	36.62	JUNE 30	36.44
Apr. 10	36.76	June 21	36.95	JULY 26	36.42
May 7	36.72	July 22	37.26	AUG 31	37.10
June 12	36.77	Aug 27	37.50	SEPT 28	36.55
July 12	37.11	Sept 17	37.60	Oct 30	36.61
Aug. [illegible]	36.13	Oct 25	37.65	NOV 29	36.70
Sept. 16	37.13	Nov [illegible]	37.75	DEC 29	36.81
Oct. 11	37.17	Jan 24, 77	37.80		

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DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

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WATER RESOURCES DIVISION

GROUND WATER BRANCH

COUNTY KANDIYOHI

STATE ____

WATER LEVELS IN OBSERVATION WELLS

REGAL - 122-33-4 bcd

Highest water level ____ 19__ ; lowest ____ 19__

Records available ____ Water level ____

Date 1979	Water level	Date	Water level	Date	Water level	Date	Water level
Jan	-						
Feb	-						
Mar 30	8.11						
APR 28	5.31						
MAY 25	5.29						
June 26	4.86						
July 28	5.78						
AUG 27	6.42						
Sept 26	7.21						
Nov 2	7.38						
Nov 30	7.83						
DEC 24	7.93						
1980							
JAN 26	8.70 ?						
Feb 28	6.23						
Mar 29	9.04						
4-25	8.95						
5-28	9.29						

GPO 938799

Water Levels in Observation Wells

Regal - 122-33-4 bcd

Date	Water level	Date	Water level	Date	Water level
1973					
May 26	6.82	Apr. 26	6.73	4-27-77	10.64
June 26	7.09	May 26	6.68	5-26	10.75
July 24	7.57	June 26	6.60	6-28	10.37
Aug. 25	6.50	July 26	7.47	7-27	10.15
Sept. 24	6.24	Aug. 26	7.85	8-26	10.74
Oct 26	6.26	Sept. 26	8.09	9-26	9.27
Nov. 26	7.60	Oct. 26	8.19	10-26	7.32
Dec. 26	7.98	Nov. 26	8.69	11-29	8.10
1974		Dec. 26	8.89	12-27	8.16
Jan. 24	7.77	1976		1978	
Feb. 26	8.45	Jan. 26	9.27	Jan 26	8.44
Mar. 26	8.11	Feb 26	8.22	MAR 4	8.69
Apr. 25	7.71	Mar. 26	7.25	MAR 27	8.49
May 25	(7.78)	April 26	7.75	APR 27	6.97
June 26	8.00	May 26	8.02	MAY 28	7.41
July 26	8.50	June 26	8.48	JUNE 26	6.26
Aug. 26	8.76	July 26	9.09	JULY 27	5.34
Sept. 26	9.15	Aug 26	9.61	AUG 26	6.15
Oct 25	9.48	Sept 26	10.08	SEPT 25	6.08
Nov. 26	9.71	Oct 26	10.48	Oct 31	6.99
Dec. 26	9.92	Nov 29	10.75	Nov 27	7.92
1975		DEC 27	10.99	DEC 28	8.15
Jan. 26	10.15	JAN 26 / 77	11.06	[illegible]	
Feb. 26	10.34	FEB 26	11.40	[illegible]	
Mar. 26	10.29	Mar 26	10.60		

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UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Report Page No. ______

WATER RESOURCES DIVISION

GROUND WATER BRANCH

COUNTY Kandiyohi

STATE ______

WATER LEVELS IN OBSERVATION WELLS

Belgrade 122-34-6 cdc 5

Highest water level ______ 19 ____; lowest ______ 19 ____

Records available ______ Water level ______

Date	Water level	Date	Water level	Date	Water level	Date	Water level
1979							
Jan	covered with snow						
Feb							
Mar 30	9.14						
APR 28	4.71						
MAY 25	7.81						
June 26	7.79						
July 28	8.66						
AUG. 27	9.42						
Sept 26	9.94						
Nov 2	9.59						
Nov 30	9.68						
Dec 24	9.68						
1980							
JAN 26	9.91						
Feb 28	10.15						
3-29	9.69						
4-25	9.33						
5-28	9.53						

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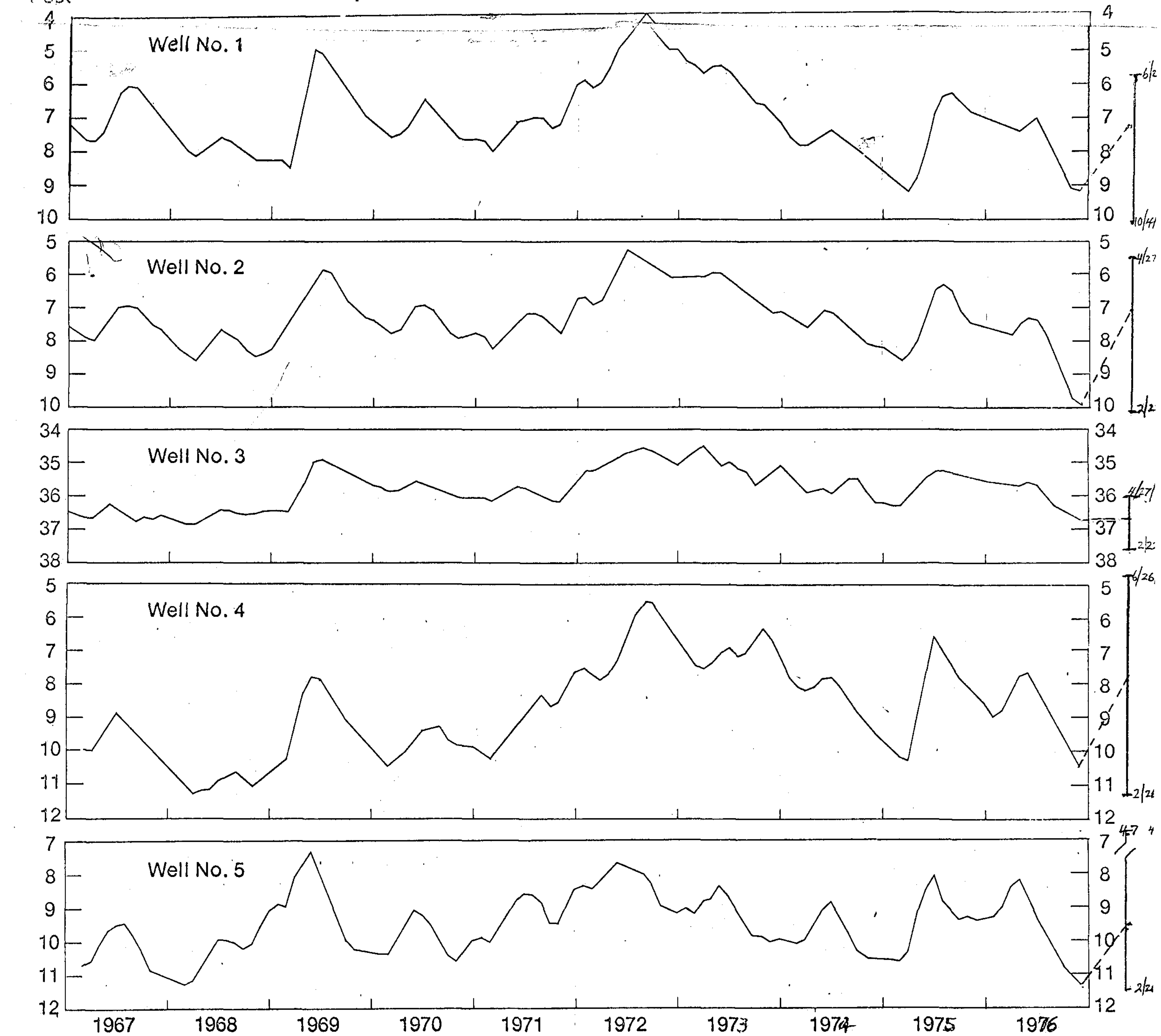
Water Levels in Observation Wells

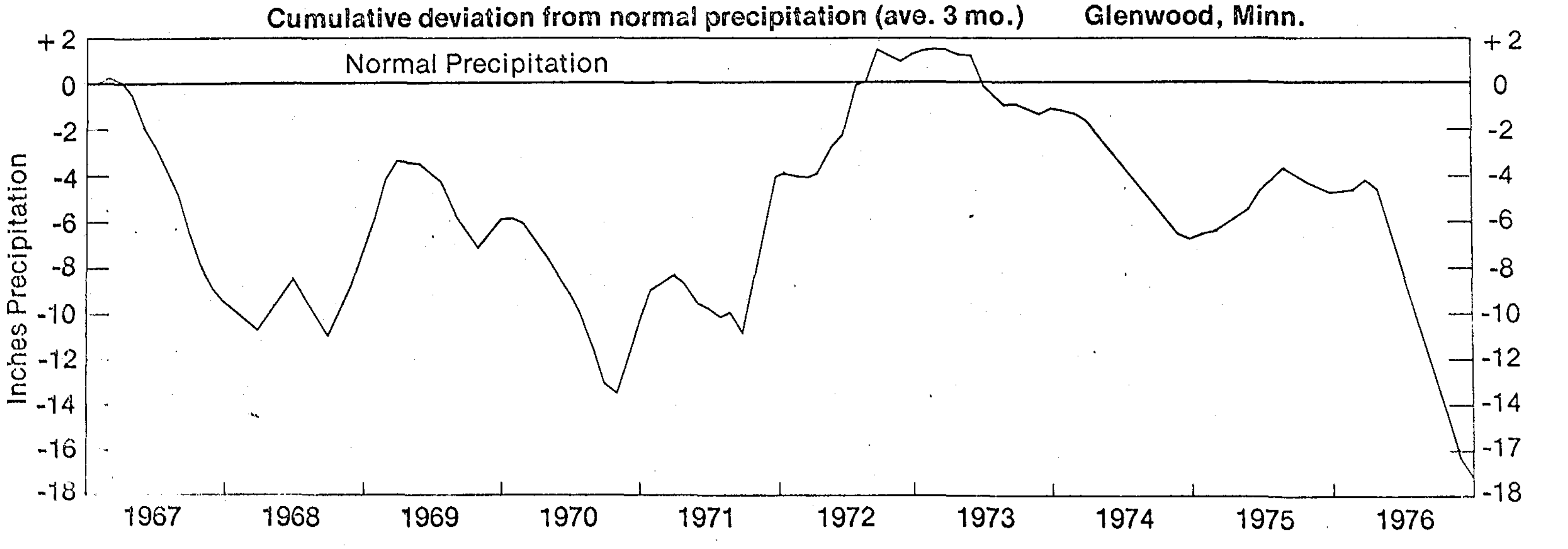
BELGRADE - 122-34-6 cbc

Date	Water level	Date	Water level	Date	Water level
1973					
March 26	8.15	Feb. 26	10.64	FEB 26	11.61
Apr. 26	8.39	March 26	9.84	Mar 26	10.72
May 26	8.42	Apr. 26	7.20	April 27	10.33
June 26	9.29	May 26	8.37	May 26	10.28
July 24	9.87	June 26	8.56	June 28	10.48
Aug. 25	9.40	July 26	9.64	July 27	10.60
Sept. 24	10.23	Aug. 26	9.18	Aug 26	10.91
Oct. 26	9.89	Sept. 26	9.29	Sept 26	10.75
Nov. 26	9.89	Oct. 26	9.38	Oct 26	10.42
Dec. 26	9.97	Nov. 26	9.31	Nov 29	9.41
1974		Dec. 26	9.28	Dec 27	9.23
Jan. 24	10.1	1976		1978	
Feb. 26	10.19	Jan. 26	9.28	Jan 26	9.41
Mar. 26	9.69	Feb 26	8.49	MAR 4	9.66
Apr. 25	8.88	March 26	7.40	MAR 27	9.30
May 24	8.65	April 26	8.62	APR 27	7.75
June 26	9.10	May 26	9.08	MAY 28	7.50
July 26	10.00	June 26	9.21	JUNE 26	8.25
Aug. 26	10.28	July 26	10.31	July 27	8.27
Sept. 26	10.50	Aug 26	10.87	AUG 26	9.24
Oct. 25	10.64	Sept 26	11.22	SEPT 25	9.24
Nov. 27	10.46	OCT 26	11.37	Oct 31	9.73
Dec. 26	10.53	NOV 29	11.43	Nov 27	9.81
1975		DEC 27	11.51	Dec 28	9.92
Jan. 26	10.61	JAN 26-77	11.58		

Depth in feet to water below land surface (ave. 3 mo.)



Cumulative deviation from normal precipitation (ave. 3 mo.) Glenwood, Minn.



Water level measurements are made by dropping a chalked steel tape into the observation well until it reaches the water level. The distance from the wetted area on the tape to the land surface area is recorded in feet. The monthly measurements from all wells are recorded and submitted annually to the USGS and the DNR.

Hydrographs of the five observation wells are shown on page six. Each point on the graph is an average of three months to smooth the curve. (The current month and the two preceeding months.) Hydrographs of actual monthly observations are on file at the USGS and offices of the authors. A graph of the cumulative departure from normal precipitation at the Cooperative United States National Weather Service Station at Glenwood is also shown as an average of three months.

The natural fluctuations in water levels can be observed on the hydrographs during the first few years of record. Snowmelt and spring rains are the major sources of recharge to the surficial aquifer and cause water levels to rise significantly. During summer most of the precipitation is used as evaportranspiration and relatively little recharge occurs. Water levels continue to decline through summer as water leaves the aquifer by underflow and seepage to streams.

After crops mature in the fall and evapotranspiration has ceased, some recharge may result from precipitation. However, water levels continue to decline through the winter and generally reach a low point in February or March before the spring thaw.

The influence of precipitation on water levels can be readily observed in the spring recharge of 1969. From December 1, 1968 to May 31, 1969 there were 13.98 inches of precipitation recorded at Glenwood. This resulted in a rise in the water levels ranging from 1.39 feet in well number 3 to 2.47 feet in well number 5. Another dramatic response to local precipitation occurred in 1975 when 12 inches of precipitation was recorded at Glenwood during April, May, and June. Water levels in the observation wells rose from 0.51 feet in well number 3 to 3.69 feet in well number 4.

Examination of the observation well hydrographs appears to show rising water levels from 1967 to a peak in 1972. If one examines both the highest levels after spring recharge and the lowest levels during mid-winter, there appears to be an upward trend. Since 1972 there appears to be a corresponding decline of both the high and the low water levels.

The graph of the cumulative departure from normal precipitation at Glenwood shows that a peak was reached in early 1973. The years 1967 and 1970 had below normal precipitation and the other years above normal. Since 1973 the annual precipitation has been below normal except during 1975. The hydrographs closely resemble the precipitation graph.

The year 1976 had the lowest precipitation on record in west central Minnesota. Total precipitation recorded at Glenwood was 11.15 inches. Spring recharge of the aquifer was also the lowest recorded, being less than two feet in any of the wells. Although water levels in three observation wells are at their lowest point since the records began, this is also the year of lowest precipitation. In 1976 there also was the greatest withdrawal of water from the aquifer for irrigation purposes. A comparison of November, 1976 water levels with previous low levels is shown in the following chart:

Comparison of November, 1976 Water Levels with Previous Low Levels

Depth to Water in Feet

	1976	Previous Low	Month and Year	Change (Feet)
Well 1	9.53	9.22	Feb. 1975	-0.31
Well 2	10.05	8.84	Feb. 1975	-1.21
Well 3	37.75	37.89	Feb. 1968	+0.14
Well 4	10.75	11.29	Feb. 1968	+0.54
Well 5	11.43	11.37	Feb. 1968	-0.06

Water levels in two observation wells in November, 1976 were higher than the previous low levels on record, even though 1976 had the lowest precipitation on record; the cumulative departure from normal precipitation fell to 18 inches below normal; and the withdrawal of water from the aquifer for irrigation was at a record volume.

Conclusions

Water levels in the surficial aquifer seem to be closely correlated with precipitation as shown by the hydrographs of the observation wells and the precipitation cumulative departure curve.

The major recharge to the aquifer occurs during snowmelt and spring rains. Water levels generally delcine after July and reach a low point in February or March.

To date these data show no evidence that the increased withdrawal of water for irrigation from the aquifer has had any significant effect on the water levels.

Monitoring of the water levels in the aquifer should be continued to detect any changes that might occur.