Spooner Aquifer Test

Thurston County

Results and Predictions

by Linton Wildrick

October 3, 1983

Open-File Technical Report 83-02

JOHN SPELLMAN
Governor

DONALD W. MOOS
Director

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
Mail Stop PV-11 • Olympia, Washington 98504 • (206) 459-6000

M E M O R A N D U M

October 3, 1983

To: Walt Bergstrom, District Supervisor
Southwest Regional Office

From: Linton Wildrick LW

Subject: Spooner Aquifer Test, Thurston Co. - Results and Predictions

At your request, we have investigated the hydrologic effects of the Spooner irrigation well (18N/1W - 31R3) on nearby domestic and municipal water supply wells. The investigation consisted of a series of pumping tests during which water levels were measured periodically to determine drawdown interference among the wells when one or all of the wells was pumped. The water level data were then analyzed to predict whether the drawdown interference caused by the Spooner well would adversely affect the operation of the nearby wells. The testing was begun on June 22, 1983 and was completed on June 27th.

Pumping Test No. 1

The first pumping test, conducted on June 22, 1983, consisted of pumping the Spooner well at approximately 156 gallons per minute (gpm) for 8.5 hours. Water levels were measured in the pumping well, in the Wilderness No. 4 well, 18N/1W-31R1, and in the Grace Community Covenant Church well (18N/1W-31R2). These observation wells are located 296 feet northwest and 296 feet northeast, respectively, from the Spooner well (Figure 1). Water levels in the observation wells were measured with an electric water-level sounder accurate to ±0.02 feet. Water levels in the pumping well were measured with an airline accurate to ±1 foot.

The Spooner well is 171 feet deep with ten feet of screen at the lower end of the ten-inch diameter casing. The Wilderness #4 well is 145 feet deep with five-feet of screen at the lower end of the six-inch diameter casing. The top of the pump bowls is at a depth of 141 feet. The Grace Church well is approximately 98 feet deep and has a six-inch diameter casing. There is no record of the construction details for this well.

Drawdown measured during the test in each of the wells is shown in figures 2, 3, and 4. In the pumping (Spooner) well, drawdown amounted to approximately 111 feet (pumping water level 142 feet below land surface) after 8.5 hours of pumping at an average rate of 156 gpm. The water level apparently stabilized after five hours of pumping. However, due to the poor accuracy of the airline measurements, small changes amounting to several tenths of a foot may have occurred which could not be measured.

Drawdown in the Grace Church observation well amounted to 3.8 feet (32.3 feet below ground surface) after six hours of pumping (Figure 3). Measurements could not be obtained during the final two and one-half hours of the test because the well was returned to service and pumped periodically. The

drawdown data plotted in Figure 3 demonstrates that the water level had not yet stabilized after six hours of testing. On the basis of subsequent testing, however, it is believed that the interference drawdown probably stabilized at 4.5 to 5 feet (below static water level) by the end of the eight and one-half hour test.

Drawdown in the Wilderness No. 4 well amounted to 12.4 feet (pumping water level 46.4 feet below land surface) after eight and one-half hours of pumping (Figure 4). Extrapolation from the drawdown data plotted in Figure 4 suggests that additional drawdown would have amounted to approximately one foot if pumping of the Spooner well had been continued indefinitely.

The relatively poor performance of the Spooner well reflected in a specific capacity of only 1.35 gpm per foot of drawdown (150 gpm final pumping rate with 111 feet of drawdown) together with the relatively large amount of interference drawdown in the Wilderness No. 4 well (12.4 feet) suggested a need for further testing to measure the pumping performance of the Wilderness No. 4 well. Wilderness No. 4 well might also have a large drawdown when pumping at normal rates, which, when combined with the interference drawdown caused by the Spooner well, could result in a water level that was dangerously close to the top of the pump bowls (water intake) at a depth of 141 feet. Figure 5 shows the construction details of the Wilderness No. 4 well.

Pumping Test No. 2

On June 23, 1983, Wilderness No. 4 well was pumped at an estimated rate of 125 gpm for four hours. Periodic water level measurements were taken. These data are plotted in Figure 6. Static water level was 34.3 feet below ground surface prior to pumping. During four hours of pumping, the water level declined 92.1 feet to a depth of 126.4 feet below ground surface. Specific capacity was 1.36 gpm per foot of drawdown, essentially the same as for the Spooner well. The data in Figure 6 indicates that the water level was tending to stabilize at the end of four hours. Theoretically, then, the Wilderness No. 4 pumping level of 126.4 feet plus the interference drawdown of 12.4 feet due to the Spooner well would result in a water level of at least 139 feet below ground surface in Wilderness No. 4 when both wells have been pumped for a few hours. This pumping level would leave only two feet of water above the pump bowls.

Interpretation of the water-level drawdown data from the pumping tests No. 1 and 2 indicate that a nearby recharge-type hydrologic boundary or overlying leaky aquifer replenishes some of the water removed from aquifer storage by pumping. The hydrologic system thus reaches a near steady-state condition wherein drawdown would not increase much beyond that measured during the tests even if pumping of all wells continued for many days.

Hydrographs for a well and lake within two miles of the site (Water Supply Bulletin No. 10 by Wallace and Noble) indicate that a seasonal decline in water levels of five feet or more often occurs between June (the month of this testing) and October. This seasonal water level decline could cause

the pumping level to fall below the top of the pump bowls (both wells pumping). The findings above lead to a third pumping test to determine if the combined drawdown and intereference would reach 139 feet below ground surface as predicted.

Pumping Test No. 3

Following the June 23, 1983 test of Wilderness No. 4, the well was returned to normal service. On the following Monday, June 26, the Spooner well also resumed pumping to irrigate the adjacent field. The water level in the Wilderness No. 4 well was measured at 132 feet below land surface approximately eight to ten hours after the Spooner well began pumping. This is seven feet higher than predicted above. It is assumed that the Wilderness No. 4 well pump was on for most of this interval based on estimates of the water demand.

However, if the Wilderness well had not been on continuously, this might account for a larger portion of the seven foot discrepancy between measured and predicted levels. In any case, the combined drawdowns are at least partly additive.

Conclusions

Pumping the Spooner well at approximately 150 gpm causes significant interference drawdown (12 to 13 feet) in the nearby Wilderness No. 4 municipal supply well. Interference drawdown in the shallower Grace Church well is much less (3 to 5 feet) and poses no problem because this well is not pumped at a high rate (probably less than 20 gpm).

When both the Spooner and Wilderness No. 4 wells are pumping (150 and 125 gpm, respectively) the water level in the Wilderness No. 4 well declines to at least 132 feet below land surface. Under this abstraction condition only nine feet of water remain above the top of the pump bowls in the latter well. A seasonal water table decline of five feet or more in late summer combined with continuous pumping by both wells due to heavy water demand for irrigation could conceivably cause the water to drop another nine feet to the pump bowls.

Recommendations

It is recommended that additional water level measurements be made in September to assess whether seasonal declines have affected pumping water levels. Although one can calculate a transmissivity and storage coefficient from the test data, these aquifer parameters are of little value in predicting future water levels because of the unresolved recharge boundary or leaky aquifer effects. Further testing would be necessary before predictions could be made with any certainty.

D2/A18

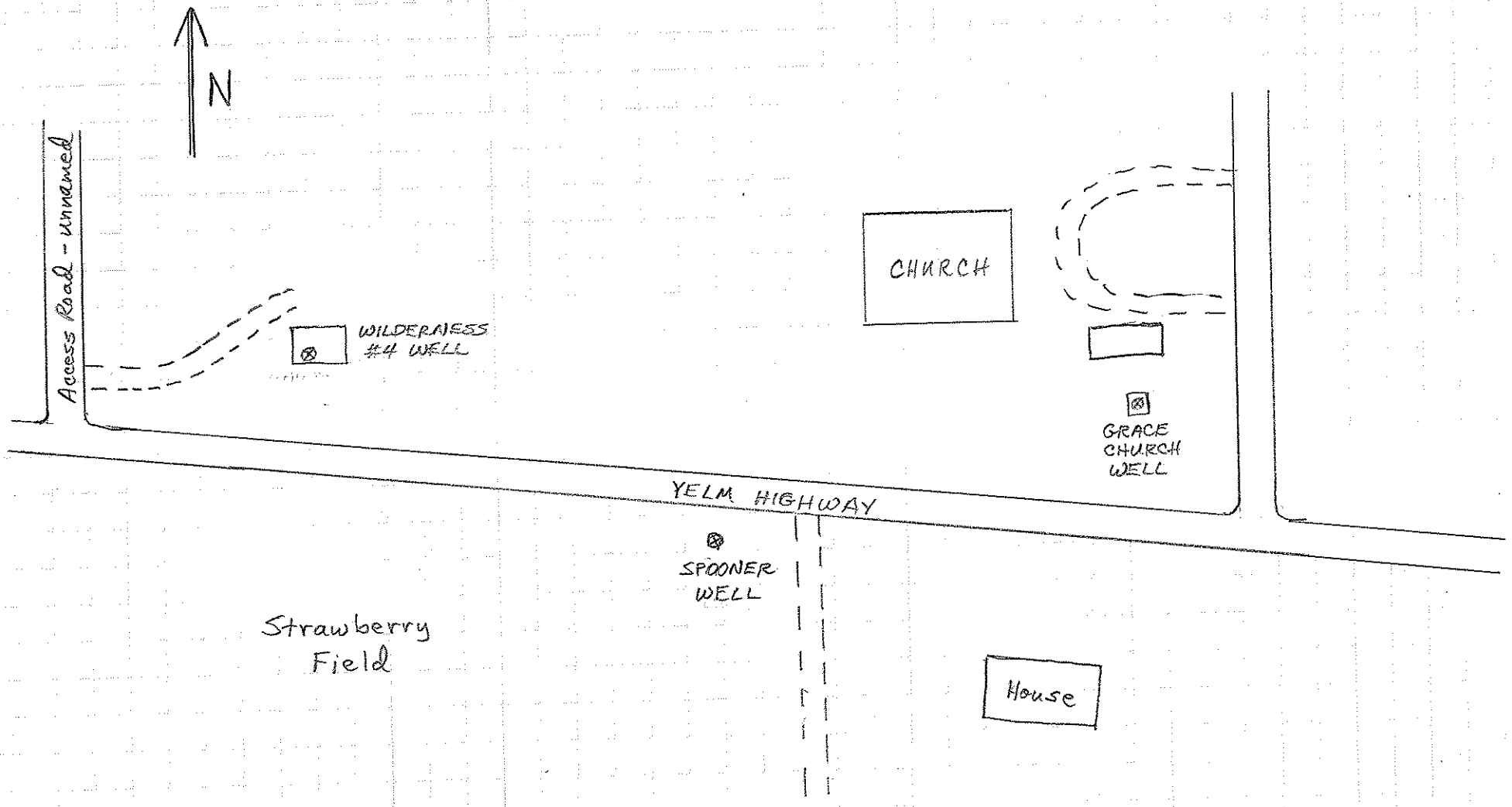

N
Access Road - unnamed
WILDERNESS #4 WELL
CHURCH
GRACE CHURCH WELL
YELM HIGHWAY
SPOONER WELL
Strawberry Field
House
SCALE
100 FEET

FIGURE 1

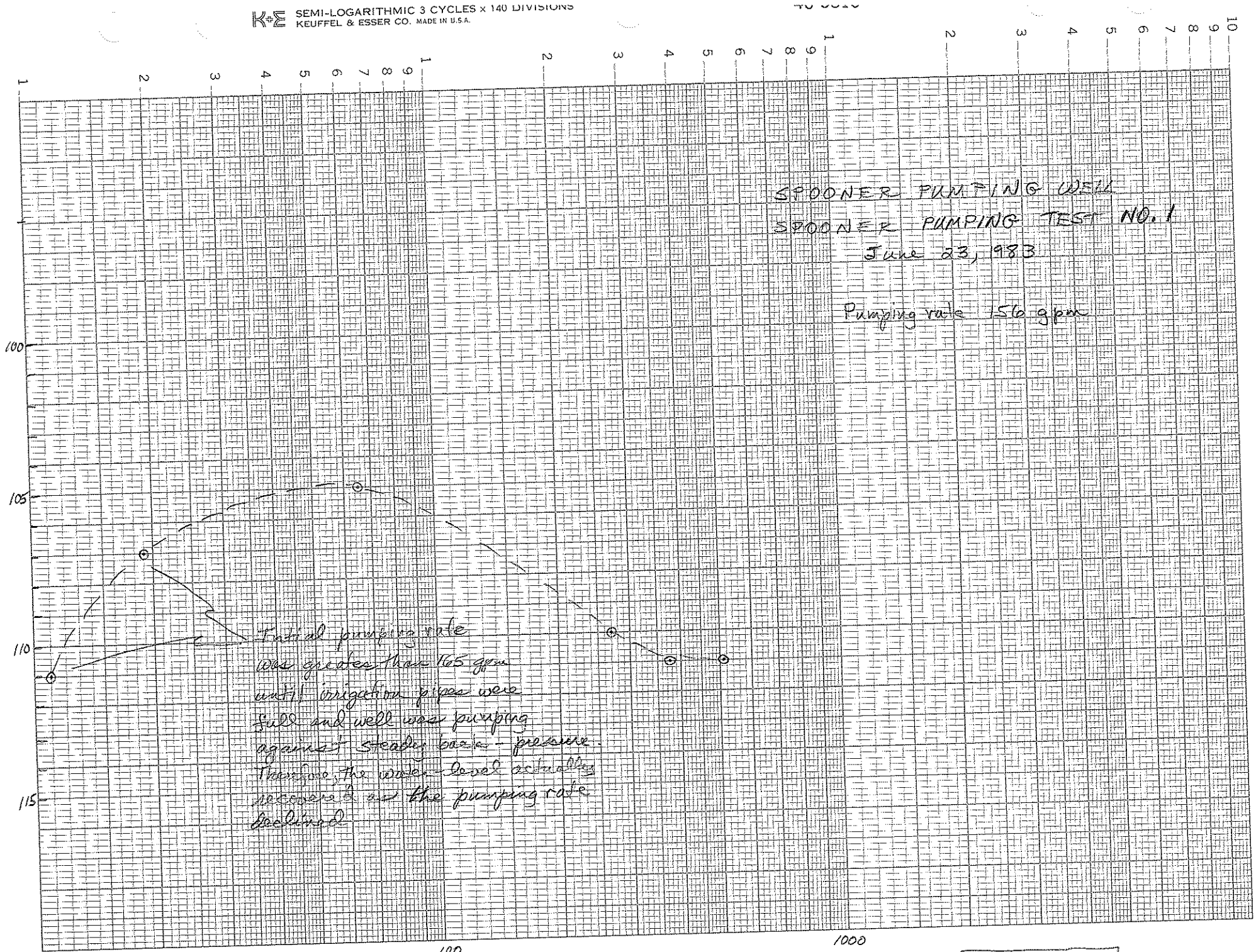

K+E SEMI-LOGARITHMIC 3 CYCLES x 140 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
SPOONER PUMPING WELL
SPOONER PUMPING TEST NO. 1
June 23, 1983
Pumping rate 156 gpm
Initial pumping rate was greater than 165 gpm until irrigation pipes were full and well was pumping against steady back-pressure. Therefore the water-level actually recovered as the pumping rate declined
100
105
110
115
10
100
1000
TIME AFTER START OF PUMPING (MINUTES)

FIGURE 2

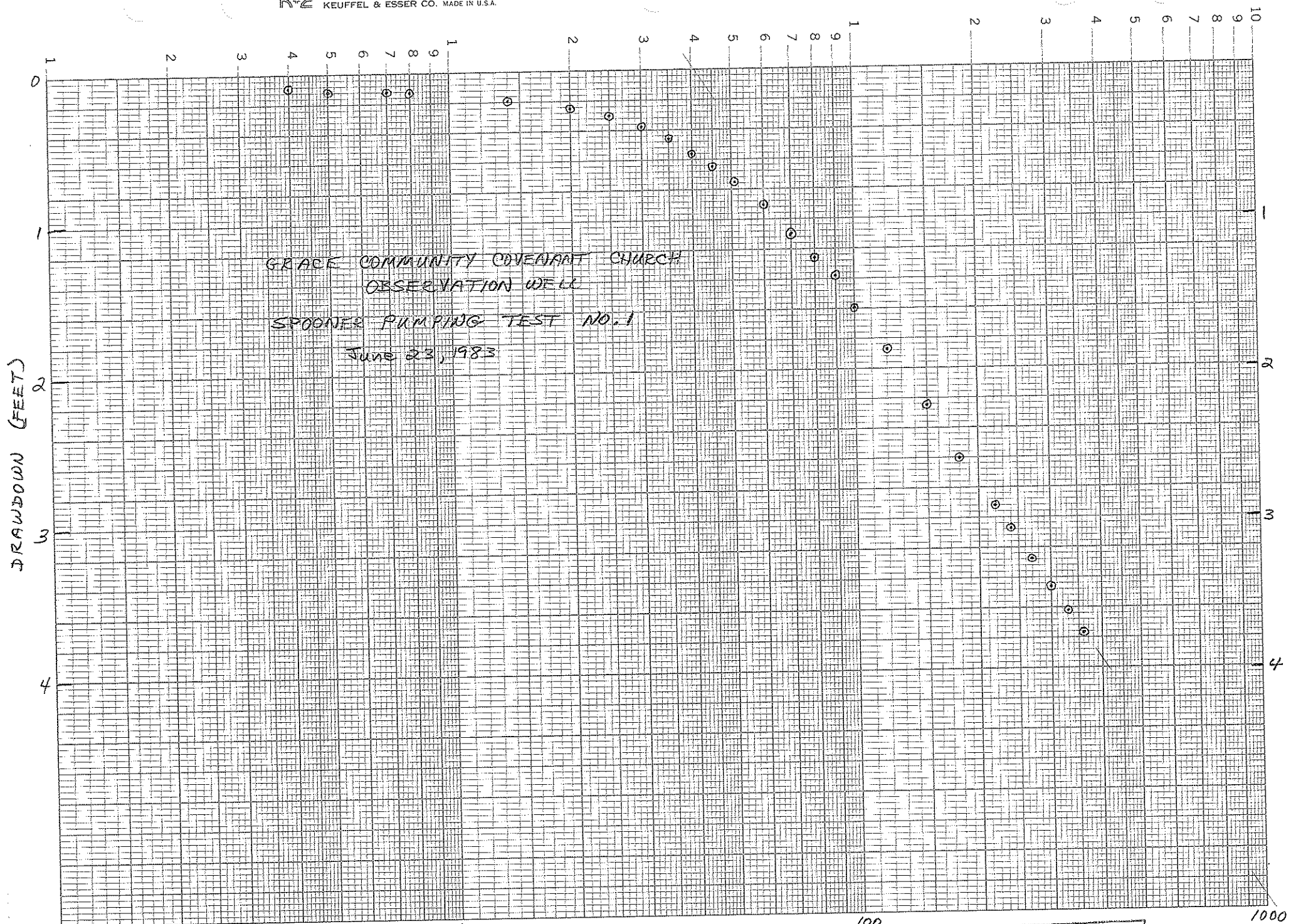


FIGURE 3

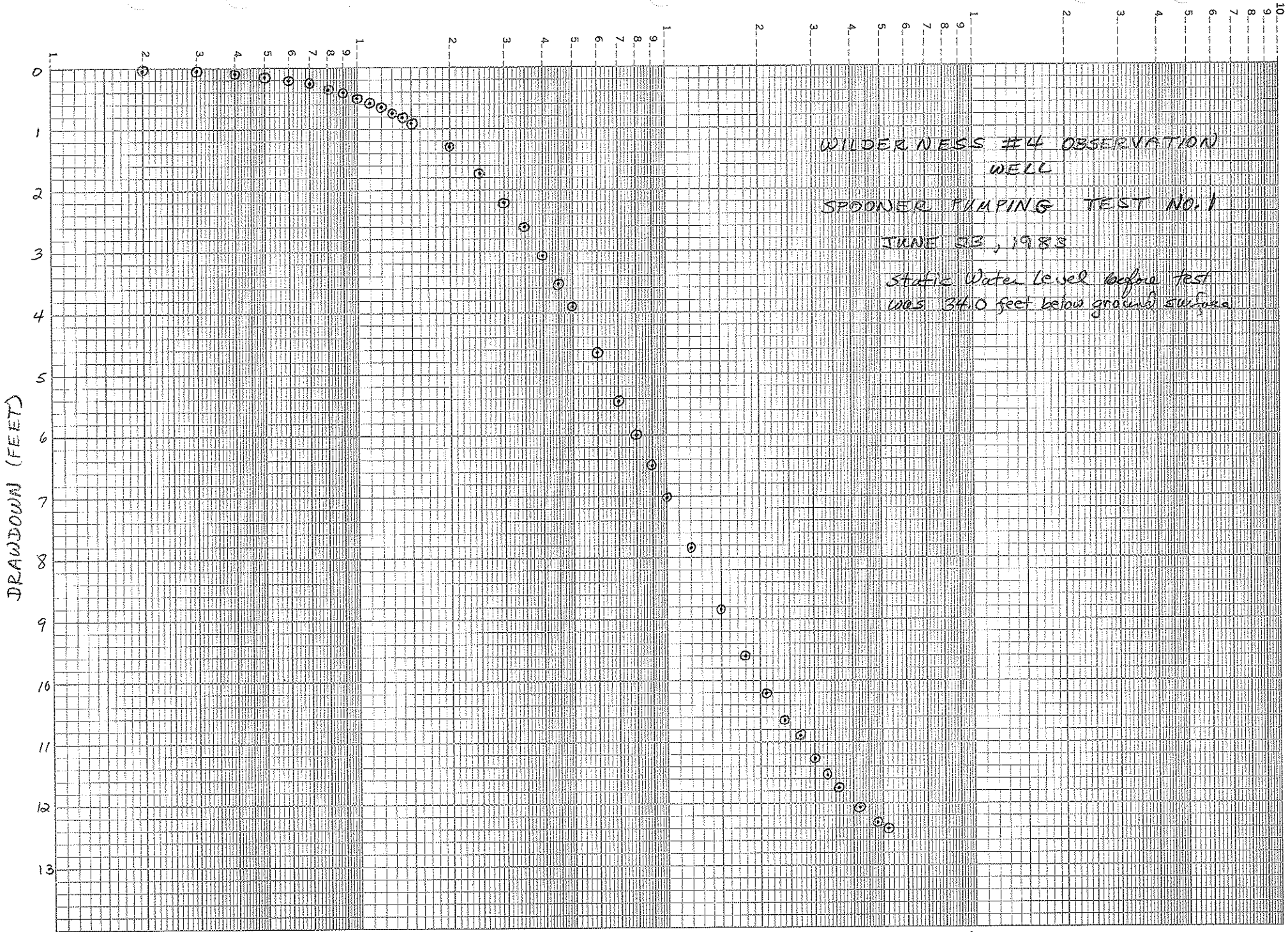
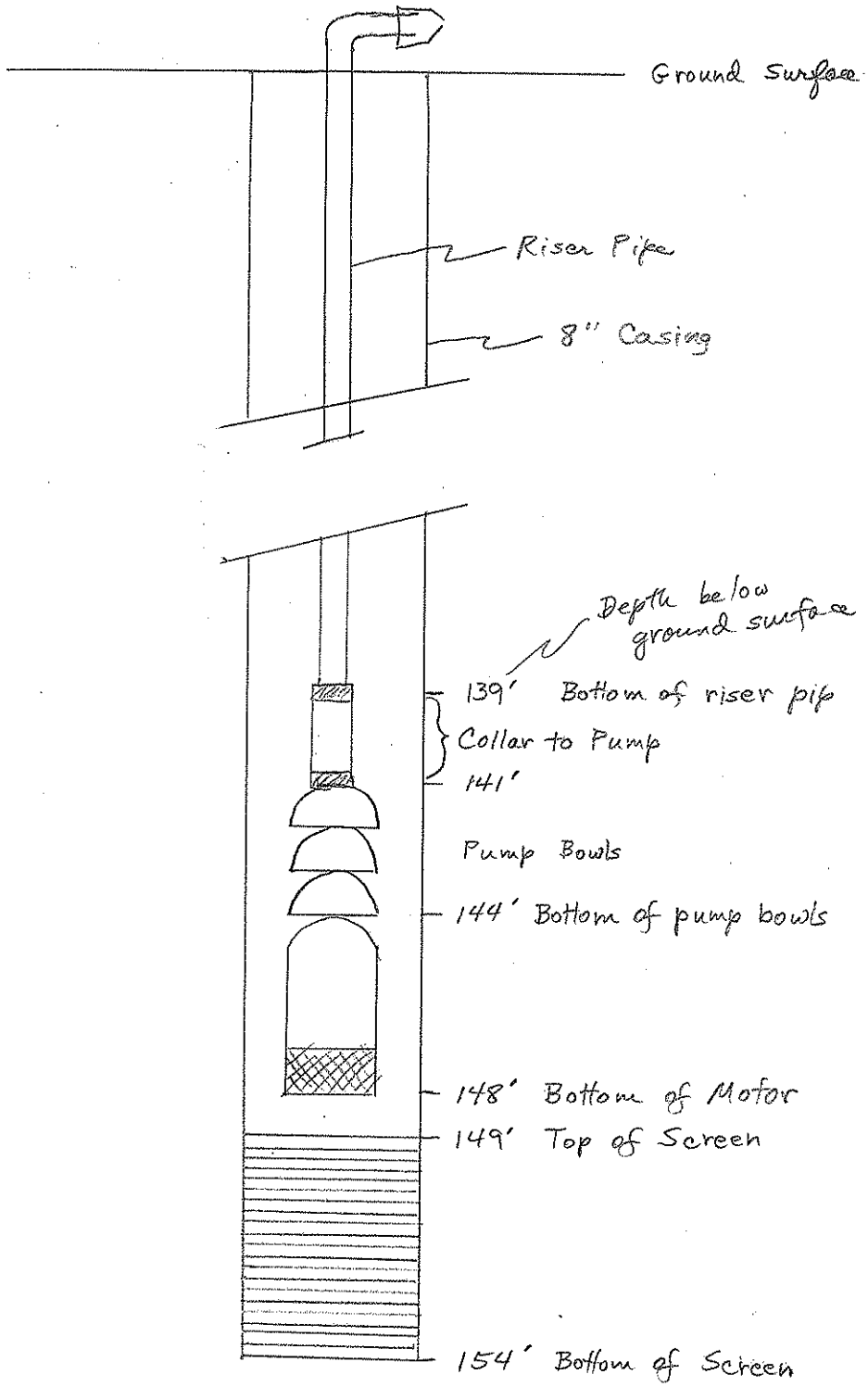


FIGURE 4



CONSTRUCTION DETAIL
WILDERNESS #4 WELL
18N/1W-31R1

FIGURE 5

K+E SEMI-LOGARITHMIC 3 CYCLES x 140 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

46 5810

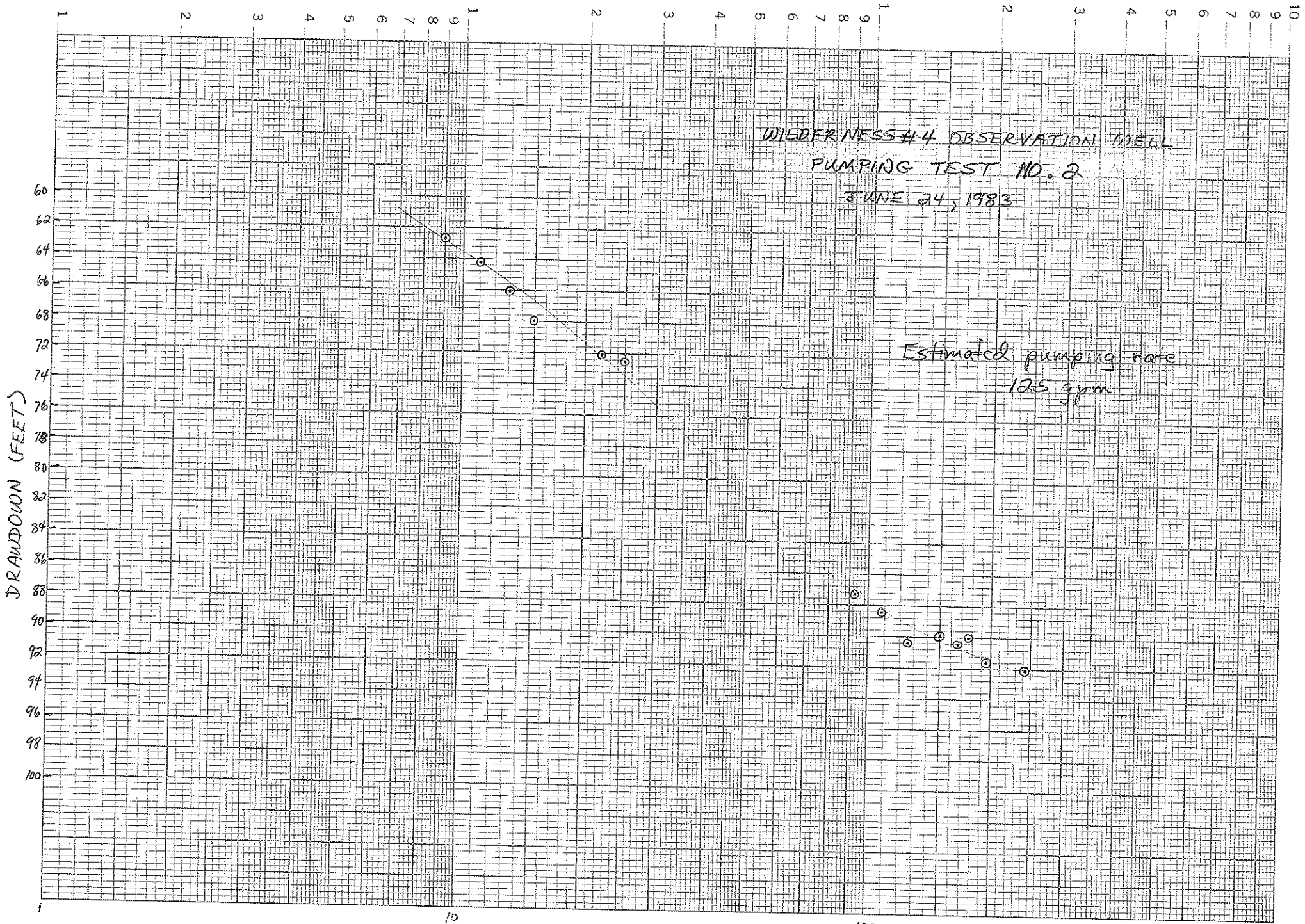


FIGURE 6

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M E M O R A N D U M

July 10, 1984

TO: Spooner Aquifer Test File

FROM: Linton Wildrick

Mathematical analysis of the Spooner Aquifer Test data was attempted for all major theoretical aquifer types: confined (Theis), leaky confined (Hantush), anisotropic unconfined (Boulton), delayed gravity response (Neuman) and hydrologic boundaries (Lohman).

The Theis curve will fit only the middle portions of the time draw down plots for the two observation wells. Using selected sets of data points, the "TFIT" program by McElwee for the HP-41CV handheld calculator was run; results were:

Wilderness Well #4, using data for 20 minutes to 210 minutes, yields T=430ft^{2}1d, S=2.7x10 feet, RMS error =0.12 feet

Grace Church Well, using data for 25 minutes to 360 minutes, yields T=1140 ft^{2}1d, S=1.3 x 10^3, RMS error =0.04 feet

An attempt was then made to fit the data to Hantush's leaky confined

aquifer curves (Plate 4, Lohman). The data for the Wilderness well obviously deviated from the leaky curve after 200 minutes. The Grace Church data from 30 minutes (and thereafter) fit the B = 2 or 3 curve quite nicely but early data did not fit.

Although driller's logs for the two wells indicated that clay was present and, therefore, that a leaky confined aquifer configuration was possible, the response in the Grace Church well indicates that an anisotropic, semi-confined aquifer response is the most realistic interpretation of the drawdown data. Hydrologic boundaries cannot be ruled out since the Wilderness well drawdown data at pumping times greater that 200 minutes departs from the Theis curve as though a "recharge" boundary (the river 1½ miles away?) had been encountered. However, at this relatively low pumping rate and considering the great distance to the river this recharge is ~~the~~ boundary somewhat hard to explain, if it is actually present. The nearby lakes are closed basin, water-table lakes and should not act as a hydrologic boundary at this distance.

Using program "DDT" with Q=156 gpm, r=296 feet, T=220ft²1d, S=0.15 drawdown is calculated at:

7 days = 0.44 feet

30 days = 6.11 feet

60 days = 11.38

This is projected drawdown for a high specific yield (strong coeff. in the water table aquifer.)

The drawdown in the Wilderness well was stabilizing at about 13 feet after 8 hours. If this is a true unconfined "delayed gravity response" the drawdown would probably start to increase after some time but would probably be less than 20 feet even after several weeks of pumping. Considering the proposed use of the well at a maximum of 12 hours a day and a 4 month pumping season, the drawdown would probably never increase much beyond what we measured during the test, i.e. 13 feet. as a third test we allowed Spooner to irrigate again on Monday June 20th. At this time the Wilderness well was also pumping most of the time, that is, at its normal pumping rate. The combined drawdown as measured in the Wilderness well was not as much as expected:

WL due to Spooner pumping = $12\frac{1}{2}$ feet drawdown

+

WL due to Wilderness pumping = 92 feet drawdown

$104\frac{1}{2}$ drawdown expected when both pumping

Actual drawdown when both pumping = 97 feet measured at 6 p.m., June 20 after Spooner had pumped 8-12 hours (not sure).

One explanation for the above is increased vertical leakage from semi-confirming beds and the overlying thin watertable. This is a source of recharge somewhat similar to a recharge boundary in that drawdown is limited by the steady leakage from above.

Judging from the driller's lithologic logs for the Spooner and Wilderness

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#4 wells, both wells produce water from essentially the same aquifer. The Spooner well fully penetrates the aquifer and terminates in clay whereas the Wilderness #4 well only partially penetrates the aquifer.

Although no strastigraphic log is available for the Grace Church well one would except the strata to be similar to that reported on the logs for the upper hundred feet in the Spooner and Wilderness #4 wells, given the proximity of the three wells. The stratigraphic logs indicate that clay-bound gravel or hardpan occurs in the interval below the bottom of the Grace Church well but above the screened intervals in the Spooner and Wilderness #4 wells. The static water levels in all 3 wells are at approximately the same elevation. the similar water levels indicate that all three wells are in the same "aquifer system", although there are two producing zones as indicated in the lithologic logs. The zone above the fine-grained strata serves the Grace Church well and the zone below serves the Spooner and Wilderness #4 wells. The fine sands and silts are saturated throughout but are significantly less per measle than the strata in the producing zones.

From the above one would anticipate less drawdown in the Grace Church well than in the Wilderness #4 well for a given rate of pumping from the Spooner well, even though the two observations wells are equally distant (296 feet) from the pumping well. Results of the June 22 test confirmed this: After six hours of pumping, drawdown in the Grace Church well was 3.8 feet compared to 11.7 feet of drawdown in the Grace Church well, initial drawdown in the well began within four minutes after the Spooner

well began pumping. This rapid reaction precludes the existence of a true confining layer between the two producing zones. Rather the drawdown reponse is that of a "semi-confined" aquifer.