STATUS REPORT

of the

SOUTH PINE CONTROLLED GROUND-WATER AREA

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by

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ABSTRACT

Hydrologic data collected and analyzed from wells within the South Pine Controlled Ground-water Area show that static water levels have been rising progressively over the past 4 to 5 years. The industrial wells that caused the initial decline in the water level in the Fox Hills-Hell Creek aquifer no longer are used for secondary oil recovery.

The only areas in the controlled ground-water area that do not show a rise in water levels are those in the southeast quarter of T.12N., R.55E., and possibly in the northwest quarter of T.11N., R.55E. The continuing decline in water levels in these wells probably is due to increased withdrawals from domestic and stock wells and a lack of water conservation measures; some wells are uncapped and allowed to flow freely.

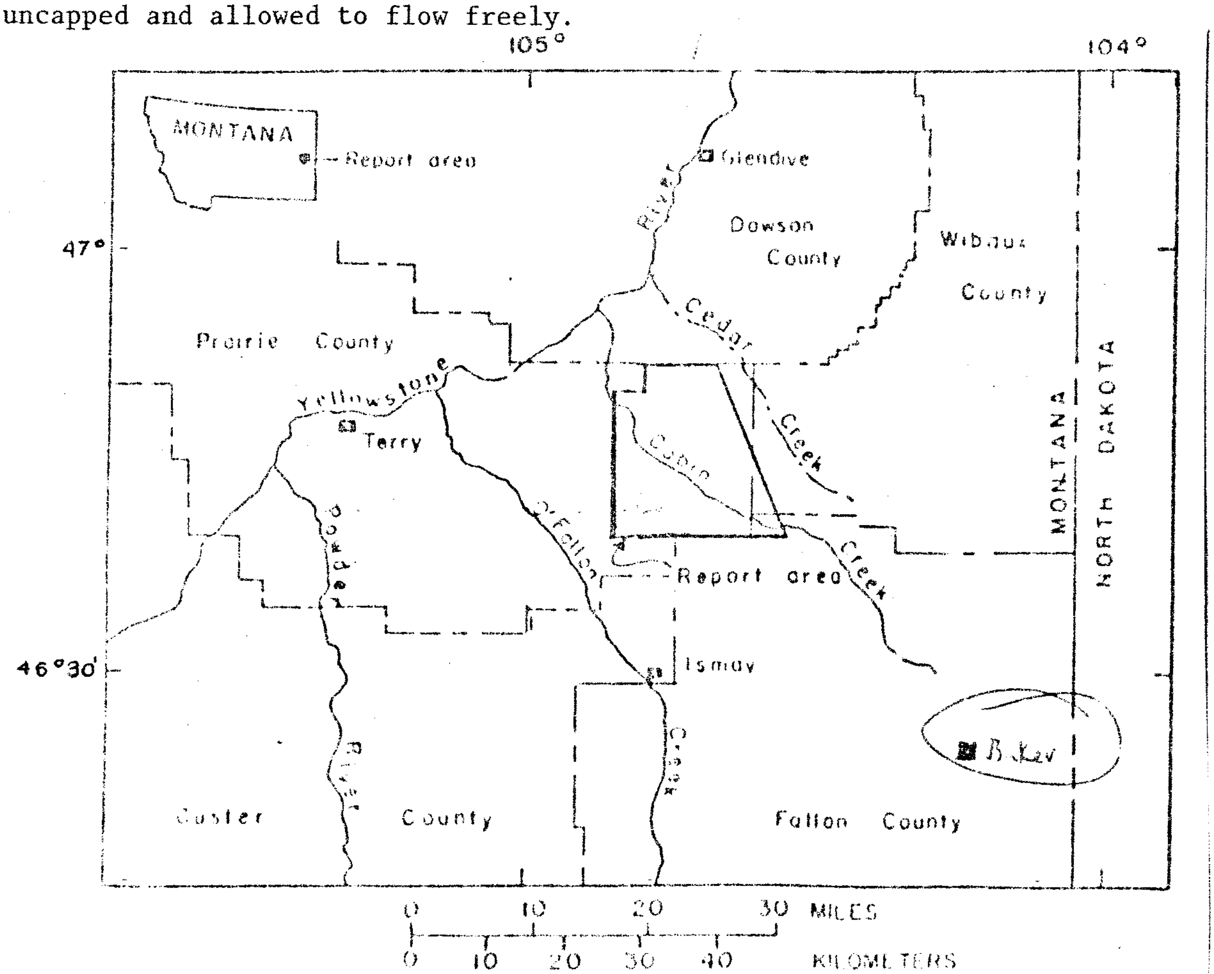

Figure 1.--Index map showing location of report area.

INTRODUCTION

The South Pine Controlled Ground-Water Area lies south of the Yellowstone River, along the western flank of the Cedar Creek anticline between Glendive and Baker, Montana.

Much of the water used in this part of Montana for municipal, rural domestic, and stock-watering purposes is drawn from the Fox Hills-Hell Creek aquifer, which underlies the eastern third of the state. The aquifer, is generally less than 1,500 feet below the surface.

This aquifer commonly is thought to be a better source of water for consumptive purposes than shallower, smaller aquifers underlying the area because it can supply large amounts of higher quality water on a reliable basis.

The South Pine Controlled Ground-Water Area was established by the Montana Water Resources Board (now the Board of Natural Resources and Conservation) on November 1, 1967, to protect the rights of existing water users and to control the observed decline in the water level of the Fox Hills-Hell Creek aquifer (see appendix A-1) which was thought to be caused by withdrawals for industrial use.

As a part of its order creating the controlled ground-water area, the board also established a monitoring program to determine the rates of water withdrawal from the aquifer and general trends in the aquifer's water level.

As a followup to that monitoring program, a geohydrologist from the Water Sciences Bureau of the Montana Department of Natural Resources and Conservation visited the South Pine Controlled Ground-Water Area in August 1980 to study current water levels and water use conditions in the area. This report summarizes the findings of that investigation.

BACKGROUND

Previous Studies

Perry's reports (1931, 1935), dealing with the location and availability of ground water in eastern and central Montana, are the earliest studies related to ground-water resources in this area.

In 1965, the Montana Bureau of Mines and Geology, Butte, published a report by Taylor (1965) in which he described ground-water levels along the Cedar Creek anticline and possible effects of pumping increased amounts of water for industrial use from the Fox Hills-Hell Creek aquifer. In response to this report, the U.S. Geological Survey (USGS) established fifteen observation wells in the area and began monitoring ground-water levels six times per year.

Coffin and Reed (1969) published a supplemental map to Taylor's (1965) report in which they reviewed and updated ground-water level data collected from the 1962-1964 study period through 1969. More recently, Coffin, et. al. (1977) published a comprehensive report documenting water levels along the Cedar Creek anticline based on 1975 hydrologic data and earlier reports.

Much of the information in this 1980 report is based on information from these earlier reports and USGS monitoring data.

Regulation Affecting Ground Water Withdrawals

Included in the 1967 order establishing the controlled ground-water area and the water level monitoring program was a procedure for submitting water permit requests or applications to the Montana Water Resources Board. These permits would be necessary to: (1) drill new wells in the area; (2) return inactive wells to production; and (3) increase the rate of withdrawal from active wells.

This order did not limit the rate of withdrawal or total amount of water which could be pumped for industrial use. However, after several meetings between the principal industry in the area, the Shell Oil Company, and the Water Resources Board, and after subsequent correspondence in the winter of 1968, it was agreed that the company would limit its withdrawal of water from the aquifer to 11,000 barrels per day, averaged on a monthly basis (Guse 1970).

On November 13, 1969, the Montana Water Resources Board, after receiving complaints from the Pure Water Control Association, a group of landowners in the area, held a public hearing on the controlled ground-water area to address charges that, due to increased industrial withdrawals, water levels in the aquifer had dropped below the levels predicted in Taylor's (1965) report. The association questioned the accuracy of Taylor's report and was concerned as to how far these levels would actually drop.

Prior to the 1969 hearing, Shell Oil Company publicly announced that it would assist ranchers in meeting their water needs, if requested. Many ranchers accepted this offer (Guse 1970).

On June 8, 1970, based on the Findings of Fact from the November hearing, the Water Resources Board modified its 1967 order (appendix A-1) and gave the Shell Oil Company two alternatives which might help solve the problem: (1) either the company limit its total withdrawal from the aquifer to 7,000 barrels per day; or (2) it provide economic support to the ranchers affected by company withdrawals. The company chose the latter alternative.

The industrial wells that evidently caused the decline in water levels were phased out of production between 1975 and 1977. Presently, no fresh water wells within the controlled ground-water area are used for secondary oil recovery. Shell's Pine #6 well, the only industrial well still in operation, is used solely for domestic, stock-watering and minor industrial purposes.

AREA GEOHYDROLOGY

The Fox Hills-Hell Creek aquifer within the Controlled Ground-Water Area is described by Coffin, Reed, and Ayers (1977) as:

> "The aquifer includes the Fox Hills Sandstone and the overlying lower part of the Hell Creek Formation, both of Late Cretaceous age. It is a zone composed mainly of sandstone, but includes interbedded siltstone and shale. The thickness of the aquifer ranges widely from place to place because of changes in thickness of the sandstone. Measured thicknesses range from 150 to 480 feet (Taylor, 1965, p. 9). The overlying beds in the upper part of the Hell Creek Formation generally are more shaly than the aquifer. Both the Hell Creek and overlying Paleocene Fort Union Formation, however, contain lenses of sandstone and coal beds that transmit and store water, but the units appear to have poor hydraulic connection with the aquifer. The Upper Cretaceous Pierre Shale, which is nearly impermeable, underlies the Fox Hills Sandstone.
>
> As shown in figure 2, the aquifer dips westward from its outcrop along the Cedar Creek anticline. About 2 miles west of the outcrop the aquifer is about 1,000 feet below land surface. Away from the anticline, dips are less steep and depth to the aquifer is generally 800 - 1,000 feet.

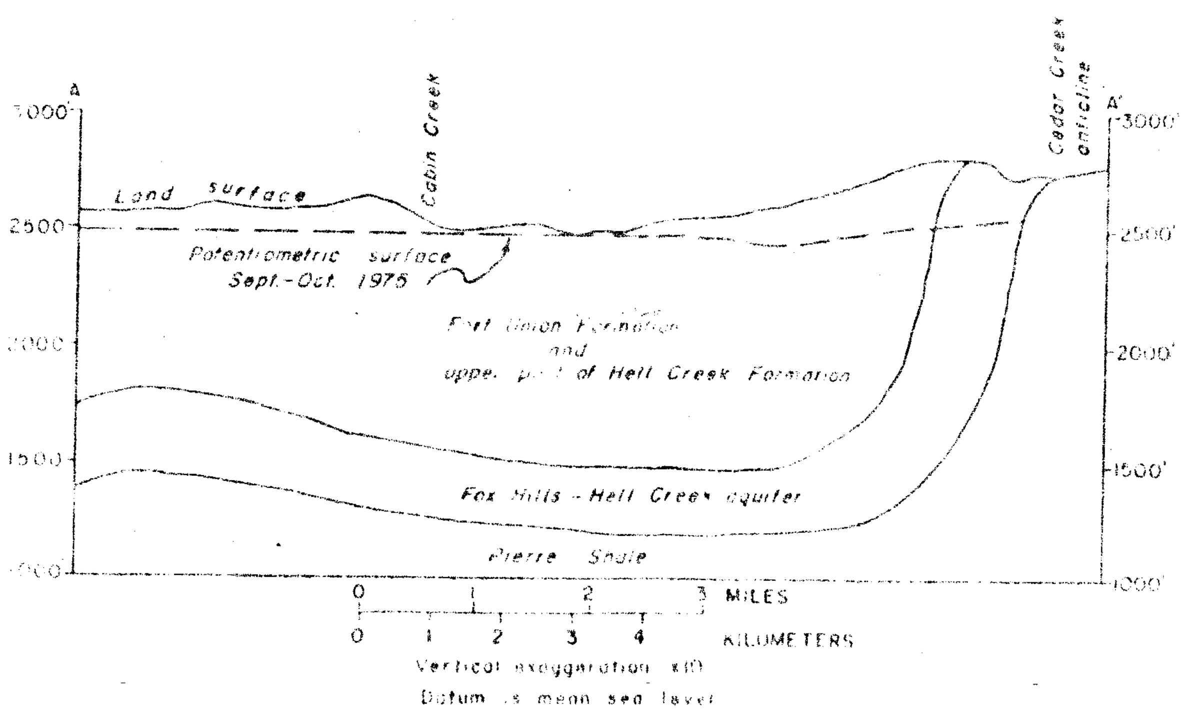

Figure 2.--Generalized geohydrologic section of the Fox Hills-Hell Creek aquifer. Trace of section shown on plate 1.

In most of the area, water in the aquifer is under pressure (confined), and rises above the level where it is first penetrated by a well or test hole. In the outcrop area, however, the water is unconfined and does not rise above the level where it was first penetrated.

In the Fox Hills-Hell Creek aquifer, water that is produced from wells is balanced by a loss of water elsewhere. The principal sources of water discharged by the wells are water that was stored in the aquifer; water that leaks into the aquifer from overlying beds as the well is pumped; and water that, before the wells were pumped, was either discharged to the Powder or Yellowstone River valleys or discharged to springs along the outcrop.

In the confined part of the aquifer, the decrease in water level that results from pumping the wells is transmitted rapidly throughout the aquifer. As the water level lowers the water that had been discharging to the river valleys or to springs is reduced. This decrease in natural discharge, in turn, decreases the rate of lowering of the water levels near the areas of pumping. Also, lowering the water level in the area of pumping may induce leakage from overlying beds, which could help decrease the rate of lowering of the water levels in the aquifer. Apparently, decreased discharge and leakage do not supply as much water to the aquifer as the wells produce, because water levels continue to decline. The decline indicates that water released from storage in the aquifer makes up a significant amount of the water produced from wells." (Coffin, Reed and Ayers, 1977).

Plate 1 gives the location and potentiometric level (the level to which water will rise in a tightly-cased well) of wells mentioned in this report. In general, the potentiometric levels in the area show a downgrade from southeast to northwest (Taylor 1965; Coffin et. al. 1977). Therefore, since ground water flows from an area of higher water levels to an area with lower water levels, water in the Fox Hills-Hell Creek aquifer within the controlled ground-water area flows in a north-northwest direction. This downward gradient is evident in a series of wells beginning in T.10N., R.58E. (southeast) and ending in T.13N., R.55E. (northwest). The difference in potentiometric levels between Abandoned Well (T.10N., R.58E.), where the water level was at 2,649 feet in 1980, and the J. Opp Well (T.13N., R.55E.), where the level was at 2,323 feet in 1980, is 320 feet.

THE 1980 STUDY

Observations

A field investigation of the controlled ground-water area was conducted by the author from August 12 to August 15, 1980. A summary of his findings follow.

According to Mr. Bill Power, supervisor for Shell Oil Company's South Pine unit, the company began producing enough water from its oil wells in 1975 to use this water for secondary oil recovery. Consequently, the company began shutting down wells which were pumping water from the Fox Hills-Hell Creek aquifer for this purpose. By 1977, the company no longer used fresh water aquifers for secondary oil recovery.

The only industrial well still pumping from the Fox Hills-Hell Creek aquifer is Pine #6, which pumps at an approximate rate of 56 to 80 gallons per minute (or 0.25 to 0.35 acre-feet per day) and furnishes water for the company's domestic use and periodic construction purposes. Several stock and rural domestic water lines, used by local area ranchers and company employees, also draw water from the well.

Several artesian wells were found flowing unrestricted within the controlled ground-water area. Some owners felt they could not shut them off because it would either damage the well, due to well casing deterioration, or that it would eventually silt in and inhibit flows. The second point is questionable.

Due to the drought conditions in eastern Montana over the past few years, surface water has not been adequate to meet stock-watering needs. Accordingly, stock-water lines are being developed within this area to provide water for better range management. With such lines, one well furnishes water to one or more pastures in different locations. Since 1975, five water line systems have been or are presently being installed within the controlled ground-water area. At one of these systems, an area rancher who leases land from the Bureau of Land Management (BLM) allowed water pumped into a stock tank to overflow without control. This rancher explained that, while he needed the land and water for his cattle, BLM had not finished building a stock-watering system on the range.

After discussing this problem with BLM personnel in Miles City, it seems they are not familiar with rules and regulations in the South Pine Controlled Ground-Water Area.

Several windmills in the area have been modified by attaching submersible pumps to their existing systems. This allows more water to be pumped from the Fox Hills-Hell Creek aquifer during peak stock-watering periods, a factor which contributes to declining water levels.

In summary, the author's observations suggest that the Shell Oil Company has not been drawing water for secondary oil recovery from the Fox Hills-Hell Creek aquifer since 1977, and that most of the water drawn from the aquifer is pumped by domestic and stock water wells, some of which are allowed to flow freely.

Results

Table 1 shows static water levels at the end of the 1962-1964, 1969, 1975, and 1980 study periods, as well as changes in water levels within each period for the Fox Hills-Hell Creek aquifer. These data are from the studies previously cited. Plate 2 shows changes in water levels from 1962 to 1980 and from 1975 to 1980. Figures 3 through 10 are hydrographs of data collected from observation wells within the South Pine Controlled Ground-Water Area from 1962 to 1980. Several deviations from the curve's general trend are evident. For example, in figure 8 the static water level of the Strobel Windmill well on July 1, 1975, was 48.75 feet. Measurements taken directly before and after this date, however, showed the static water level to be at 39.5 feet and 40.17 feet. This deviation, as noted in USGS field notes, probably was caused by pumping directly prior to measuring these levels.

Overall, the static water level in the Fox Hills-Hell Creek aquifer exhibited a declining trend between 1962 and late September 1969. In an area covering about 300 square miles, the static water level dropped 10 feet or more through 1969. A maximum decline of 133.4 feet was seen in T.12N., R.56E. during this period (Coffin, et. al., 1977).

At least for the first 4 1/2 to 5 years of the 6-year study period from late September 1969 to late September 1975, a declining trend in water levels still was noticeable. This decline is shown in figures 5, 6, 9, and 10. A maximum decline of 222.4 feet was witnessed in T.12N., R.56E., where several of the major, high-yielding wells were located. Industry pumped a large amount of water from the Fox Hills-Hell Creek aquifer during this period. Late in 1973, the downward trend in water levels began to reverse. This reversal is illustrated in figures 9 and 10, which are hydrographs of data collected from wells located in an area (T.12N., R.55E.) where water levels declined the most due to pumping from industrial wells. Figure 9 shows the hydrograph of a well (Pine #1) that was used for both industrial withdrawals and water-level monitoring. Erratic fluctuations in the static water level are due to intermittent pumping from the well. The static water level of the well decreased 255 feet from 1962 to 1973. In 1973, the static water level began to increase and was still increasing as of the 1980 monitoring date. This level increased 198.1 feet since reaching its low point. However, this level is still 66 feet lower than that level originally recorded in 1962.

Figure 10 is a hydrograph of data collected from the Shell Observation Well, a well surrounded by industrial wells but used strictly for water level monitoring. The hydrograph's pattern resembles that in figure 9, except that this hydrograph reflects a broader range of impact; this well was directly affected, not by a single well, but by a group of industrial wells. The well's static water level decreased 157.2 feet between 1962 and 1973. Although this downward trend reversed from 1973 through 1976, water levels again fell, though only slightly, during 1976 and 1977. These levels have continued to rise since that time. The water level in the well increased 90.5 feet between 1973 and 1980, but this level is still 66.7 feet lower than that level originally recorded in 1962.

Water levels also are rising in other areas previously depleted by industrial withdrawals. For example, figures 5 and 6 are hydrographs of data collected from the McNaney and Hoffer wells, from which water is drawn for domestic and stock-watering purposes.

The water level in the McNaney well, located on the southeastern boundary of the South Pine Controlled Ground-Water Area, decreased 46.7 feet between 1963 and late 1974. Between 1974 and September 1980, however, this level increased 21.8 feet. The 1980 level is still 24.8 feet lower than that recorded in 1963.

Data from the Hoffer well indicate that water levels have risen along the western border of the controlled ground-water area as well. From 1962 to late 1973, the water level in the well decreased 23.7 feet. This trend reversed in late 1973, and since that time the water level has been rising. Although the level has risen 19.5 feet since 1973 testing, this level is still 4.2 feet less than that level recorded in 1962.

A definite trend in regional water levels is apparent. Coffin, et. al. (1977) reported that static water levels over an area extending 300 miles declined 10 feet between the 1962-1964 study period and 1969. By 1975, this decline had spread to cover an area of 400 square miles. However, during the last five years, static water levels have risen significantly throughout the region. In T.12N., R.57E. (see plate 2), water levels rose 70.4 feet from

September 1975 to late August 1980. Minor fluctuations in this trend are noticeable (see figures 3 and 4). These inconsistencies probably can be attributed more to site specific pumping and seasonal fluctuations in aquifer water levels than to industrial pumping.

The only area in which this rising trend is not evident is in the southeast quarter of T.12N., R.55E. Water levels in both the T. Strobel and Strobel Windmill wells here declined 3.5 feet and 2.6 feet from 1975 to 1980 (see figures 7 and 8). Coffin, et al (1977) theorized that an observed decline in water levels in this area between the 1962-1964 study period and 1975 was influenced by withdrawals from domestic and stock wells. The decline apparently continued from 1975 to 1980. The hydrographs in figures 7 and 8 show this declining trend. Water levels in the T. Strobel and Strobel Windmill wells decreased 13.6 feet and 42.8 feet between the 1962-1964 study period and the 1980 monitoring date.

As of September 1980, static water levels of most wells in the region had not yet returned to their pre-1962 levels. In contrast, static water levels in the Pine #3 and Abandoned wells (figures 3 and 4) had exceeded their 1962-1964 measured levels by 30.8 feet and 9.8 feet. In these cases, it appears that either the 1962-1964 measurements were taken directly after major withdrawals of water, or that long-term water use had already decreased water levels in these wells significantly.

SUMMARY AND CONCLUSIONS

Most ground water withdrawn from the South Pine Controlled Ground-Water Area is from water stored within the Fox Hills Sandstone and basal Hell Creek formations. The main water recharge areas for these formations are the exposed outcrops along the northern flank of the Black Hills Uplift and the western flank of the Cedar Creek anticline.

The primary sources of ground water discharge in this area are domestic and stock wells, some of which are allowed to flow without control. For the past 3 years, no industrial wells within the controlled ground-water area have pumped water for use in secondary oil recovery. Presently, Pine #6 is the only industrial well pumping water from the Fox Hills-Hell Creek aquifer.

Static water levels within the area were lowered as much as 273.2 feet by 1973. Since that time, water levels have risen by as much as 206.3 feet.

This rise in static water levels reflects the general trend in all areas except the southeast quarter of T.12N., R.55E., where water levels in some stock and domestic wells continue to decline. On a regional basis, this rising trend probably reflects the drastically reduced withdrawal of water for industrial use.

The continued decline in static water levels in wells west of the Fox Hills-Hell Creek outcrop suggests that water use in this part of the controlled ground-water area has remained about the same or increased since previously measured. This use has offset the rise in water levels observed in other wells within the area.

If water levels throughout the region continue to rise, as documented in 1975 by Coffin, et al (1977), water levels within most of the controlled ground-water area also should keep rising. However, in areas where domestic and stock well yields remain the same or increase, or where these wells are allowed to flow freely, water levels may continue to decline.

Reference

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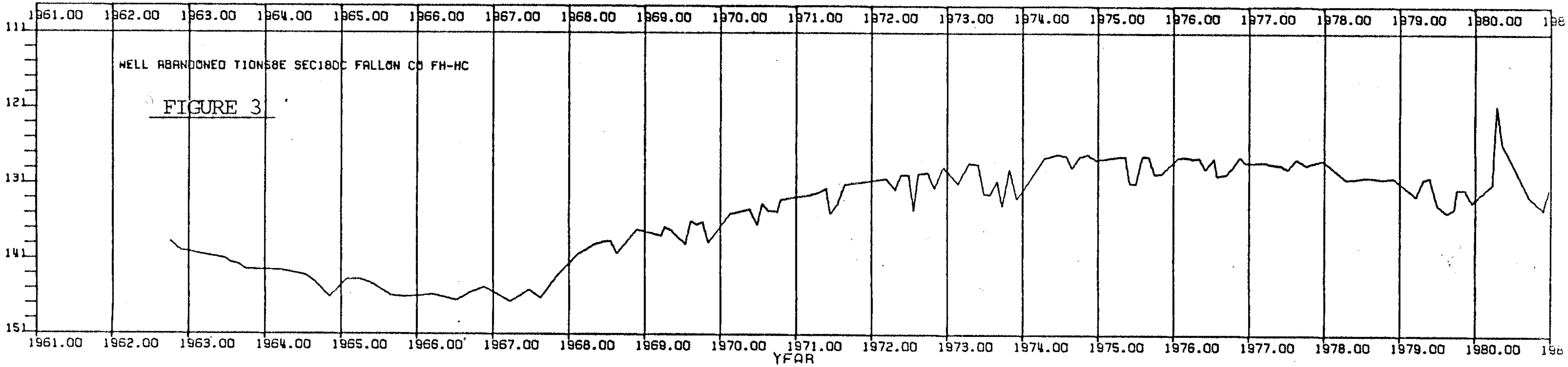
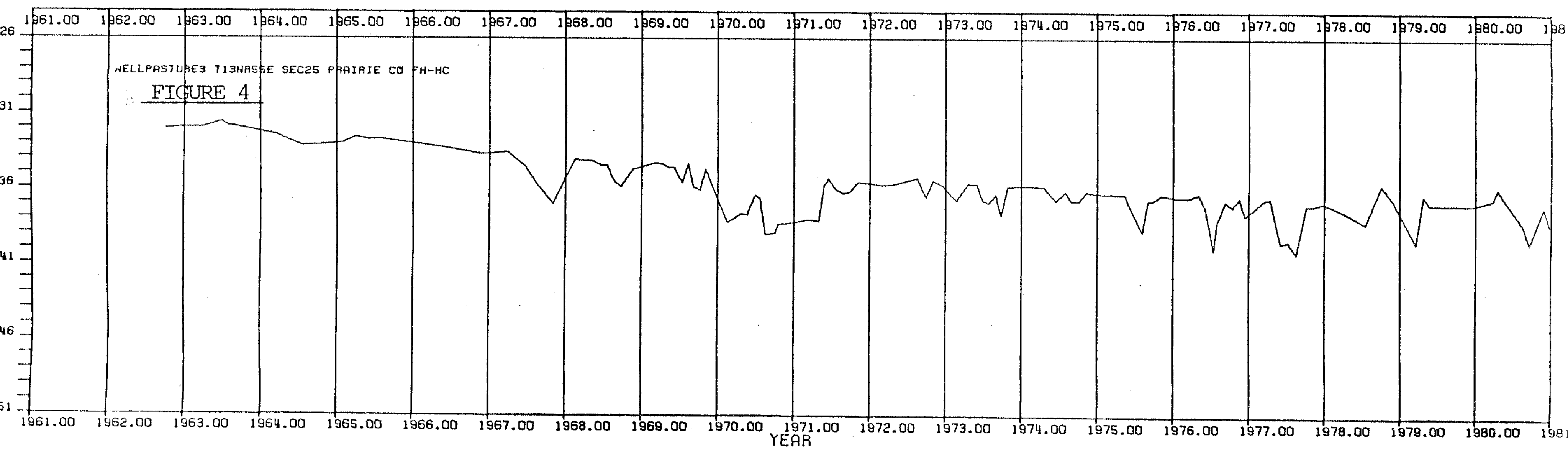
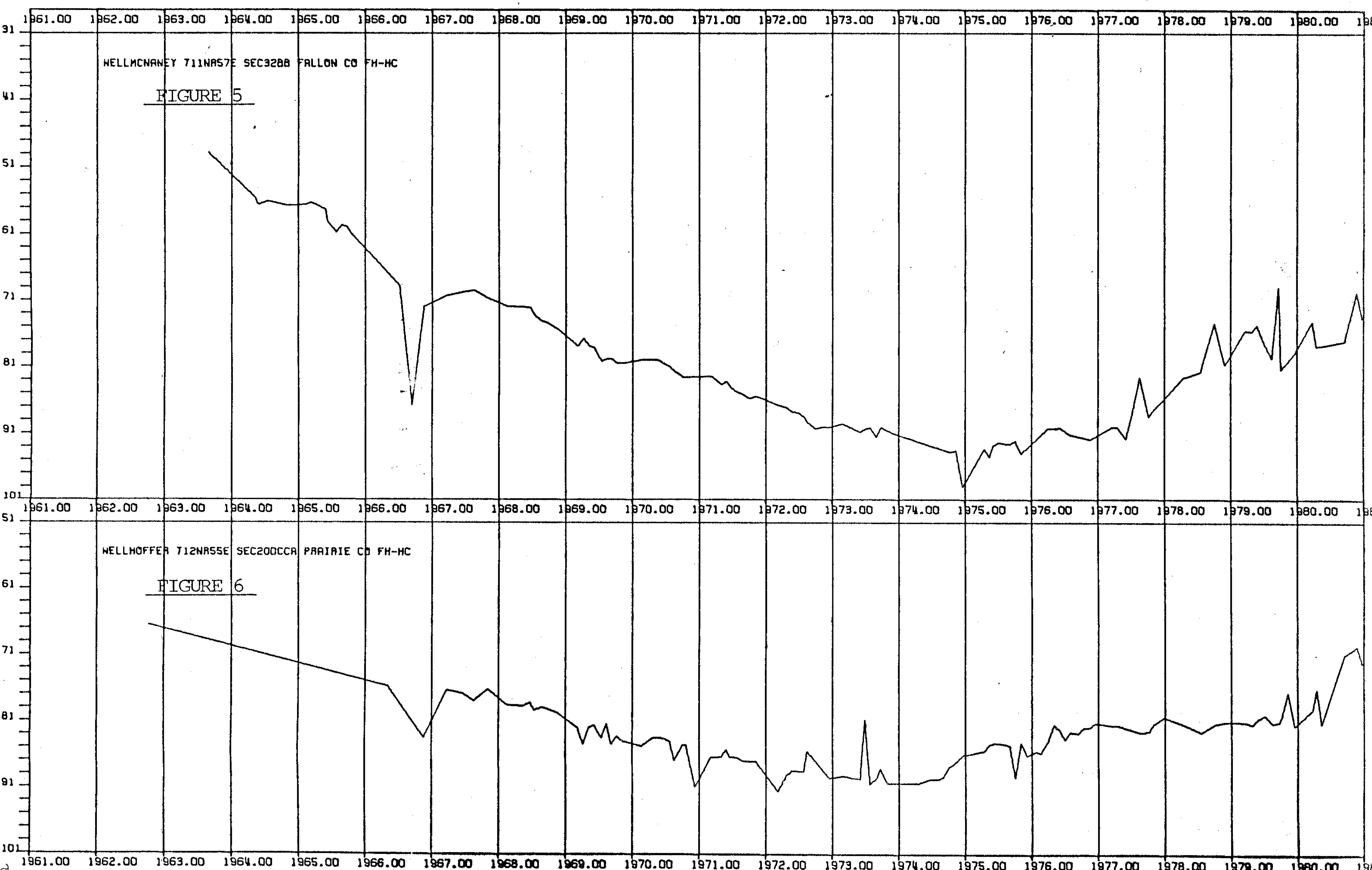
HYDROGRAPHS OF STATIC WATER LEVEL





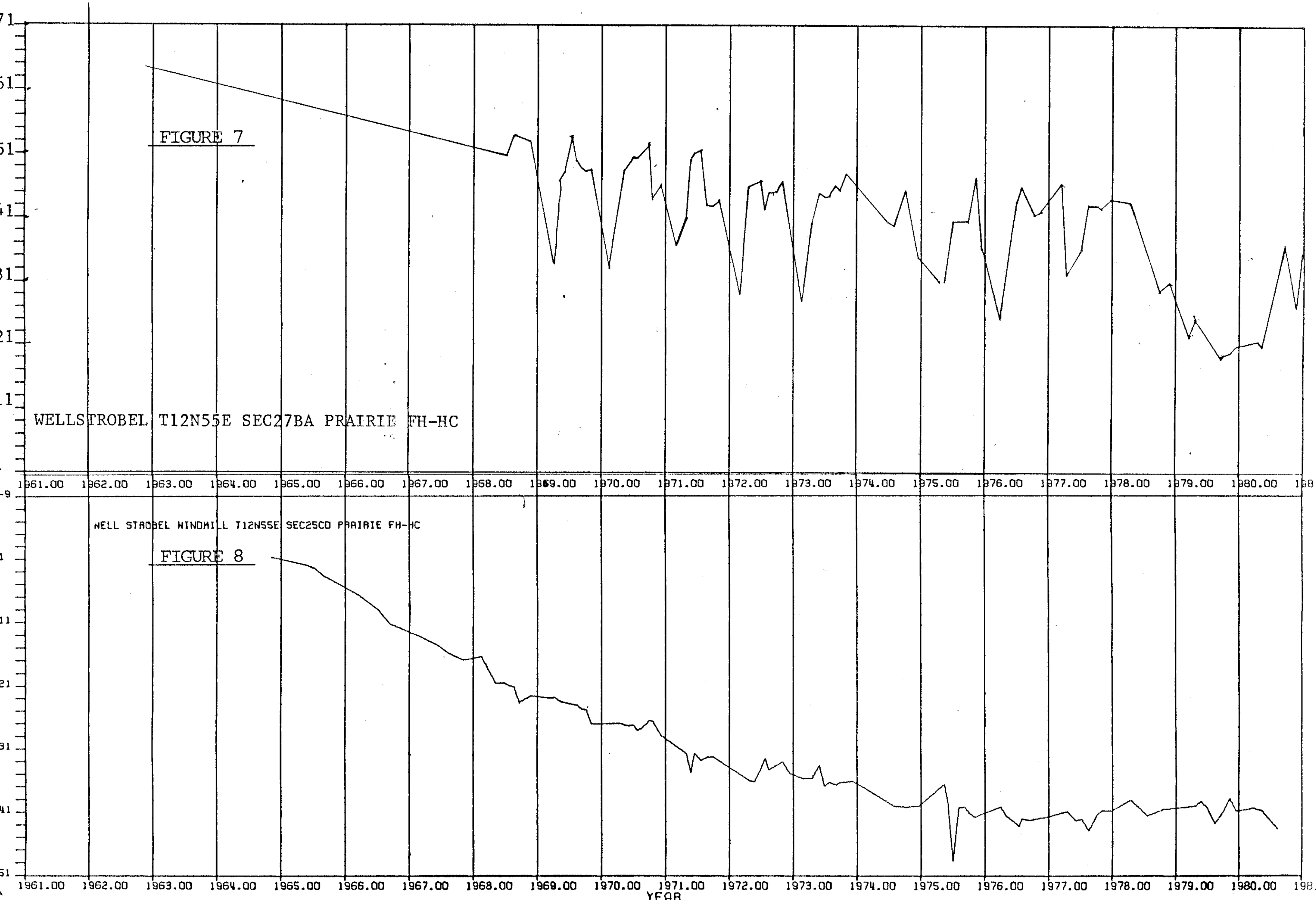
FIGURES 3 & 4

HYDROGRAPHS OF STATIC WATER LEVEL



FIGURES 5 & 6

HYDROGRAPHS OF STATIC WATER LEVEL



FIGURES 7 & 8

HYDROGRAPHS OF STATIC WATER LEVEL

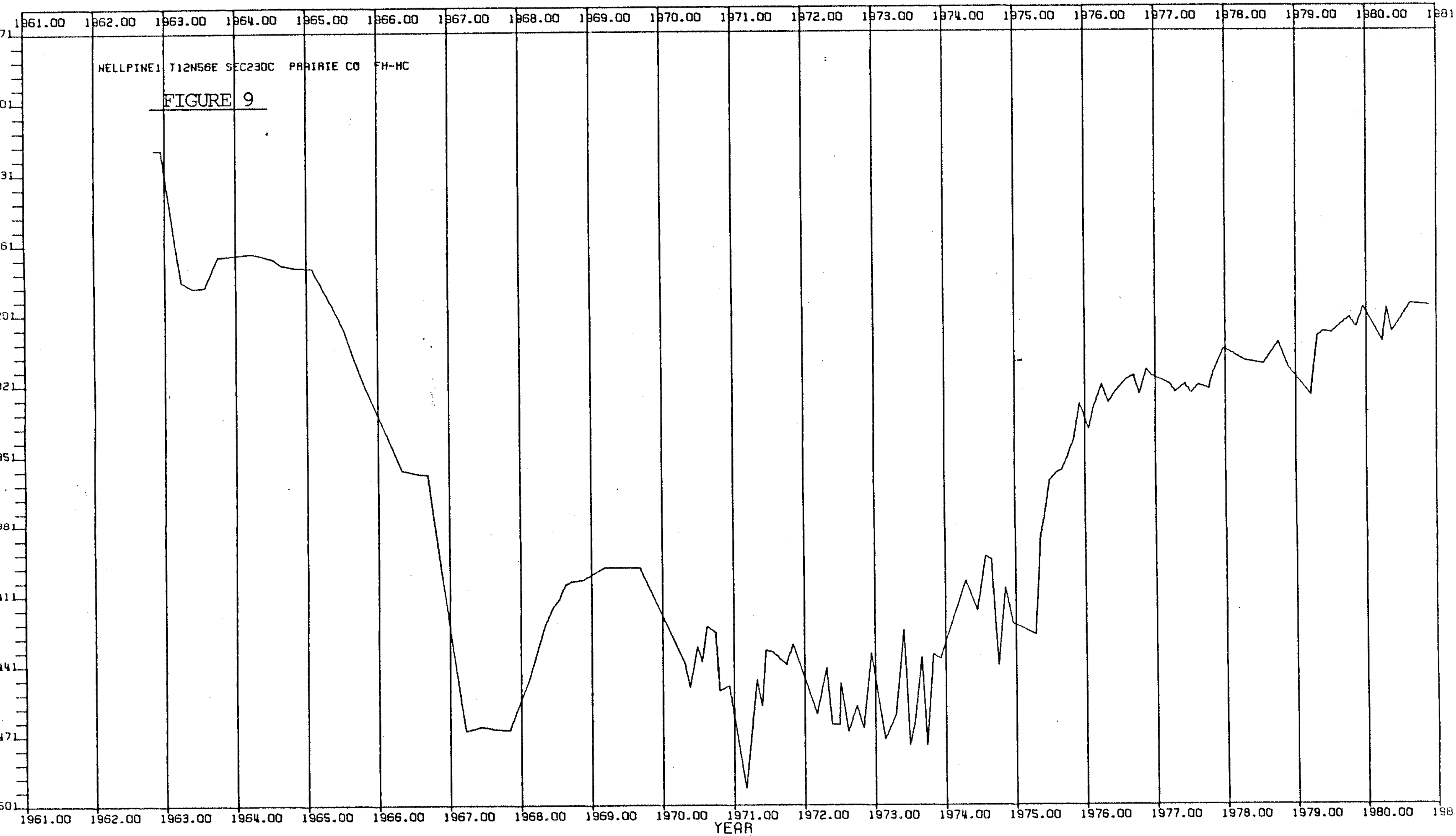


FIGURE 9

HYDROGRAPH OF STATIC WATER LEVEL

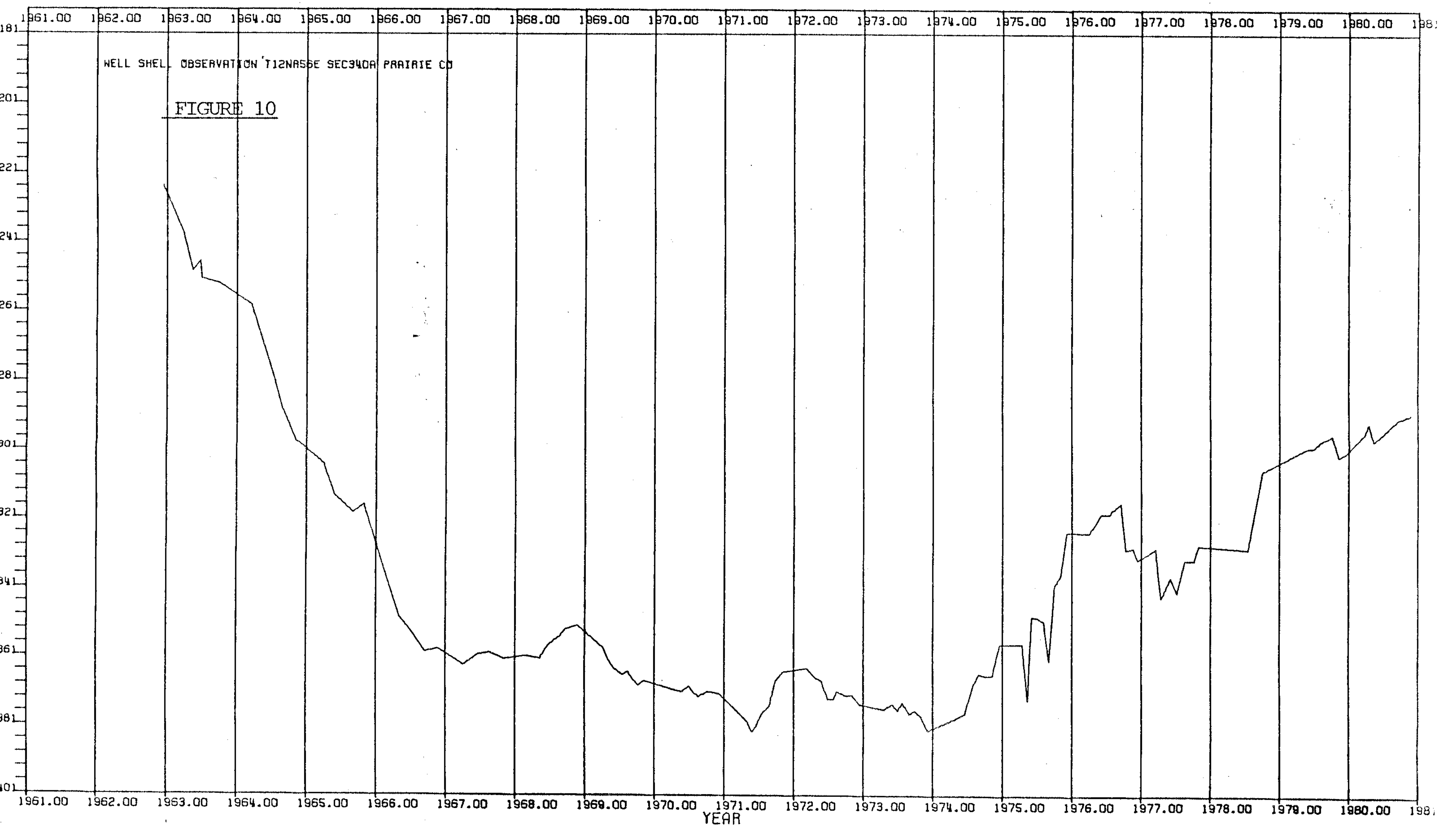


FIGURE 10

Table 1. Wells Completed in the Fox Hills-Hell Creek Aquifer within the South Pine Controlled Ground-Water Area.

	ove (+) or below land surface datum				Water level change (2) in feet					
e	1962-64	1969	1975	1980	1962-64 to 1969	1969-75	1962-75	1962-80	1975-80	Date of 1980 Measurement
	77.38	77.12	81.04	77.85	+.3	-3.66	-3.92	-.47	+3.19	9-17-80
d	142.39	136.17	129.59	132.55	+6.22	+6.58	+12.80	+9.84	-2.96	9-17-80
der	--	--	--	+34.71	--	--	--	--	--	8-18-80
tner	flows 1 gal/min	4.3	6.51	flows 1 gal/min	>-4.3	-2.2	>-6.5	0	+6.5	8-18-80
	96.27	86.59	72.11	65.43	+9.68	+14.48	+24.16	+30.84	+6.68	8-18-80
	52.3	79.95	92.05	77.12	-27.65	-12.10	-39.75	-24.82	+14.93	9-17-80
r	66.59	83.33	89.41	70.81	-16.74	-6.08	>-17.6	-4.22	+18.6	9-17-80
obel	--	+23.7	+6.2	flows 1 gal/min	--	-17.5	>-17.6	--	--	8-18-80
el	+7.0	24.68	41.02	43.59	-31.7	-16.34	-48.02	-50.59	-2.57	8-18-80
	--	+26.8	+14.0	flows 1 gal/min	--	-12.8	> -8.7	--	--	8-18-80
el	+64.36	+48.3	+40.5	+37.0	-16.1	-7.8	> -8.7	-27.36	-3.5	9-17-80
ey	--	--	--	+32.34	--	--	--	--	--	8-18-80
ld	12.71	12.92	12.15	12.80	-.21	+.77	+.56	-.09	-.65	8-18-80
	265.80	399.16	353.01	287.53	-133.36	+46.15	-87.21	-21.73	+65.48	9-17-80
	187.4	--	--	258.35	--	--	--	-70.95	--	8-18-80
	253.29	367.51	361.97	291.57	-114.22	+5.54	-18.85	-38.28	+70.4	9-18-80
3	31.88	35.93	36.57	39.50	-4.05	-.64	-4.69	-7.62	-2.93	8-18-80
	+14.55	--	17.28	17.0	--	--	-31.83	-31.55	+2.8	12-31-80

deral system of land subdivision. The first number indicates the township; the second, the range; and the third, the section. he section number denotes the 160-acre tract; the second, the 40-acre tract. Sequential numbers are added where more than one ame tract.

evel decline; plus indicates water-level rise.