STATE OF CALIFORNIA—RESOURCES AGENCY GEORGE DEUKMEJIAN, *Governor*

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August 5, 1987

Mr. Bill Van Orden
Executive Coordinator
City of Willits
111 East Commercial
Willits, CA 95490

Dear Mr. Van Orden:

This report presents the findings of a one-year cooperative City of Willits-Department of Water Resources ground water study. It discusses Little Lake Valley geology, ground water, and ground water quality conditions. A separate Morris Reservoir limnology and water quality report will be completed in December 1987.

The study concluded that sufficient ground water is available in Little Lake Valley to help meet the City of Willits' water demands well into the Twenty-First Century. It also found that blending the Park well with Morris Reservoir waters would yield sufficient water of acceptable quality to meet the present City of Willits' municipal demands. The mixing of Morris Reservoir and the Park well water would help solve Morris Reservoir's turbidity and other quality problems and the Park well ground mineral quality problems.

The report recommends that the City of Willits should: conduct a profile on the Park well to determine the poor ground water quality source, continue to monitor ground water levels and quality, and study the feasibility of establishing a well field in Little Lake Valley.

Sincerely,

Wayne S. Gentry

Wayne S. Gentry, Chief
Northern District

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I. INTRODUCTION

Morris Reservoir is the main source of domestic water for the City of Willits. Ranches and residences outside the city obtain water from individual wells and springs. Historically, the city has experienced water shortages during dry years. It is not known whether sufficient ground water resources are available to supplement or replace existing municipal supplies. Therefore, the City of Willits requested information on the availability, occurrence, quantity and quality of ground water. This investigation was undertaken to enable the city to decide on how to meet present and future water needs.

The Department of Water Resources (DWR), in cooperation with the City of Willits, completed this one-year ground water hydrology study in Little Lake Valley, Mendocino County. DWR and the City of Willits jointly funded this study.

Area of Investigation

Little Lake Valley is in the central part of Mendocino County, California. The valley has an area of approximately 12.5 square miles and an average elevation of 1,350 feet. The surrounding low hills encompass an additional 5 square miles. Several small streams, including Baechtel, Broaddus, Berry, Davis, Haehl, and Willits Creeks, flow through the valley and drain into a marshy area near the north end of the valley. Outlet Creek, a tributary of the Eel River, drains the marshy area.

Water Demands and Supply

Kennedy/Jenks Engineers (1985) projected the City of Willits' average annual water demand to be 1,344 acre-feet (AF) in 1985 and 2,930 AF by 2015. Detailed water supply and demand data are included in their 1985 report.

Presently, all the municipal supply, except park irrigation, is from Morris Reservoir. Morris Dam is 51.2 feet high and has an available storage capacity of about 725 AF when 2.5-foot flashboards are installed. Morris Reservoir has a 90-percent safe yield of 1,000 AF or 0.9 million gallons/day (mgd) (Kennedy/Jenks Engineers, 1985).

There is an estimated 60,000 AF of ground water available in Little Lake Valley. Farrar (1986) estimated total ground water pumpage at about 2,000 AF/year.

The Morris Reservoir yield is fixed and can be increased only by raising the dam. There appears to be ample ground water available to help meet Willits future water demands. Coordinated use of Morris Reservoir and Little Lake Valley ground water could solve Willits' water quality and quantity demands well into the twenty-first century.

Methods of Investigation

An extensive geologic and hydrologic literature search was conducted. Subsurface geology data were obtained from previous studies and well logs. Two studies relating to the hydrogeology of Little Lake Valley were conducted by the U. S. Geological Survey (USGS) in 1965 and 1986. Cardwell (USGS, 1965) described the occurrence, availability, and quality of ground water in seven valley areas in Sonoma and Mendocino Counties. Farrar (USGS, 1986) described the ground water resources in Mendocino County. Some background information in this report is taken from these two studies.

DWR and the City of Willits jointly conducted a survey of water-well owners in the study area. Wells were field located wherever possible and observation wells near the City Park well were then selected. On August 20, 1986, the City Park well was pumped for 4.5 hours to see which wells were affected by the pumpage and what range of drawdowns would be encountered. Both agencies measured water levels in selected wells. During the investigation, three separate aquifer performance tests were conducted: one on September 3-4, 1986, the second on January 26-February 2, 1987, and the third on March 24-April 3, 1987. Each test consisted of pumping the City Park well (18N/13W-18K2) and carefully measuring the drawdown in the pumped well and in observation wells. One shallow observation well (18N/13W-18K1) was equipped with a Stevens Type F continuous water-level recorder during the March-April test. Test data were used to determine ground water basin properties, such as aquifer transmissivity and storage coefficients and well interference at various spacings and pumpage rates, other than those employed during the test itself.

Water quality samples for mineral and metal analysis were collected at the beginning and near the end of the test. Temperature, pH, and electrical conductivity (EC) were monitored for changes throughout the test.

II. SUMMARY AND CONCLUSIONS

The Department of Water Resources and the City of Willits agreed in 1986 to conduct a cooperative ground water study of the ground water resource and a limnology study of Morris Reservoir. We agreed to complete the ground water study in June 1987 and the Morris Reservoir study in December 1987. This report discusses the ground water study and a separate DWR December 1987 report will cover the limnology study.

The Little Lake Valley ground water basin includes most of the Holocene alluvium with at least 60,000 AF available ground water in storage in the Holocene alluvium. The alluvium consists generally of lenticular beds of unconsolidated gravel, sand, silt, and clay. The aquifers appear to be both free and confined. Semiconsolidated Quaternary continental basin deposits and consolidated Jurassic through Tertiary basement rocks underlie the alluvium. The older rocks contain limited quantities of recoverable ground water and, therefore, are not considered a major source of ground water.

Three separate aquifer tests were conducted on the Park well to determine its yield, influence on adjacent wells, and the quality of water pumped. These tests show that the park well can be pumped continuously 365 days/year at 390 gallons/minute (gpm) with a 53-foot drawdown. Assuming no recharge during a 6-month dry period, the maximum drawdown 2 miles north of the Park well would be about 5 feet.

The chemical quality of the Little Lake Valley ground water in the Holocene alluvium is generally acceptable for domestic, industrial, and agricultural uses. It is a calcium-magnesium-bicarbonate water with chloride and sodium as minor constituents. The dissolved solids range from less than 100 to about 350 milligrams/liter (mg/L). Iron and magnesium concentrations generally exceed EPA secondary drinking standards. Water pumped from the Park well is generally similar except for arsenic levels above EPA standards.

The Park well can be used to supplement the existing supply from Morris Reservoir if it can be treated to reduce the arsenic, iron, and manganese to acceptable levels. Mixing the Park well and Morris Reservoir waters should resolve the quality problems. This will be discussed in the forthcoming DWR December 1987 limnology report.

Additional high-capacity municipal wells could be constructed in Little Lake Valley to provide water as the demand arises. Individual well yields up to 1,000 gpm, capable of producing 1,110 AF/year, are possible.

The projected water demand for the City of Willits is about 3,000 AF/year in 2015. Morris Reservoir provides about 1,000 AF/year. Little Lake Valley ground water basin has about 60,000 AF of available ground water and is producing about 2,000 AF/year. With proper ground water development and treatment, the basin should be capable of producing the additional 2,000 AF/year necessary to meet the 2015 water demands.

III. RECOMMENDATIONS

- The City should run a vertical water quality profile of the Park well. This could define the poor water quality zone(s) so the City could determine the feasibility of sealing off the zone(s).

- The City should experiment with mixing (diluting) the Park well water with Morris Reservoir water. This could help improve the Morris Reservoir winter turbidity problems and the Park well's iron, manganese, and arsenic problems.

- Standard water quality monitoring should continue at the well in order to detect changes that may occur as the well is put into service.

- Water-level measurements should be made monthly at the Park well and four observation wells around it.

- The City should study the feasibility of establishing a well field in Little Lake Valley.

IV. GENERAL GEOLOGY AND HYDROGEOLOGY

Three geologic units occur in the vicinity of Little Lake Valley. They are from oldest to youngest: the Tertiary through Jurassic Franciscan Complex, Quaternary and Tertiary continental basin deposits, and Quaternary-Holocene alluvium. The surface geology of the valley is shown in Figure 1.

Franciscan Complex

The Franciscan Complex is a melange of highly sheared graywacke and mudstone enclosing blocks of graywacke, chert, greenstone, serpentinite, blueschist and limestone. These rocks are generally fine-grained or cemented. According to Cardwell (USGS, 1965), a few domestic wells around the margins of Little Lake Valley obtain water from Basement rocks. Well yields vary widely depending on local rock type and degree of fracturing. Many dry holes have been drilled in this unit. Farrar, however, notes that yields of up to 200 gpm have been reported (USGS, 1986).

Continental Basin Deposits

Continental basin deposits were deposited directly on basement rock during Late Pliocene to Pleistocene time. The deposits crop out over about 5 square miles along the east, south and the southwestern parts of the valley. The basin deposits extend across most of the valley in the subsurface. Thickness ranges from zero at the valley margin to several hundred feet in the central part and up to 1,500 feet thick in the southwestern part of the valley. These deposits consist of a heterogeneous mixture of compact to semi-consolidated, poorly sorted gravel, sand, silt, and clay. Sand and gravel beds are typically lenticular and interfinger with beds stratigraphically above and below. The beds in the southwestern part of the valley are composed mostly of clay, silt, shale, and mudstone.

LEGEND

EXPLANATION FOR FIGURE 1

Qal	**Holocene Alluvium** - Unconsolidated gravel, sand, silt, and clay; includes most productive water-bearing formations, high porosity, and permeability.
QTc	**Continental Basin Deposits** - Semi-consolidated to unconsolidated gravel, sand, silt, and clay, some mudstone and shale; poorly productive water-bearing formation; high porosity, but low permeability.
TKJf	**Franciscan Complex** - (Undifferentiated basement) highly sheared graywacke and mudstone enlcosing blocks of chert, graywacke, greenstone, serpentinite, blueschist, and limestone. Poorly productive water-bearing formation; low porosity and permeability except where rock type and fracturing are favorable.

Maacama Fault Zone - dashed where approximately, dotted where concealed, and queried where extent unknown.

Line of geologic section.

Well location and number.

Ground water basin boundary.

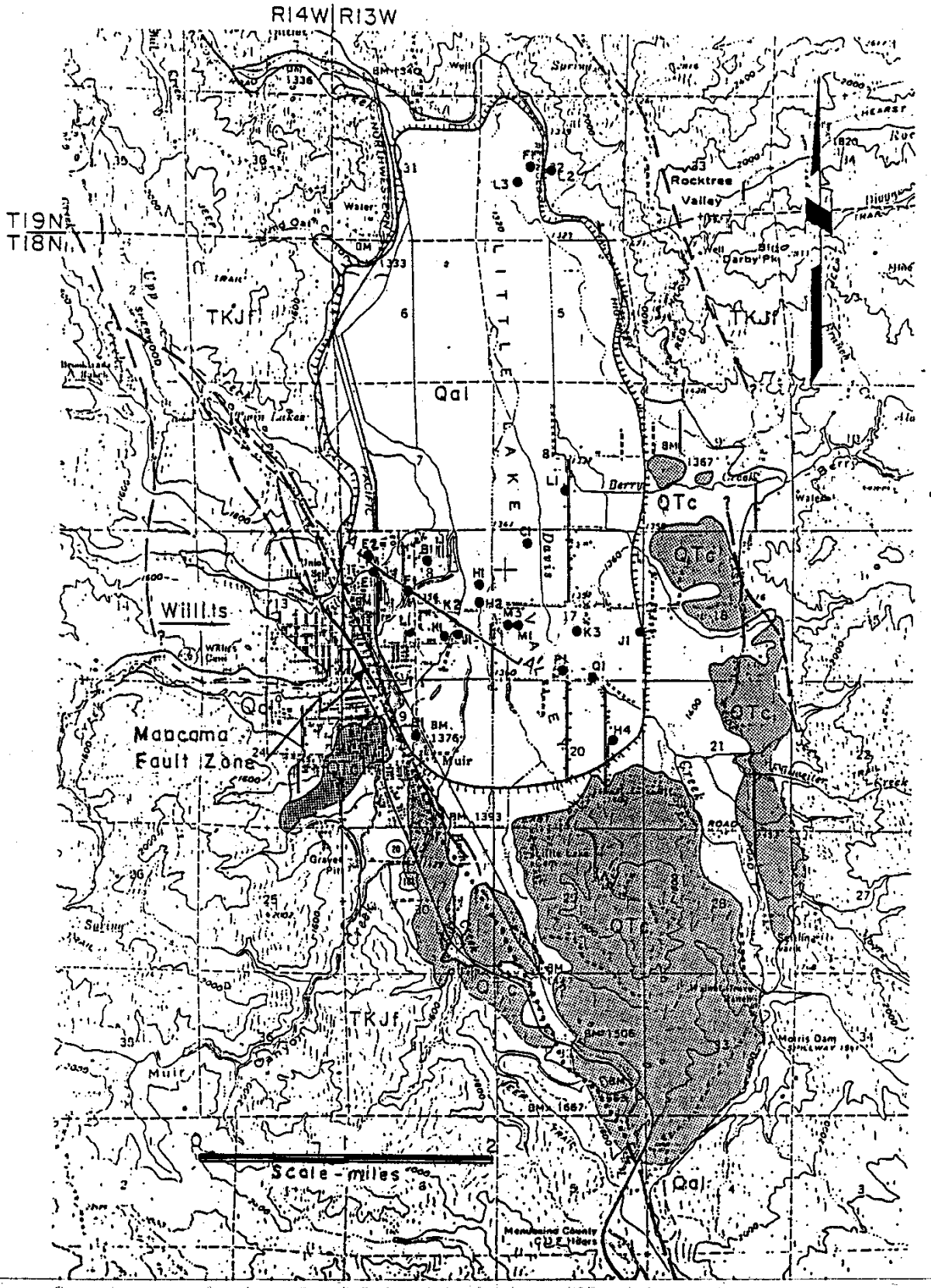

Figure 1. Geology of Little Lake Valley, well locations, and line of geologic section. Geology modified from CDMG (1982), Cardwell (1965), and Farrar (1986).

The widespread basin deposits have high porosity but low permeability, which limits well yields. Farrar inventoried 12 wells that obtain water solely from the basin deposits and found that specific capacities (yield to wells per foot of drawdown) range from less than 1 to 2.5 gpm/foot (ft). Specific capacities of seven wells range from 0.7 to 2.5 gpm/ft; five wells were less than 0.7 gpm/ft. A compilation of specific capacities from Farrar's (1986) study and from review of 19 additional drillers' well logs is shown in Table 1.

Table 1. Specific Capacity Compilation (gpm/ft)

	Number of Wells Tested					
Specific capacity from basin deposits (Farrar, 1986)	12	5 Wells <0.7	7 Wells 0.7-2.5	Range <0.7-2.5	Average 1.5	
Specific capacity from Holocene alluvium (Farrar, 1986)	19	9 Wells <0.1	1 Well >11	Range 0.3-83	Average 2.8	
Specific capacities from 19 additional wells in alluvium and basin deposits (DWR, this study)	19	17 Wells <2.5	2 Wells >9	Range 0.06-15	Average 1.7	Average 0.6

Holocene Alluvium

Holocene alluvium overlies continental basin deposits over most of the valley floor. The outcrop area is about 12 square miles. Thickness ranges from a few feet to 250 feet south and east of central Willits. Well logs indicate that the alluvium consists of gravel, sand silt, and clay. The coarse material was deposited in lenticular bodies on alluvial fans and stream channels and is locally very thick. The contact between alluvium and underlying continental basin deposits cannot be determined precisely because of the similarities in the drill-cutting descriptions.

The coarse-grained, unconsolidated alluvium is high in porosity and permeability. Around the margins of the valley where alluvium is thin, these deposits may be dry in late summer and early autumn (Farrar, 1986). Cardwell (1965) found that the alluvium yields several hundred gallons per minute to properly constructed wells throughout the valley except near the valley perimeter. Farrar found that specific capacities for 19 wells in Holocene alluvium ranged from 0.3 to 83 gpm/ft. The mean specific capacity, excluding the high value of 83 gpm/ft, is 2.8 gpm/ft.

Nineteen water well drillers' reports were reviewed for this study, in addition to those reviewed by Farrar (1986). These wells penetrate various depths and water-bearing strata and have an average well depth of 98 feet. The average specific capacity of these wells is 1.7 gpm/ft. If the two wells with specific capacities of 9 and 15 gpm/ft are excluded, the average specific capacity is 0.6 gpm/ft. This lowers the overall average for the 38 wells to 2.2 gpm/ft and is probably more representative of average specific capacities in the basin.

Geologic Structures and Faults

Major geologic structures in Mendocino County have a predominant northwest to north-northwest trend. The long axis of Little Lake Valley is aligned along this trend. The active Maacama Fault trends northwest through the central part of the county and bounds the southwestern edge of the valley (Figure 1). The Maacama Fault is a zone of parallel to subparallel en echelon breaks with right lateral displacement.

Little Lake Valley is a down-dropped fault block (graben) that was created by oblique extension and normal faulting along two parallel fault zones (McLaughlin and Nilson, 1982). Sedimentation began in-filling at the onset of basin formation and continued concurrent with further down dropping of the graben. As a result, in excess of 450 feet of valley fill has accumulated in Little Lake Valley.

Geologic faults and other subsurface barriers can impede the movement of ground water and act as impervious boundaries. The Maacama Fault zone is an impervious boundary along the southwestern margin of the valley, as identified from aquifer test analyses.

V. GROUND WATER HYDROLOGY

Geologic formations can be divided into water-yielding and nonwater-yielding. Water-yielding formations (or aquifers) readily absorb, transmit, and yield usable quantities of ground water to wells. Materials considered water-yielding are unconsolidated sand and gravel deposits of the Holocene alluvium. Clay and consolidated rocks are usually considered low to nonwater-yielding.

The Little Lake Valley ground water basin is filled with alluvium. These deposits contain both unconfined and confined ground water. The relatively shallow unconfined aquifer is recharged mostly from direct infiltration of precipitation and surface runoff. Water levels in shallow wells that tap this aquifer reflect the free water table. The deeper, confined aquifer is overlain by a relatively impervious layer. It cannot receive direct recharge from the surface; rather, recharge occurs upslope of the confining (impervious) layer. Water moves under hydraulic pressure in confined aquifers. Ground water will rise in a well to a level called the potentiometric level. Water levels in two nearby wells can vary greatly if the wells tap different aquifers.

Ground water occurrence, availability, movement, and fluctuations can be determined by analyzing well logs and water-level data. Ground water in the basin has been classified by Farrar (1986) into four type-areas (Figure 2):

Type I - This 7.5-square-mile area coincides with the valley floor and is underlain by thick valley fill including the thickest Holocene alluvium. Ground water is generally abundant, and production rates and supply are sufficient for agriculture, industrial, municipal, and domestic uses.

Type II - This 3-square-mile area forms a concentric band around the Type I area, but extends wider and further from the flat valley floor along creek channels that drain into the valley. Type II area is underlain by thin Holocene alluvium. Some ground water generally is available year-round for domestic use and may be adequate for irrigation or industrial use.

Type III - This area includes about 7 square miles around the southern margin and low hills of the valley. Type III area is underlain by continental basin deposits. Ground water is generally sufficient for domestic use, but production rates are low or seasonally limited.

Type IV - This area occupies the mountainous terrain surrounding the valley. Type IV area is underlain by the Franciscan Complex basement which is generally considered nonwater-producing. Ground water occurrence is restricted to local areas that are lithologically or structurally favorable. These areas may provide adequate supply for livestock or domestic use.

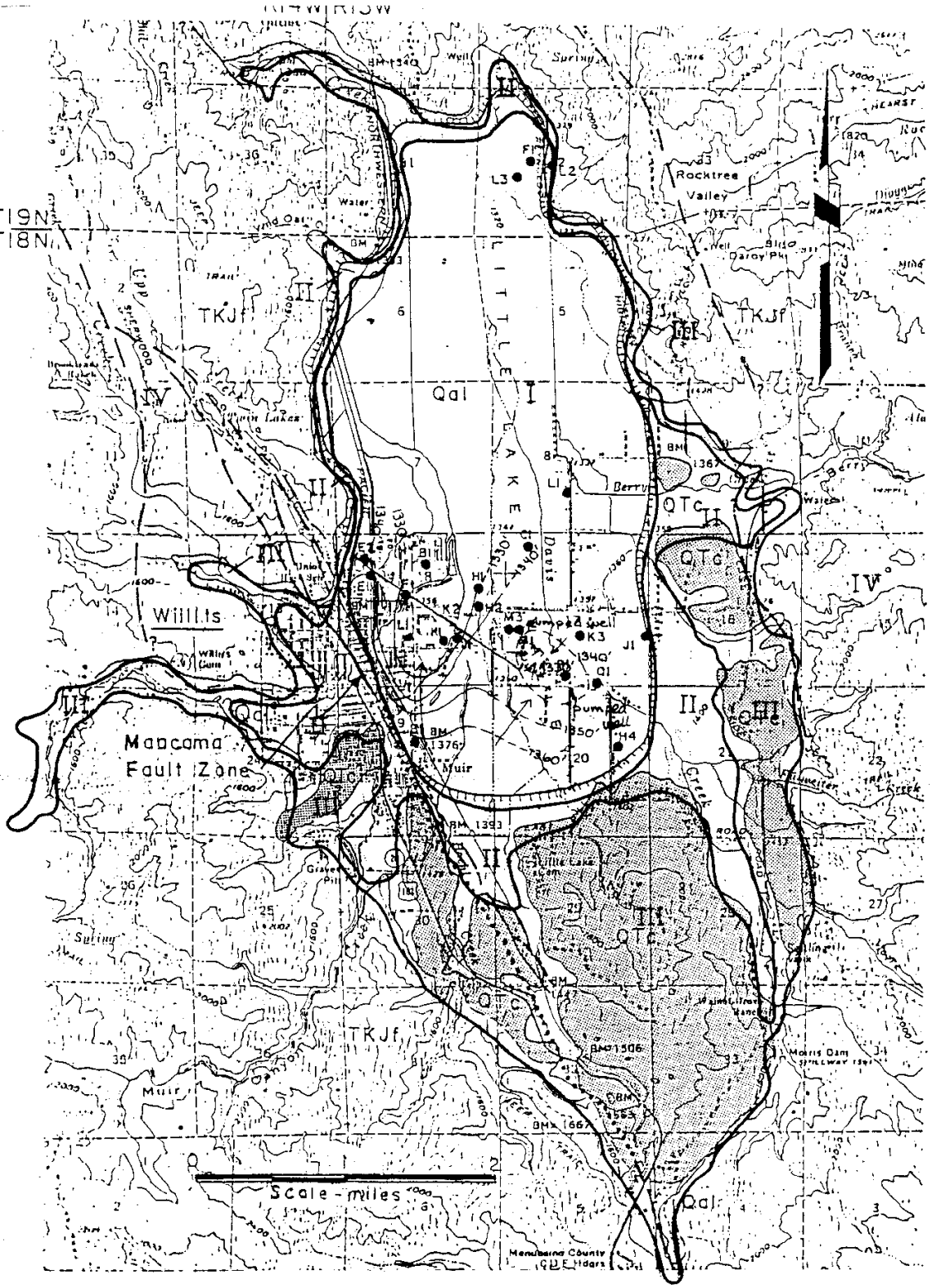

Figure 2. Availability of ground water (after Farrar, 1986); and spring 1987 ground water elevation contours. Arrows indicate direction of ground water movement. Note depression caused by pumped wells.

Most of the available ground water for municipal and industrial use is in the Holocene alluvium in Type I area. Types II, III, and IV areas are underlain by strata that have some available ground water in storage but have marginal capacities to yield water to wells. Therefore, the boundary of the ground water basin that the Park well draws from includes only the Type I area.

Recharge to Little Lake Valley includes precipitation, surface-water infiltration, and domestic and agriculturalreturn flows. Some recharge may occur from upward flow of ground water along faults or fracture zones. Surface water recharges the aquifers by infiltration along creek channels draining into the valley. Downward percolation of surface water from livestock or irrigation ponds may also recharge ground water. Return flows from sewage-disposal facilities, septic tanks, and excess irrigation water are minor sources of recharge.

Discharge of ground water from the valley includes well pumpage, vegetative evapotranspiration (ET), and discharge to streams. Ground water moves generally from the valley sides toward the center and from south to north (Figure 2). Water-level measurements were made in wells of differing depths that penetrate different aquifers. Water-level contours in Figure 2 show the approximate elevations of a composite ground water system representing both the unconfined and confined aquifers.

Ground Water in Storage

Most of the ground water in storage is in the valley fill of Type I area. To estimate the amount of storage in Type I material, an average specific yield1/ of 8 to 10 percent was used. The specific yield was estimated from the nature of the materials recorded in water well drillers' reports of wells tapping alluvium and from field observations of outcrops. Cardwell (1965) and Farrar (1986) have estimated ground water storage capacities, which are shown in Table 2.

Table 2. Estimated Storage Capacities of Upper 100 feet of Valley Fill

	Type I Area	Type II Area
Cardwell (1965)	50,000 AF	No estimate.
Farrar (1986)	35,000 AF	9,000 AF

1/ Specific yield is defined as the ratio of the volume of water that will drain by gravity from a saturated sample of material to the total volume of the sample, expressed as a percentage.

Water-Level Fluctuations

Ground water levels fluctuate annually in response to pumpage, evapotranspiration, springs, base flow to streams, and recharges from subsurface inflow and precipitation. Long-term fluctuations occur when recharge is above or below discharge. Four long-term hydrographs spanning 15 years or more through 1983 were made by Farrar and extended to spring 1987 during this study. If precipitation is 75 percent or more of normal during the preceding rainfall season, ground water levels recover completely in the spring (Farrar, 1986). Water levels are usually highest in the winter and spring and lowest in the fall. Since 1980, DWR has measured 12 wells semi-annually in the basin. Seasonal water levels fluctuate between 8 feet and 18 feet. The average fluctuation is 12 feet.

VI. AQUIFER TESTS

Aquifer test results are used to predict yield, drawdown in a pumping well and its interference on neighboring wells. Test results, tables, and calculations are presented in Appendix A.

Three separate aquifer tests were conducted on the City Park well: September 3-4, 1986, January 26 to February 2, 1987, and March 24 to April 3, 1987. The aquifer tests were to determine:

- the yield from the City Park well;
- the influence on adjacent wells;
- the quality of water pumped.

A Stevens continuous recorder, installed on a shallow 41-foot well (18K1), recorded water levels during the March-April, 1987 aquifer test. Water levels were also measured at the pumped well and in twelve observation wells. (See Figure 1 for well locations.) Figure 3 shows water-level fluctuations at three of the wells during pumping and recovery. Data from the continuous recorder showed no change in the free water table due to pumping from the confined system. The record shows a constant decline in water level in response to regional ground water decline following a storm. This indicates that there is no hydraulic connection between the upper-unconfined and lower-confined aquifers at this point. Water levels in the observation wells (18N/13W-17M1, -18F1, and -18L1) did respond to pumping from the confined system. Therefore, these wells tap an aquifer that is hydraulically connected to the deeper confined aquifer system. Once pumping ceased, water levels began to recover almost immediately .

Figure 4 is a geologic section showing well locations and relative depths to upper and lower aquifers. The two aquifers--one unconfined extending to a depth of about 40 feet; the other confined from depths of 80 feet to about 250 feet--are separated by a confining 35- to 40-foot-thick clay layer. It is not known if the clay layer is a continuous stratum. Time-drawdown measurements from observation well 18F1 indicate that the lower aquifer might be partially confined. Some surface recharge may also be occurring from Broaddus Creek. This suggests that the clay layer is either discontinuous or leaky at this point.

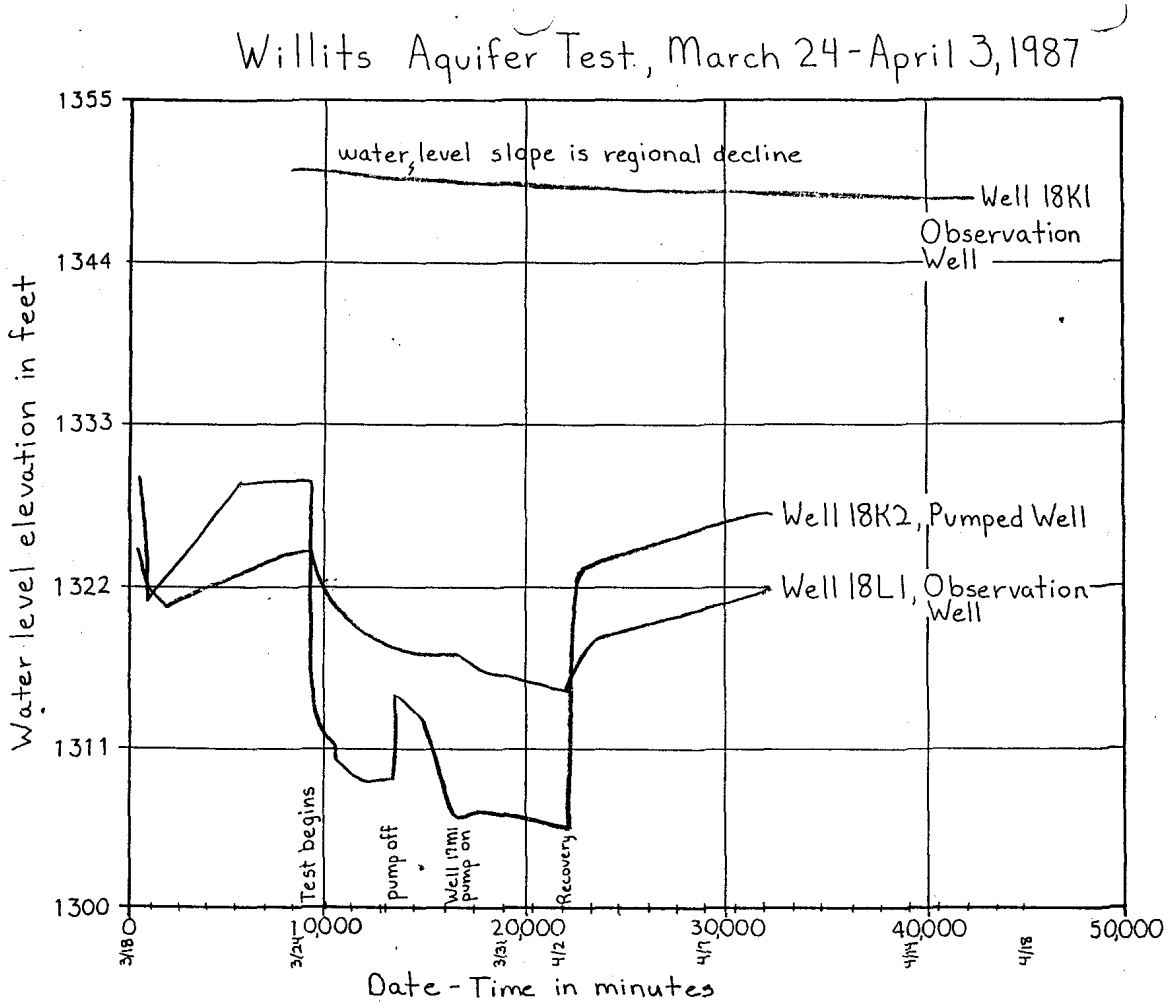

Figure 3. Water-level fluctuations in wells 18N/13-W-18K1, -18K2, and -18L1. Well 18K1 was equipped with a continuous recorder.

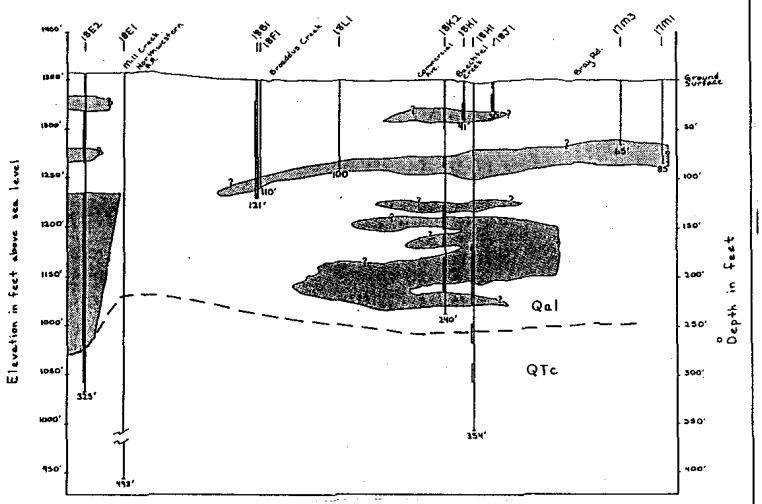

Figure 4. Geologic section, Little Lake Valley (location shown in Figure 1).

EXPLANATION

- Qal — Holocene Alluvium
- QTc — Continental Basin Deposits
- Water-bearing Units
- Low Water-yielding Units
- Geologic contact
- Hydrogeologic contact, queried where approx.
- 18K2 — Well number; well seal
- perforation
- 240' — depth

Predicted Well Yield

Well yield can be defined as the maximum pumping rate that can be supplied by a well without lowering the water level in the well below the pump intake (Cherry and Freeze, 1979). To maximize well yield, it is important that pumping levels do not drop below the first screened interval. Water levels below this interval can cause cascading water in the well and reduce well yield.

Figure 5 shows a graph of discharge versus drawdown for various durations of pumping between 10 and 365 days. The graph indicates that as the well is pumped, the water-level continues to drop. The pumping-level is dependent on time and discharge. For example, after 10 days of pumping at 200 gpm, the drawdown is 10.6 feet; at 400 gpm, the drawdown is 21.2 feet. By doubling the discharge, the drawdown is also doubled.

To calculate the pumping rate when water levels are lowest, use Figure 5 and example cases below. First, calculate specific capacity (discharge/feet of drawdown) for a given pumping duration. Second, determine available drawdown. To find this, predicted pumping levels based on seasonal changes and drawdowns from neighboring well interferences are summarized. In addition, to keep the pumping level above first screen interval, assume a safety factor of 10 feet. For example:

Observed static level (highest point)	23.0 feet
Drop in seasonal level including interference from neighboring wells	20.0 feet
Safety factor	10.0 feet
Sum of the net lowest anticipated static-level. . . .	53.0 feet
Maximum pumping-level (top of first screen)	80.0 feet
Available drawdown is the maximum pumping-level minus the lowest anticipated static level:	
80.0 feet - 53.0 feet =	27.0 feet

Assuming 27.0 feet is a good estimate, Figure 5 shows that 390 gpm can be pumped continuously from the Park well for 365 days (equals 628 AF annually).

Radius of Influence of Park Well

When pumping of ground water lowers the potentiometric surface, a cone of depression (or drawdown curve) is created in the immediate vicinity of the well. As the well is pumped, the cone expands and deepens at a decreasing rate with time. Figure 6 shows two cones of depression. Cone (a) will continue to enlarge until aquifer recharge equals pumpage. If the expanding cone of depression encounters an impervious boundary on one side of the well, it can expand no further in that direction. As a result, cone (b) must expand and deepen more rapidly in all other directions to maintain the yield of the well.

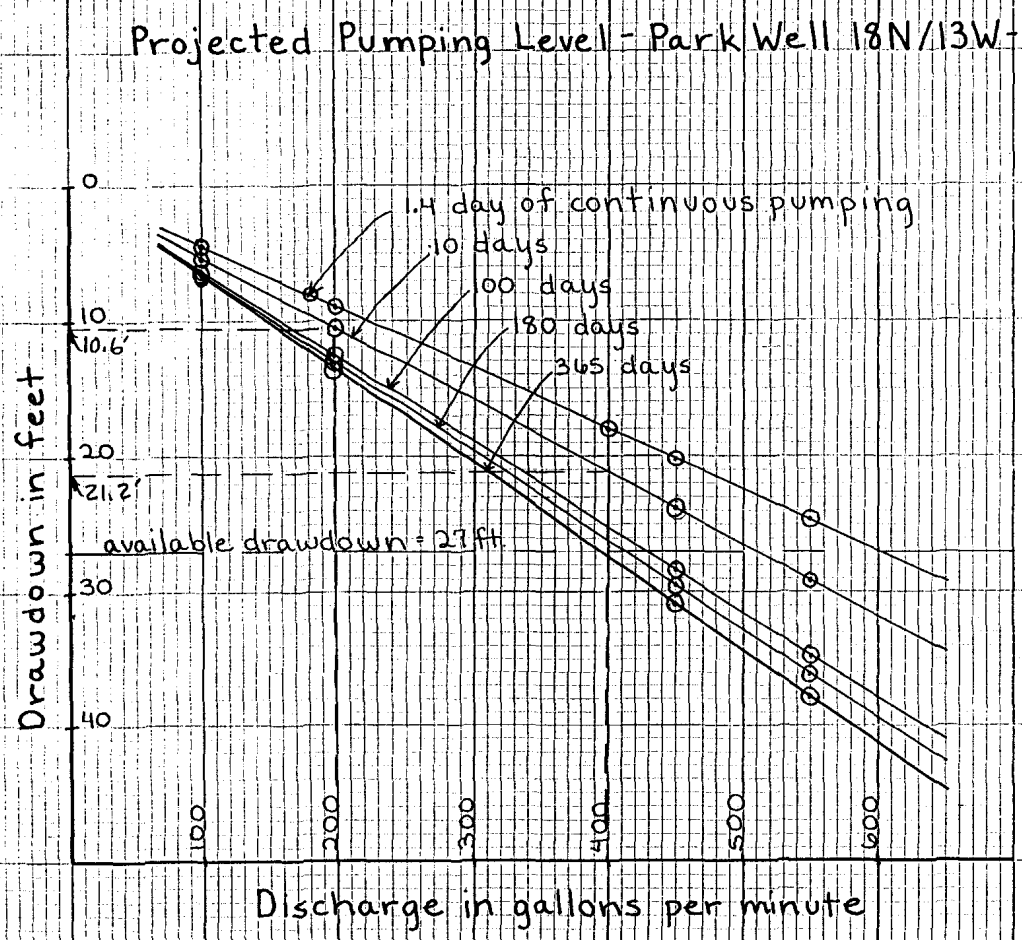

Figure 5. Discharge versus drawdown graph; Data in Appendix B.

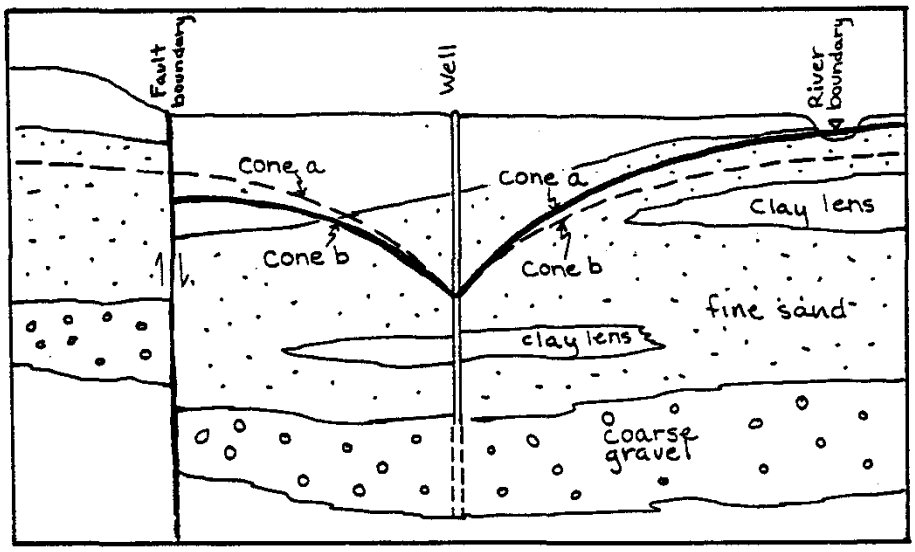

Figure 6. A) Cone of depression receiving recharge from river and unaffected by an impervious boundary.

B) Cone of depression affected by an impervious boundary. In this case, the boundary is a fault.

_____ drawdown curve as a result of both recharge and discharge boundaries.

-- -- drawdown curve unaffected by boundary conditions.

Analysis of the 27-hour September test did not indicate a boundary condition because the cone of depression did not expand to the boundary for the test duration. Analysis of the 9-day March to April drawdown test did, however, reveal the existence of an impervious boundary, probably the Maacama Fault zone. An impervious boundary causes the slope on time-drawdown graphs to steepen. Observation wells closest to the boundary show evidence of the boundary before wells further away do. Time-drawdown graphs from well 18L1 shows a steepening slope earlier than does well 18F1 or well 17M1 (Appendix I, Figures 13-15).

After 4 days of pumping, the cone expanded the distance to the impervious boundary. As a result, drawdowns around the pumped well are asymmetrical. Drawdown is greater near the boundary. Drawdown contours after 5, 6, and 30 days of pumping are shown in Figure 7.

Figure 8 shows the radial influence of pumped well (18K1) as a function of time, distance from the well, and pumping rate. Note that the maximum distance of influence (or interference) is related to duration of pumping and to pumping rate. For example, there would be 5.5 feet of drawdown at a well 1,000 feet away after 1.4 days of pumping at 450 gpm. The maximum radius of influence at the end of 1.4 days is about 2 miles. Doubling the pumping rate does not extend the distance of influence. It does, however, double the drawdown interference within the radius of influence.

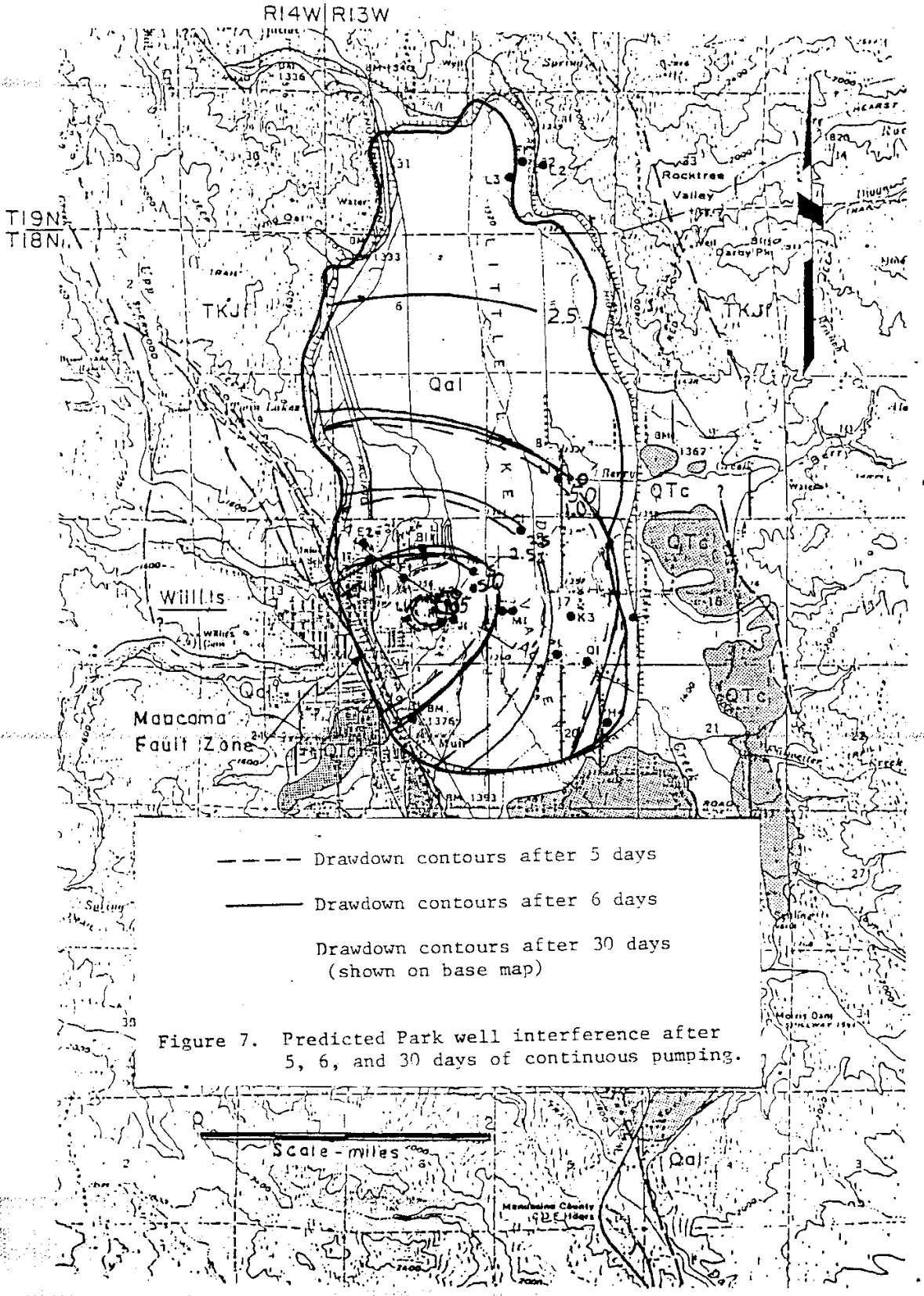

Figure 7. Predicted Park well interference after 5, 6, and 30 days of continuous pumping.

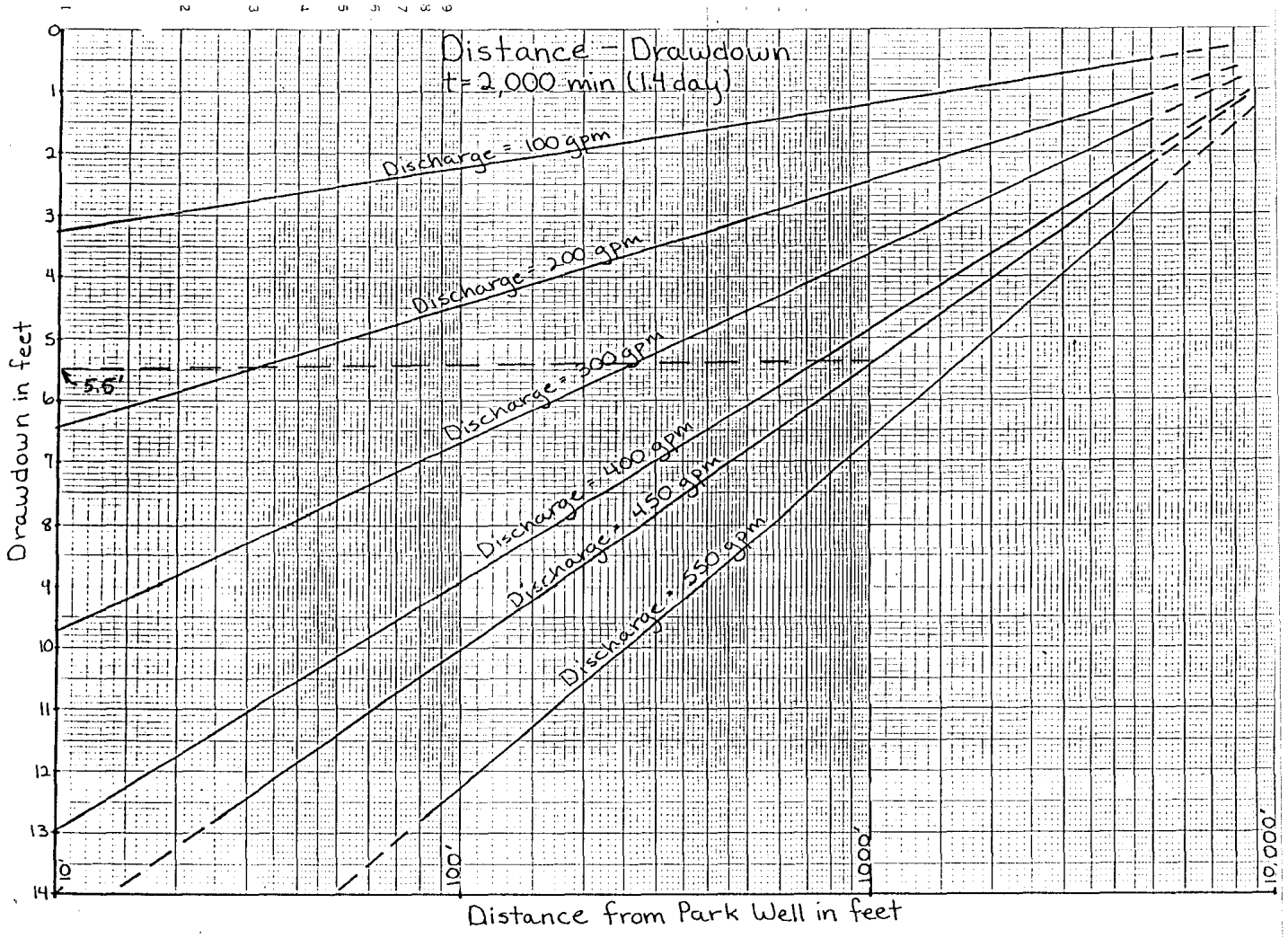

Figure 8. Radial influence of Park well as a function of pumping rate. Data calculated from observation well 18N/13W-18L1.

Water levels can be predicted from the time-drawdown graph after long periods of continuous pumping. If the City Park well was pumped continuously at 450 gpm for 15 or 180 days, the maximum radius of influence would extend beyond 2.3 miles. Figure 9 is another type of a distance-drawdown graph. Discharge from well 18K1 is constant while time is variable. After 180 days of pumping, a well 1,000 feet from the Park well will have a drawdown of about 15 feet.

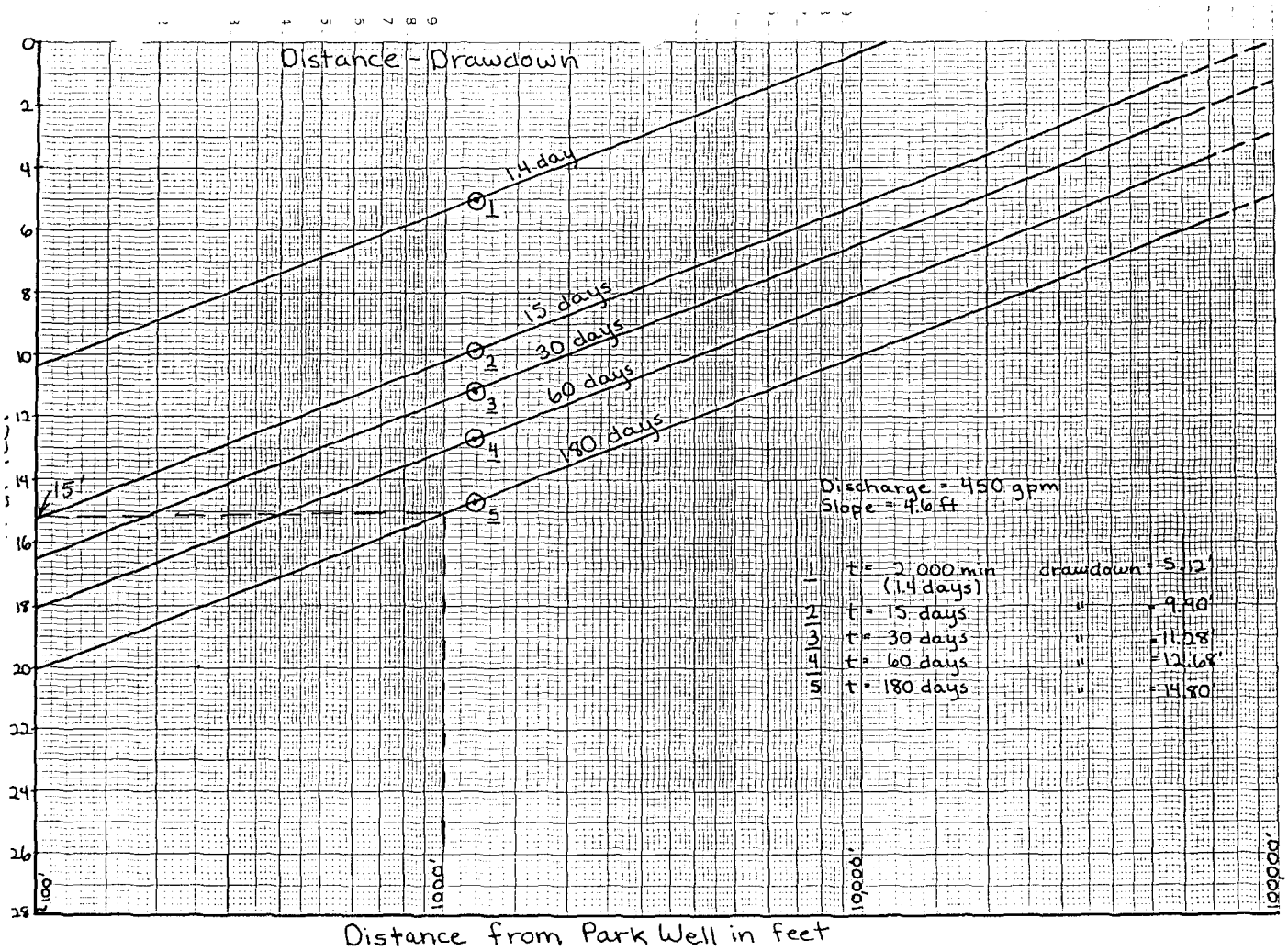

Figure 9. Radial influence of Park well as a function of time (duration). Data calculated from observation well

VII. WATER QUALITY

Samples were taken at beginning and end of each aquifer test to determine Park well water quality after prolonged pumping. During the tests, pH, temperature, and EC were monitored for changes. Laboratory analyses of Park well water collected in September are complete for both standard and minor elements (refer to Appendix B). During the March-April test, water samples were also collected from 12 wells throughout the valley. Unfortunately, all the sample analyses have not been completed at this time.

The USGS (1986) collected and analyzed 20 samples from 17 wells in Little Lake Valley. Two distinct water types were identified from the data: (1) water in which calcium-magnesium bicarbonate is predominant and sodium and chloride are minor, and (2) water in which sodium and chloride are predominant and total dissolved solids are high relative to the first type. Mean concentrations of iron and manganese from both water types exceed Environmental Protection Agency (EPA) standards1/.

Park well water analysis is similar to the first water type, in which calcium-magnesium is predominant and sodium and chloride are minor. Arsenic (0.12 mg/L), iron (1.1 mg/L), and manganese (3.2 mg/L) concentrations all exceed EPA standards. Table 3 lists chemical quality of ground water in the valley (Farrar, 1986) relative to Park well water concentrations and EPA standards.

Temperature, pH, and turbidity did not change during either aquifer tests. Analysis of Park well water, field EC and pH measurements, and USGS water quality analyses, show there are no aquifers or zones that can be identified. The water quality from the Park well represents the quality that will be supplied to the municipal system during normal pumping operations.

Water extracted from the Park well may be drawn from several aquifers which have differing qualities. Refer to Figure 4 for well construction and perforation intervals. The well is sealed against pollution to a depth of 50 feet. The first perforation interval occurs at a depth of 80 feet. At this depth, the water is confined and is not locally hydraulically connected to the upper unconfined aquifer. Therefore, samples collected from the Park well do not reflect water quality of the unconfined aquifer.

Water samples should be obtained from various perforation intervals. This may identify aquifers or zone from which high concentrations of arsenic, iron, and manganese are found.

1/ EPA Standard: National Interim Primary Drinking Water Regulation, U. S. Environmental Protection Agency, 1975; and National Secondary Drinking Water Regulations, U. S. Environmental Protection Agency, 1977.

Table 3. Chemical Quality of Ground Water in Little Lake Valley

	Number of Analyses	Maximum	Minimum	Mean	Park Well	EPA Standard
Major Constituents, in milligrams per liter						
Alkalinity as $CaCO_3$	17	380	67	170	344	-
Calcium	17	89	11	37	56	-
Chloride	17	770	2.9	80	8	250
Fluoride	17	3.4	.1	.35	-	1.8
Magnesium	17	39	4.9	17	41	-
Nitrogen NO_2+NO_3 as N	17	7.2	-	0.7	-	10
Potassium	17	2.9	0.5	1.2	0.7	-
Silica	17	57	11	28	-	-
Sodium	17	510	6.0	58	26	-
Sulfate	17	24	5.0	7.5	4	250
Sum of dissolved constituents	16	1,710	97	340	-	-
Minor Constituents, in micrograms per liter						
Aluminum	8	<100	<100	<100	-	-
Arsenic	8	16	1.0	4.1	122	50
Barium	8	500	40	185	-	1,000
Boron	20	127,000	20	8,600	200	-
Cadmium	8	<30	<1.0	<5.6	-	10
Chromium	8	<10	<10	<10	-	50
Copper	8	40	<10	<24	-	1,000
Iron	18	16,000	<10	<2,250	1,100	300
Lead	8	<100	-	<88	-	50
Manganese	17	1,700	3.0	528	3,200	50
Mercury	8	1.8	<.1	<.58	-	2
Nickel	8	<100	<100	<100	-	-
Zinc	8	150	5.0	37	-	5,000

VIII. REFERENCES

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APPENDICES

A. Summary of Aquifer Test and Drawdown Graphs

B. Data Sheets (used for calculations found in text)

C. Lab Analysis of Park Well

APPENDIX A. Summary of Aquifer Test and Drawdown Graphs

Three separate aquifer tests were conducted. Each test consisted of pumping the City Park well (18K2) at a constant rate. DWR conducted the first test for 1,248 minutes (<1 day) on September 3-4, 1986. The test duration was insufficient for a thorough analysis of data. It was necessary to extend the duration of the aquifer test. To do this, the City of Willits pumped the Park well continuously for 8,650 minutes (6 days) and measured static level and drawdown after one day of pumping. For a number of reasons, extending these data onto the first test data proved inconclusive. DWR conducted the third test for 10 days from March 24 through April 3, 1987. During this test, drawdown and recovery measurements were made in the pumped well and in three observation wells: 18L1, 18F1, and 17M1. A Stevens Type F continuous recorder was placed on a shallow well (18K1) to measure any influence from pumpage of well 18K2.

After 3 days of pumping, the pump was off about 6 hours. This was quickly remedied and the test resumed. Periodic pumping from neighboring wells and in well 17M1 influenced drawdown measurements in observation well 17M1. However, this did not significantly influence drawdown measurements in the other wells.

After 4 days of continuous pumping, the cone of depression from the Park well expanded to an impervious Maacama fault boundary. A steepening change in slope on time-drawdown graphs indicates a fault boundary. Wells closer to the boundary showed a boundary effect earlier in the test than wells farther away.

Early and late test data were used to calculate aquifer coefficients. All drawdown and some recovery are plotted against time in fractions of minutes. Coefficients of transmissivity (T) and storativity (S) are tabulated below. Results of aquifer coefficients are based on three types of analyses: Theils, Nonequilibrium, Artesian Method, Cooper-Jacob Method, and Hantusch Leaky Artesian Method. Values of T and S that best represent aquifer characteristics in vicinity of Park well are 24,000 gpd/ft and 7.5×10^{-4}.

Results of Aquifer Tests: Coefficients of Transmissivity and Storativity

Well No.	Date	Aquifer Coefficients T (gpd/ft)	Aquifer Coefficients S
18N/13W-18L1	9/3/-4/86	59,900 (a)	6.4×10^{-5} (a)
		58,000 (a)	5.7×10^{-4} (a)
		e - 45,200 (b)	e - 3.9×10^{-4} (b)
		1 - 39,800 (b)	1 - 5.3×10^{-4} (b)
		57,300 (c)	2.2×10^{-4} (c)
	1/26-2/2/87	1 - 19,900 (b)	1 - 9.8×10^{-4} (b)
	3/24-4/3/87	e - 39,700 (a)	e - 4.3×10^{-5} (a)
		1 - 26,200 (a)	1 - 6.9×10^{-4} (a)
		e - 34,900 (b)	e - 5.1×10^{-4} (b)
		1 - 23,800 (b)	1 - 7.5×10^{-4} (b)
18N/13W-18F1	3/24-4/2/87	e - 38,200 (a)	e - 2.3×10^{-3} (a)
		1 - 32,600 (a)	1 - 2.1×10^{-4} (a)
		e - 29,200 (b)	e - 1.7×10^{-3} (b)
		1 - 17,600 (b)	1 - 3.6×10^{-3} (b)
18N/13W-17M1	3/24-4/2/87	28,400 (a)	2.0×10^{-4} (a)
		e - 35,500 (b)	e - 1.6×10^{-4} (b)
		1 - 21,600 (b)	1 - 3.6×10^{-4} (b)
18N/13W-18K2	9/3-4/86	32,700	N/A
	3/24-4/2/87	27,000	N/A
Averages		35,200	7.8×10^{-4}
Average Early Time		37,100	8.5×10^{-4}
Average Late Time		25,900	1.0×10^{-3}

Notes: (a) - Theis Nonequilibrium Method
(b) - Cooper-Jacob Method
(c) - Hantusch Leaky Artesian Method

e - Results from early-time data
1 - Results from late-time data

Willits Aquifer Test
3/24-3/31/87-drawdown

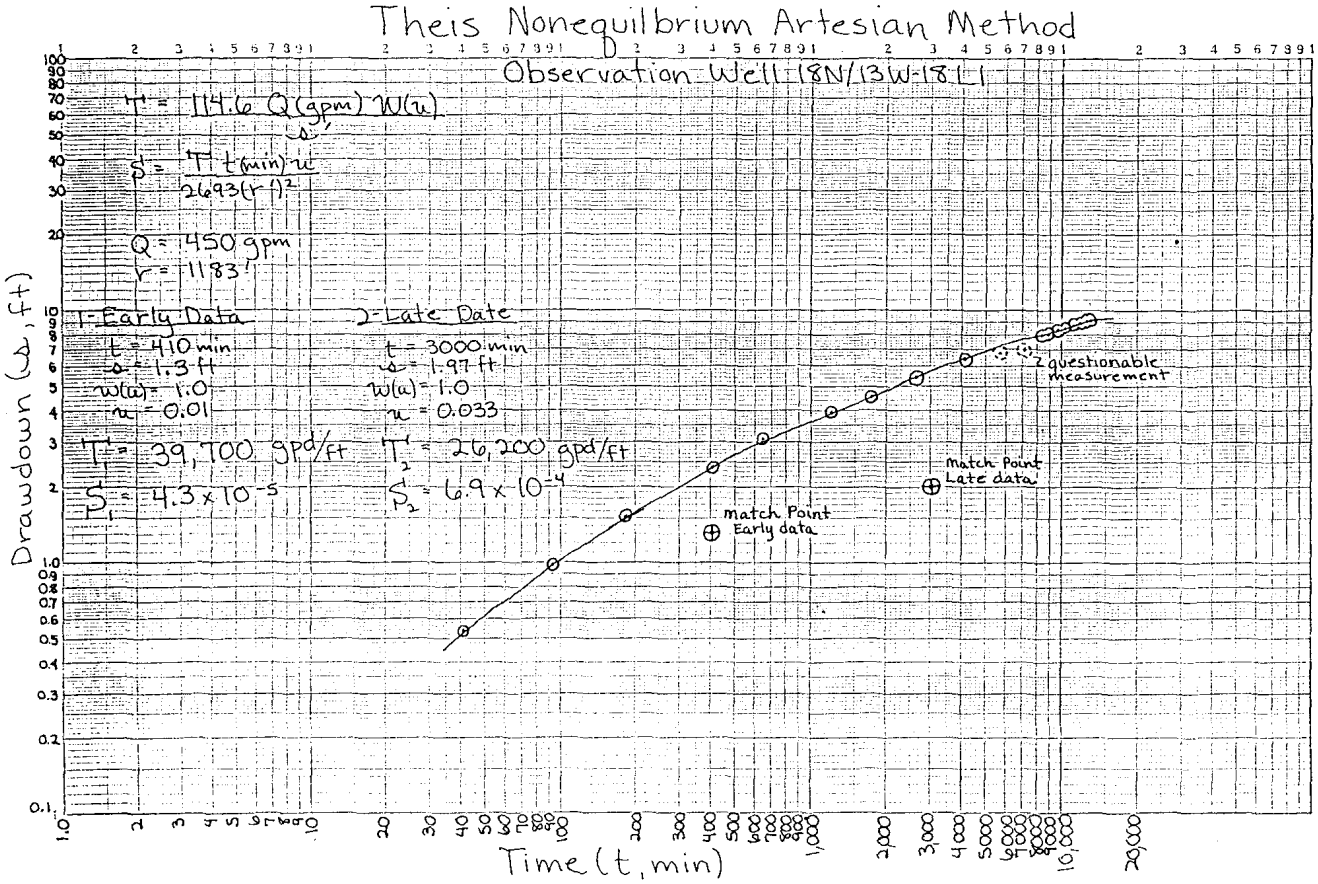

Figure A-10-- Well 18N/13W-18L1

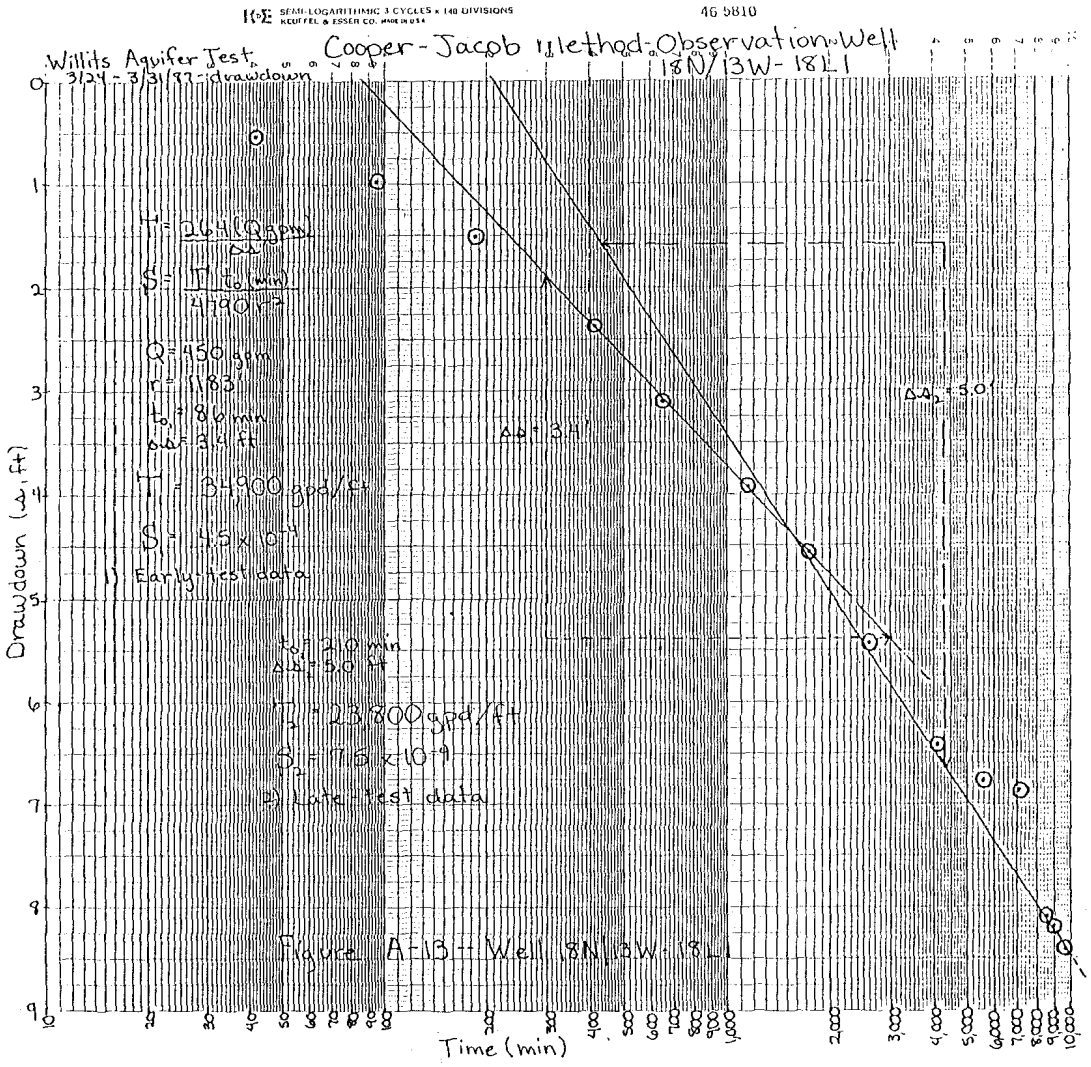

Figure A-13 -- Well 18N/13W-18L1

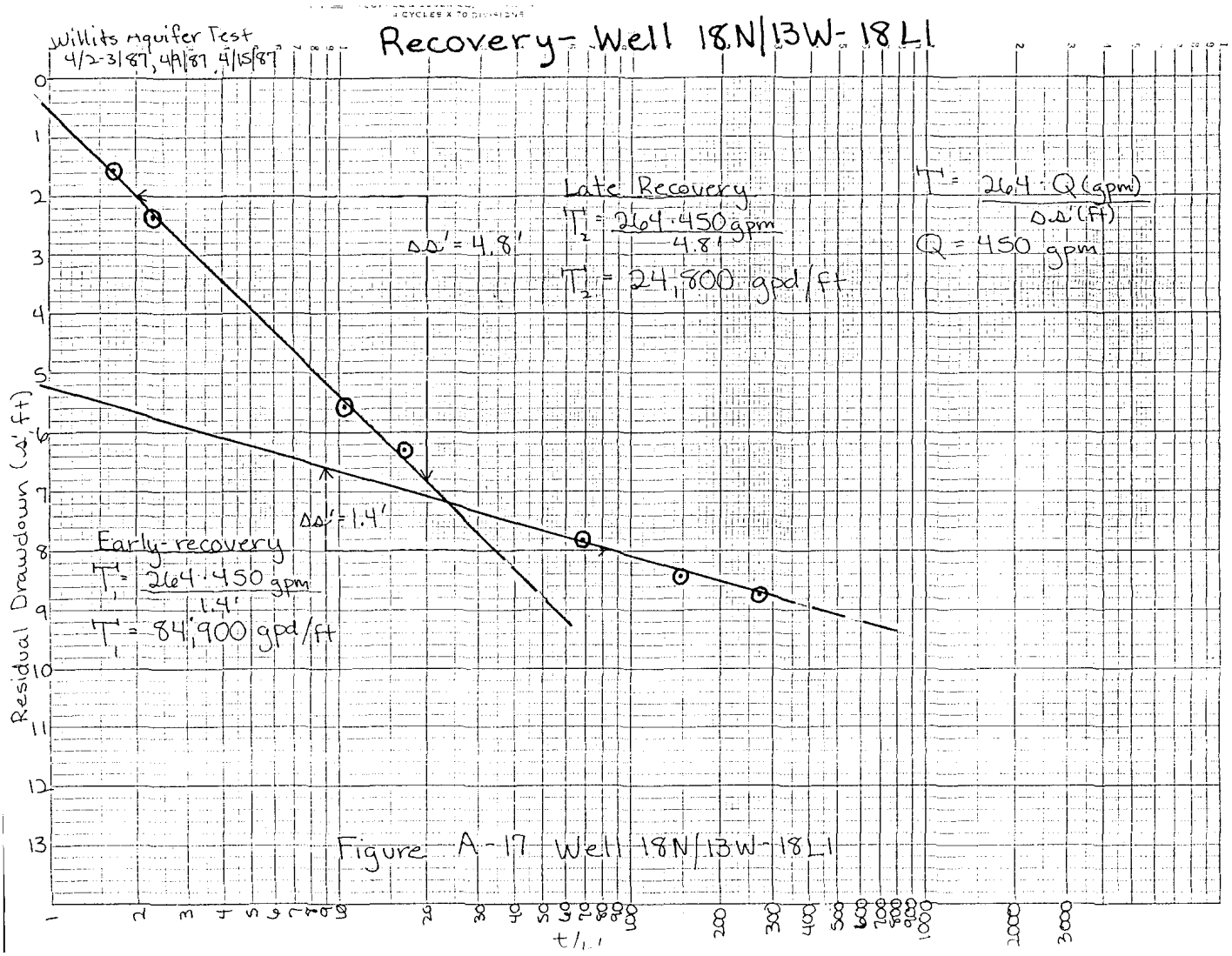

Figure A-17 Well 18N/13W-18L1

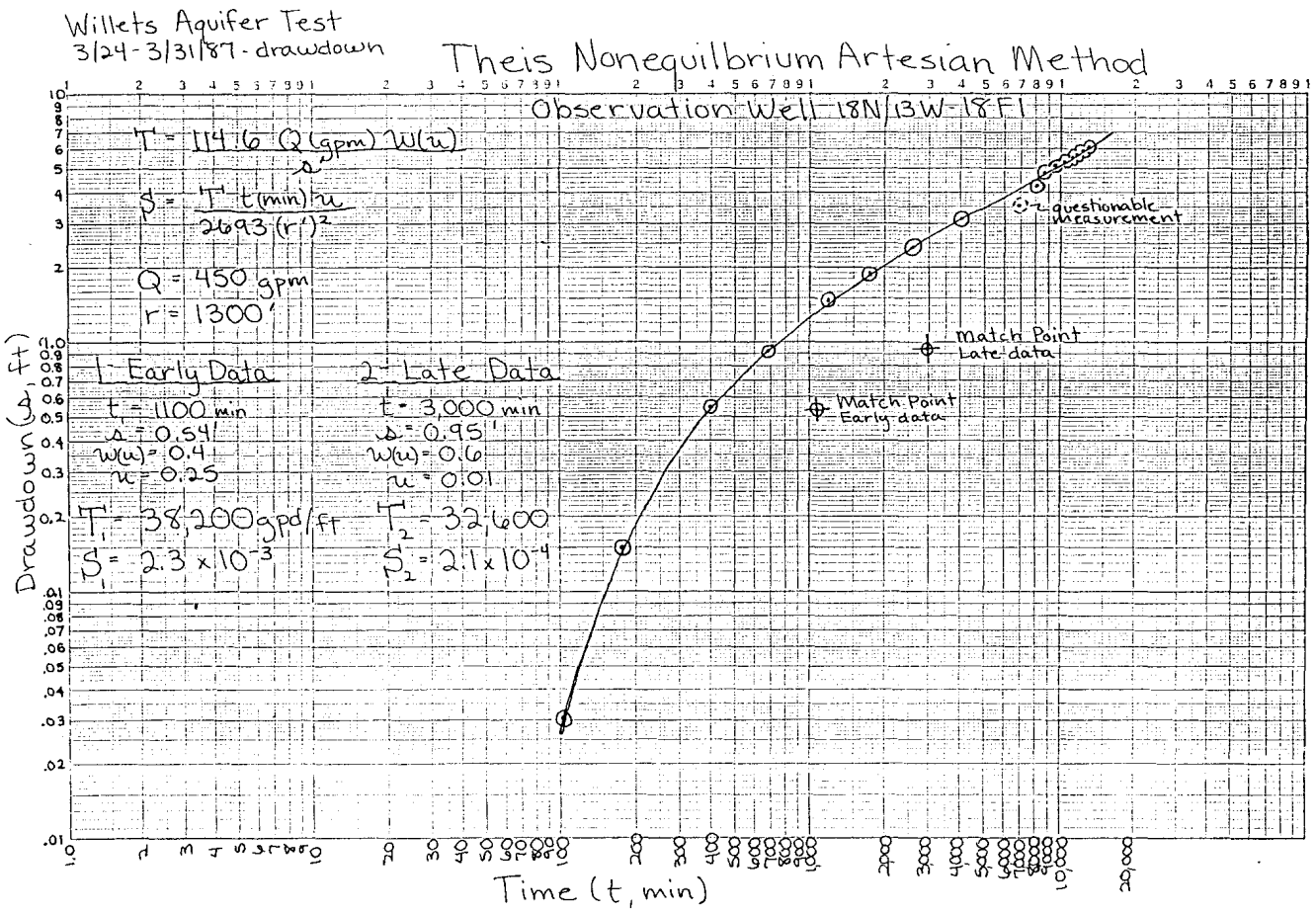

Figure A-11-- Well 18N/13W-18F1

Willets Aquifer Test
3/24 to 3/31/87 - drawdown ∞ Cooper-Jacob Method, Observation Well 18N/13W-18F1

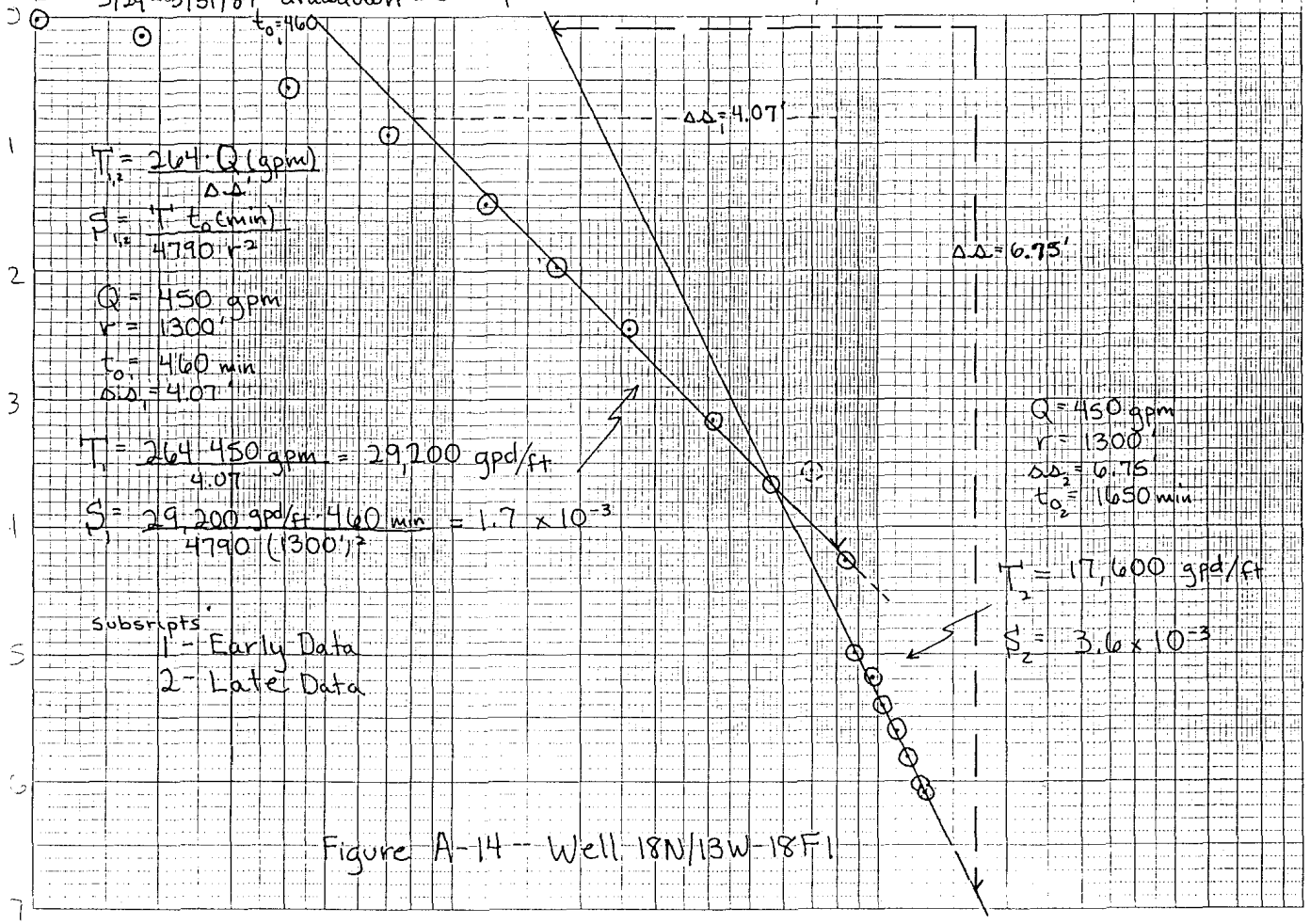

Figure A-14 -- Well 18N/13W-18F1

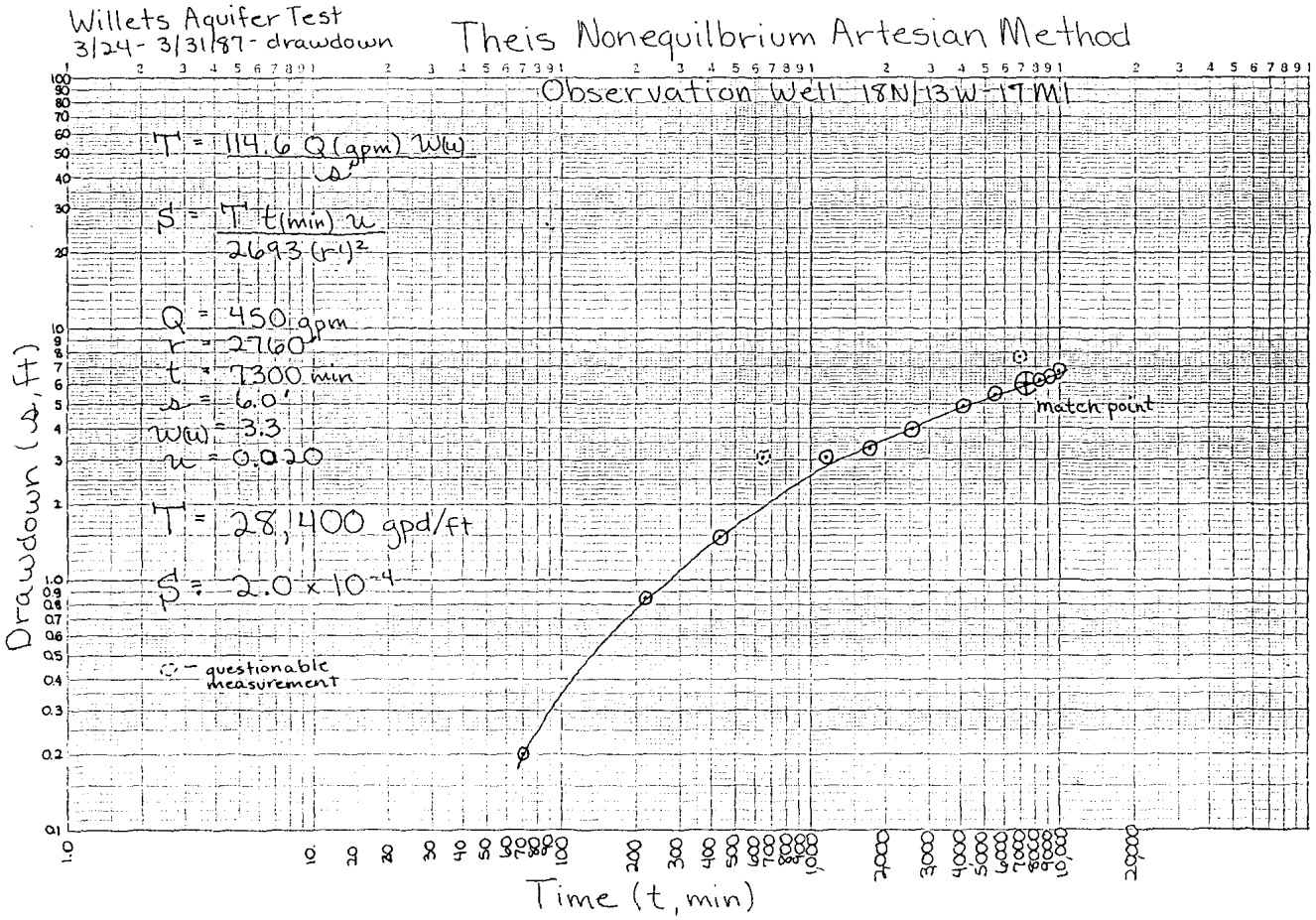

Figure A-12 Well 18N/13W-17M1

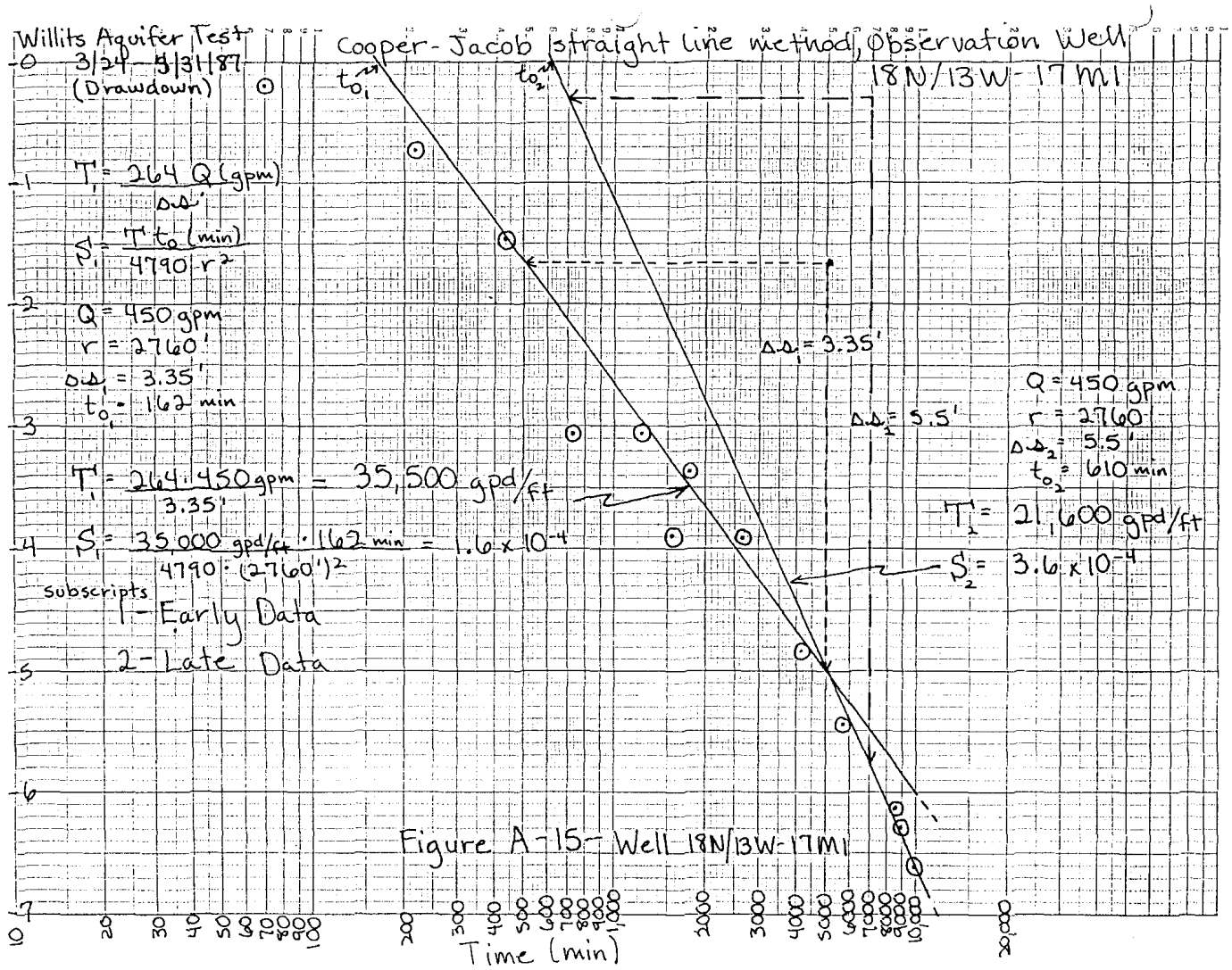

Figure A-15 - Well 18N/13W-17M1

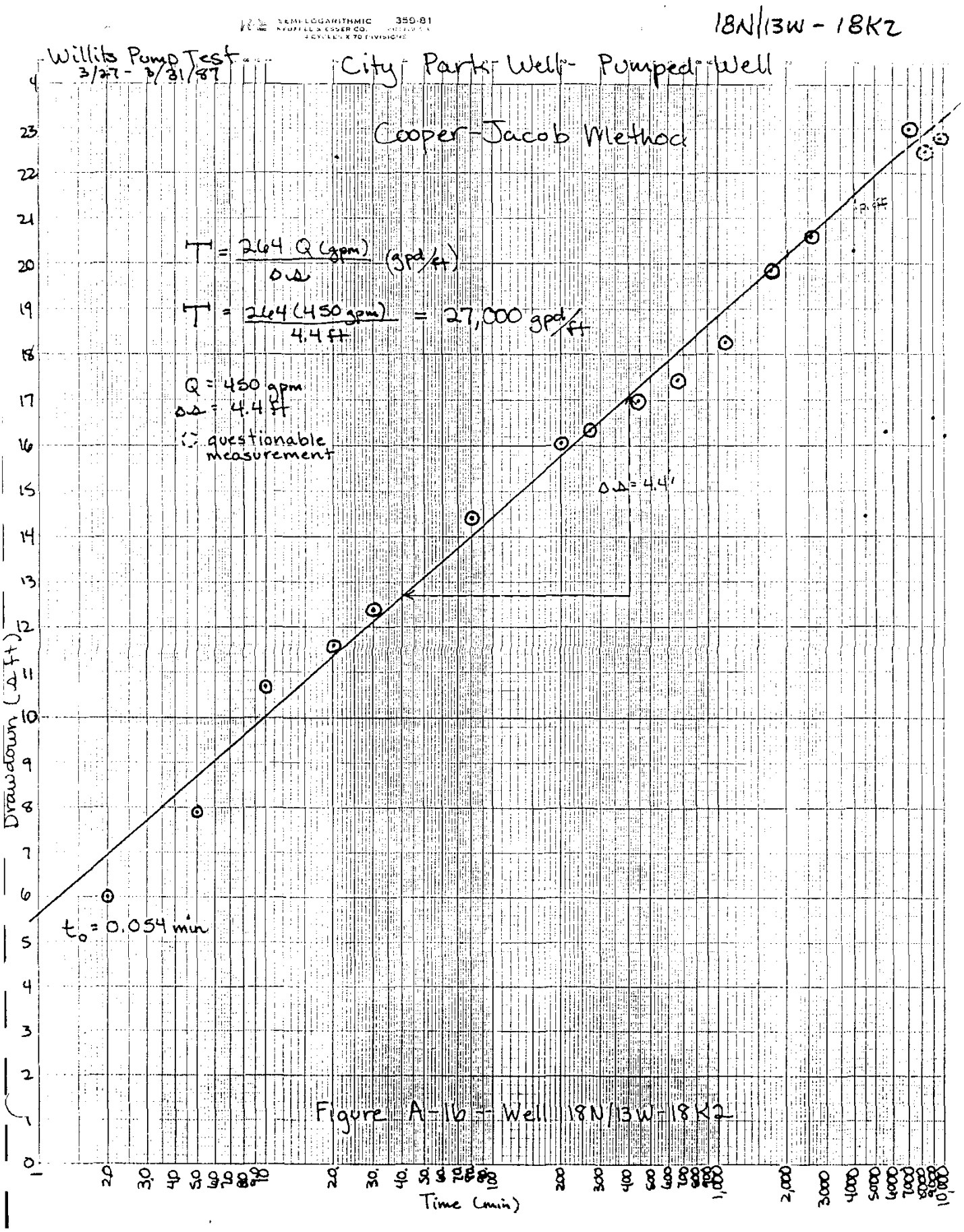

Figure A-16 - Well 18N/13W-18K2

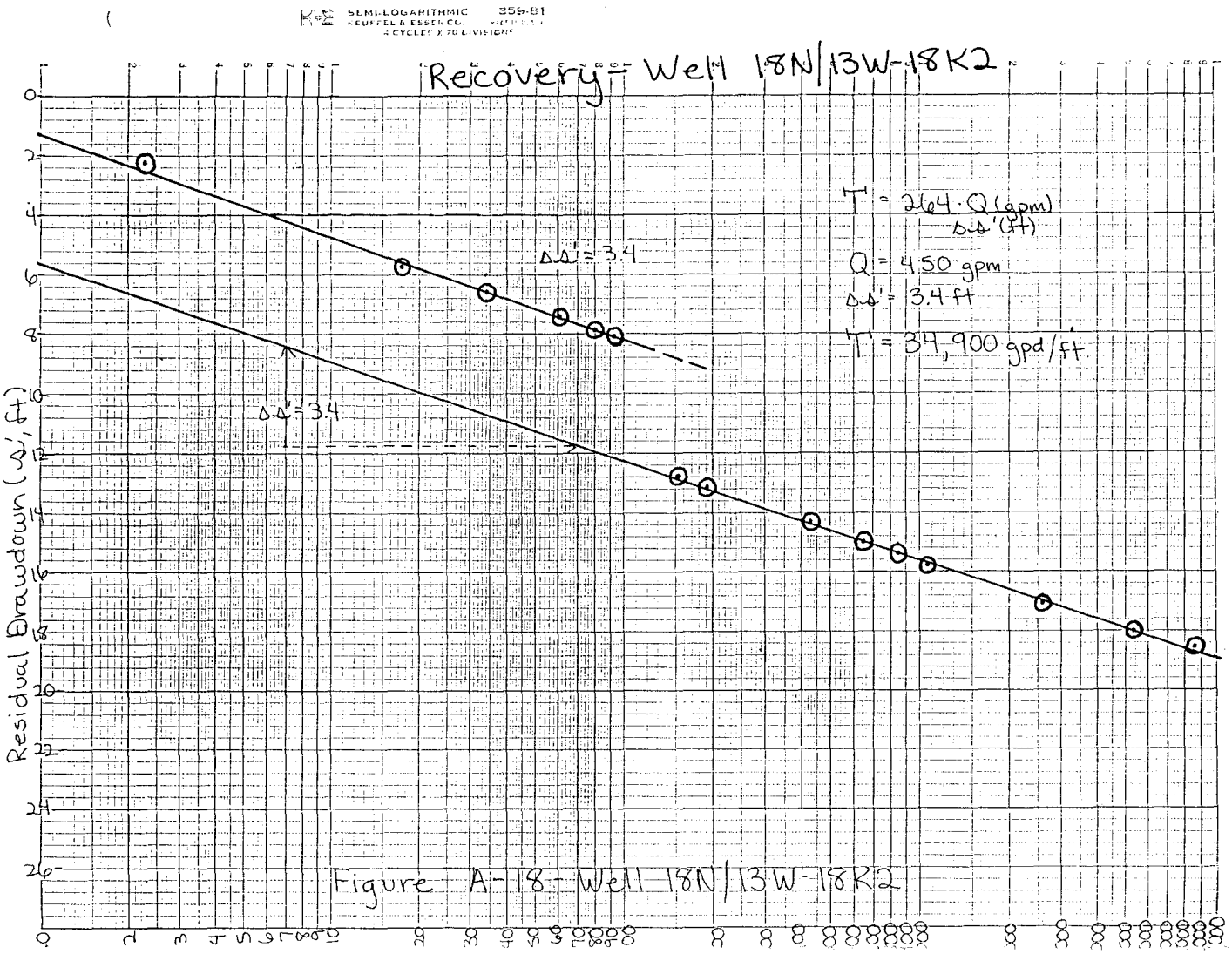

Figure A-18 - Well 18N/13W-18K2

APPENDIX B. Data Sheets

Discharge (Q) - Drawdown (s)
City Park Well, 18N/13W-18K2

Time = 1.4 day

Q (gpm)	s (ft)
100	4.5
200	9.0
400	18.0
450	20.2
550	24.7

Time = 10 days

Q (gpm)	s (ft)
100	5.3
200	10.6
450	23.9
550	29.2

Time = 100 days

Q (gpm)	s (ft)
100	6.3
200	12.6
450	28.4
550	34.7

Time = 180 days

Q (gpm)	s (ft)
100	6.6
200	13.1
450	29.5
550	36.1

Time = 365 day = 524,000 min

Q (gpm)	s (ft)
100	6.9
200	13.8
450	31.0
550	37.9

Data calculated from Cooper-Jacob Plot; data used in Figure 5.

Distance - Drawdown Data

	18N-13W-18L1	18N-13W-18F1	18N-13W 17M1
Distance from Park Well (feet)	1183 ft.	1300 ft.	2760'
Discharge = 100 (gpm)			
Drawdown (s' ft)	1.14 ft	0.49 ft	0.80 ft
Δs'/log cycle	1.02 ft	0.72 ft	0.93 ft
Discharge = 200 (gpm)			
Drawdown (s' ft)	2.28 ft	0.98 ft	1.60 ft
Δs'/log cycle	2.04 ft	1.44 ft	1.86 ft
Discharge = 300 (gpm)			
Drawdown (s' ft)	3.41 ft	1.47 ft	2.40 ft
Δs'/log cycle	3.07 ft	2.17 ft	2.79 ft
Discharge = 400 (gpm)			
Drawdown (s' ft)	4.55 ft	1.96 ft	3.20 ft
Δs'/log cycle	4.09 ft	2.89 ft	3.72 ft
Discharge = 450 (gpm)			
Drawdown (s' ft)	5.12 ft	2.20 ft	3.60 ft
Δs'/log cycle	4.60 ft	3.25 ft	4.18 ft
Discharge = 550 (gpm)			
Drawdown (s' ft)	6.26 ft	2.69 ft	3.40 ft
Δs'/log cycle	5.62 ft	3.97 ft	5.11 ft

Data obtained from Cooper-Jacob plots; data used for figures 8 and 9.

3/24-4/2/87

Table 2- Aquifer Test
Aquifer Coefficients

18N/13W18 F1		-17 L1	-17 M1	-17 K2
Distance (r)	1300'	1183'	2760'	0
Depth	100	91	67	240
Transmissivity Coefficient, T (gpd/ft)	38,200 (a)	39,700 (a)	28,400 (a)	24,100 (a)
	29,200 (b)	34,900 (b)	35,500 (b)	27,000 (b)
Storativity Coefficient, S (dimensionless)	2.3×10^{-3} (a)	4.3×10^{-4} (a)	2.0×10^{-4} (a)	N/A
	1.7×10^{-3} (b)	5.1×10^{-4} (b)	1.6×10^{-4} (b)	N/A

Average T = 32,900 (gpd/ft)

Average S = 8.9×10^{-4}

(a) Theis Type Non-equilibrium method

(b) Cooper-Jacob straight-line method

% diff 30%

Coefficients influenced by impermeable boundry:

	18F80	17L80 1 day	17M80 3.2 day	Park
T (gpd/ft)	22,850	23,800	21,600	N/A
S	4.7×10^{-3}	7.5×10^{-4}	3.6×10^{-4}	N/A

Average T = 22,800 (gpd/ft)

Average S = 1.9×10^{-3}

(Determined after 3.2 days of pumping by Cooper-Jacob straight-line method.)

Well Interference Calculations

$$T = \frac{114.6\ Q(gpm)\ W(u)}{s(ft)} \Rightarrow s = \frac{114.6 \cdot Q \cdot W(u)}{T}$$

$$S = \frac{T(gpd/ft)\ u\ t(min)}{2693\ (r(ft))^2} \Rightarrow u = \frac{S \cdot 2.693 \cdot r^2}{T \cdot t}$$

Aquifer Constants: $T = 32{,}900\ (gpd/ft)$

$S = 8.9 \times 10^{-4}$

$\therefore\ Q/T = 1.37 \times 10^{-2}$

$\therefore\ S/T = 2.7 \times 10^{-8}$

$s(ft) = 1.6\,(W(u))$ $\quad u = \dfrac{7.3 \times 10^{-5}\,(r(ft))^2}{t(min)}$

Conditions: $t = 7200$ min $= 5$ day.
$Q = 450$ gpm

r (ft)	u	W(u)	s (ft)
200	0.00041	7.1	11.4
400	0.0016	5.9	9.4
600	0.0037	5.0	8.0
1000	0.010	4.0	6.4
1500	0.023	3.2	5.1
2000	0.041	2.6	4.2
3000	0.091	1.8	2.9
4000	0.16	1.5	2.4
5000	0.25	1.0	1.6
6000	0.37	0.75	1.2
7000	0.50	0.54	0.86
8500	0.73	0.35	0.56
10000	1.0	0.23	0.37

$t = 8640$ min $= 6$ day

200	0.00034	7.2	11.5
400	0.0014	6.0	9.6
600	0.0030	5.2	8.3
1000	0.0084	4.3	6.9
2000	0.033	2.8	4.5
3000	0.076	2.0	3.2
4000	0.14	1.6	2.6
5000	0.21	1.2	1.9
6000	0.30	0.88	1.4
7000	0.41	0.68	1.1
8500	0.61	0.44	0.70
10,000	0.84	0.28	0.45

$T = 32,900$ (gpd/ft) $t = 30$ day
$S = 8.9 \times 10^{-4}$ $t = 43,200$

$s = 1.6\,(W(u))$ $u = \dfrac{7.3 \times 10^{-5}\ r^2}{43,200}$

$s = 1.6\,(W(u))$ $u = 1.69 \times 10^{-9}\,(r)^2$

r (ft)	u	W(u)	s (ft)
200	6.8×10^{-5}	9.0	14.4
400	2.7×10^{-4}	7.7	12.3
600	6.1×10^{-4}	6.75	10.8
1000	1.7×10^{-3}	5.8	9.3
1500	3.8×10^{-3}	5.0	8.0
2000	6.8×10^{-3}	4.4	7.0
3000	1.5×10^{-2}	3.7	5.9
4000	2.7×10^{-2}	3.0	4.8
5000	4.2×10^{-2}	2.7	4.3
6000	6.1×10^{-2}	2.2	3.5
7000	8.3×10^{-2}	1.9	3.0
8500	0.12	1.7	2.7
10000	0.17	1.4	2.2
15000	0.38	0.72	1.2
20000	0.68	0.38	0.6
11000	0.20	1.2	1.9
12000	0.24	1.05	1.7
13000	0.29	0.9	1.4

$t = 526,000$ min $= 365$ days
$Q = 390$ gpm
$T = 32,900$ (gpd/ft)
$S = 8.9 \times 10^{-4}$

r(ft)	u	W(u)	s (ft)
10,560 (2 miles)	1.54×10^{-2}	3.7	5.0

Willits Aquifer Test 3/24/87 - 4/2/87

Drawdown Data - Well 18N/13W-18K2

Date/Time	Time Elaspe (min)	Static Water Level	Drawdown (ft)
3/24/87 11:25am	0.0	25.9 ft	0.0
	2		6.0
	5		7.9
	10		10.7
	20		11.6
	30		12.4
	80		14.4
	202		16.05
	270		16.35
	445		17.00
	725		17.45
	1240		18.28
	1525		19.10
	1799		19.85
	2665		20.62
	4185		20.33
	4550		14.45
	5795		16.30
	7205		23.00
	8485		22.50
	8985		16.16
	9846		22.80
	10,157		16.23
4/2/87 End of drawdown	12,960		27.35

Willits Aquifer Test 3/24-4/2/87
Drawdown Data- Well 18N/13W-18L1

Date/Time	Time Elaspe (min)	Static Water Level	Drawdown (ft.)
3/24/87 11:25AM	0.0	28.32 ft	0.0
	42		0.53
	95		0.96
	185		1.50
	412		2.36
	645		3.10
	1,210		3.93
	1771		4.59
	2,628		5.45
	4,150		6.43
	5,670		6.78
	7,155		6.88
	8,460		8.01
	8,944		8.18
	9,829		8.40
	10,400		8.63
	11,263		8.88
	11980		8.98
	12730		9.24
	12935		9.28
4/2/87 End of drawdown	12960		9.28

Willits Aquifer Test - 3/24/87 - 4/2/87
Drawdown Data - Well 18N/13W-18F1

Date/Time	Time Elaspe(min)	Static Wate Level	Drawdown (ft)
3/24/87 11:25 AM	0.0	28.58 ft	0.0
	37		0.0
	103		0.03
	180		0.15
	404		0.55
	697		0.92
	1205		1.49
	1765		1.92
	2622		2.47
	4140		3.17
	5645		3.67
	7145		3.57
	8445		4.27
	8940		4.91
	9823		5.18
	10,390		5.42
	11,255		5.62
	11,915		5.82
	12,765		6.05
	12,917		6.09
	12,935		6.09
4/2/87 End of drawdown	12,960		6.09

Willits Aquifer Test 3/24-4/2/87
Drawdown Data - Well 18N/13W-17M1

Date/Time	Time Elaspe(min)	Static Water Level	Drawdown(ft)
3/24/87 11:25 AM	0.0	21.9 ft	0.0
	70		0.2
	218		0.84
	435		1.48
	725		3.07
	1220		3.08
	1455		3.90
	1780		3.38
	2645		3.93
	4160		4.86
	5675		5.45
	7175		7.65
	8470		6.16
	8975		6.31
	9837		6.63
	10,408		6.93
	11,900		8.80
	12,695		9.58
	12,900		7.55
4/2/87 End of drawdown	12,960		7.55

Recovery, 4/2-3/87

t'	t	t/t'	Residual Drawdown 18N/13W-18K2	-18L1
4/2/87 11:25	12960.0	0	27.35	9.28
1.5	12961.5	8641	18.5	—
2.5	12962.5	5185	18	—
5.0	12965	2593	17.1	—
12.0	12972	1081	15.8	—
15.0	12975	865	15.45	—
20.0	12980	649	15.0	—
30.0	12990	433	14.35	—
43.0	13003	302	—	—
48.0	13008	271	—	8.78
60.0	13020	217	—	—
68.0	13028	192	13.2	—
85.0	13045	153	12.8	—
90.0	13050	145	—	—
95.0	13055	137	—	8.42
125.0	13085	105	—	—
140.0	13100	94	8.08	—
165.0	13125	80	7.87	—
215.0	13175	61	7.47	—
224.0	13184	59	—	7.81
240.0	13200	55	—	—
253.0	13213	52	—	—
395.0	13355	34	6.62	—
4/3/87				
779	13739	18	—	—
785	13745	17.5	5.67	—

Recovery, 4/2-3/87

t'	t	t/t'	Residual Drawdown 18N/13W-18K2	-18L1
4/2/87 11:25	12960.0	0	27.35	9.28
1.5	12961.5	8641	18.5	—
2.5	12962.5	5185	18	—
5.0	12965	2593	17.1	—
12.0	12972	1081	15.8	—
15.0	12975	865	15.45	—
20.0	12980	649	15.0	—
30.0	12990	433	14.35	—
43.0	13003	302	—	—
48.0	13008	271	—	8.78
60.0	13020	217	—	—
68.0	13028	192	13.2	—
85.0	13045	153	12.8	—
90.0	13050	145	—	—
95.0	13055	137	—	8.42
125.0	13085	105	—	—
140.0	13100	94	8.08	—
165.0	13125	80	7.87	—
215.0	13175	61	7.47	—
224.0	13184	59	—	7.81
240.0	13200	55	—	—
253.0	13213	52	—	—
395.0	13355	34	6.62	—
4/3/87				
779	13739	18	—	—
785	13745	17.5	5.67	—

t'	t	t/t'	18K2	18L1
795	13,755	17.3	—	—
815	13,775	16.9	—	6.31
1260	14,220	11.3	—	—
1365	14,325	10.49	—	—
1370	14,330	10.5	—	5.58
4/9/87				
10175	23,135	2.3	2.2	2.38
4/15/87				
18,720	31,680	1.69	-19.1 pumping?	1.58

STATE OF CALIFORNIA

DEPARTMENT OF WATER RESOURCES
COMPUTATION SHEET

THE RESOURCES AGENCY

Project WILLITS AQUIFER TEST Sheet 1 of 3

Feature WL meas Designed Date 3/24/87

Item DRAWDOWN Checked well elev - 1355 Date

Date	time	elapse time (min)	City Park well 18N/13W-18K2	Munson 18N/13W-18L1	Fish 18N/13W-17M1	Giese 18N/13W-18F1	Remarks
4	11:15	STATIC WL=	25.9	28.32	21.9/1.7	28.58	
	11:25	start pump					hour meter= 496.45
	11:27	+2	31.9				cf " 76097
	11:30	+5	33.8				Q = 375 gpm
	11:35	+10	36.6				set Q@ 450 gpm
	11:45	+20	37.5				
	11:55	+30	38.3				
	12:02	+37	—			28.58	
	12:07	+42	—	28.85			
	12:35	+70	—		22.1/1.75		
	12:45	+80	40.3				
	13:00	+95	—	29.28			
	13:08	+103	—			28.61	
	14:25	180	—			28.73	
	14:30	185	—	29.82			
	14:47	202	41.95				Q=450 cf=77,320
	15:03	218	—		22.74/1.75		
	15:55	270	42.25				
	18:09	404				29.13	
	18:17	412		30.68			
	18:40	435			23.38/1.78		
	18:50	445	42.90				
	23:02	697				29.5	
	23:10	705		31.42			
	23:20	715			24.97/1.75		Q=450
-11-	23:30	725	43.35				80,454 cf
5	07:30	1205				30.07	
	07:35	1210		32.25			
	07:54	1220			24.98/1.65		Q=450
	0805	1240	44.13				83,451 cf

DWR 133 (REV. 12-64)

28.9

STATE OF CALIFORNIA — DEPARTMENT OF WATER RESOURCES — THE RESOURCES AGENCY

COMPUTATION SHEET

Project: Willits Aquifer Test 3/24-4/2/87 Sheet: 2 of 3

Feature: Drawdown Designed: Date:

Item: 916-527-6530 Checked: Date:

	Time	Well No. 18N/13W-18F1	Giese		Well No. 18N/13W-18L1 Munson		Well No. 18N/13W-17M1 Fish		Well No. 18N/13W-18K2 City well		Remarks	
	0730	1205	30.07									
5	0735	1210			32.25							
	0754	1229					24.98	1.65				
	0805	1240							44.13		086810	(450)
	1650	1765	30.50									
	1656	1771			32.91							
	1705	1780					25.28	1.88				
	1724	1799							45.75			
	0707	2622	31.05									
6	0713	2628			33.77		25.83	1.89				
	0730	2645										
	0750	2665							46.52		092180	(450)
7	0825	4140	31.75									
	0835	4150			34.75							
	0845	4160					26.78	1.78				
	0910	4185							46.23		100958	(450)
	1515	4550	Found pump not running						40.35			
			Power surge at about 11:00 am pos. shut down pump									
28	0930	5645	32.25									
	0955	5670			35.1				probe line probably cut but not severed			
	10.00	5675					27.35	1.80	?		This is ? reading	
29	1020	5795							42.2		108738	450
29	1030	7145	32.15								117693	
	1040	7155			35.2							
	11:00	7175					29.55	2.2			~~lost probe end??~~	
	11:30	7205					↑ Running		48.9		~~(43.92)~~	
	8:10	8445	33.3				SPRINKLERS					
	8:25	8460			36.33							
	8:35	8470					28.06	2.45				
	8:50	8485							48.4		125507	(450)

DWR 133 (REV. 12-64)

STATE OF CALIFORNIA

DEPARTMENT OF WATER RESOURCES
COMPUTATION SHEET

THE RESOURCES AGENCY

Project: WILLITS DRAWDOWN TEST

Sheet:

Feature: March - April 87

Designed:

Date:

Item:

Checked: -3.75

Date:

Te	TIME		Giese		Munson		Fish		Citywell		Reading
0	1625	8940	33.49								
	1629	8944			36.50						
	1643	8944	Willits Ready mix				Gravel Plant well				29.50,
	1700	8975					28.21	2.66	(?)		cut probe line reading.
	1710	8985							(42.06)		EC: 705 PH: 7.0 Temp: 62
1	0708	98213	33.76								
	0714	9829			36.72						
	0722	9837					28.53	2.80			found 3.75' cut off elec probe from friction in well
	0731	9846	EC = 700 PH = 7.1		Temp = 68			good	~~48.70~~	probe end	133692 (450)
	1242	10,157							45.88 - 3.75 =	(42.13)	(?) cut probe reading
	1600	10,355	11.73	Ready mix			45.00 No H2O Pump Kicked on - using all day				probe line is now broken
	1635	10390	34.00								
	1645	10,400			36.95		will use well for 2-3 HRS. Tonite				
	1653	10,408					28.64	2.85			
	1704	10,419							52.57 - 3.75 =	48.82	137106 (450)
1	0700	11,255	34.22								
	0708	11,263			37.20						elec. probe meter stick
	0723	11,278					28.83	2.99			
	0742	11,297	(Had problem getting This!)						52.78 - 3.75 =	49.03	
	1715	11,880							52.87 - 3.75 =	49.12	145774 (450)
	1725	11,880			39.1 / 37.3						
	1745	11,900					30.7 cycling	3.03			sprinklers on all time
	1800	11,915	35.6 / 34.4								
12	0700	12,695					31.48 cycling	3.10			
	0735	12,730			37.56						
	0740	12,735	34.63								
	0810	12,765					8:15 sprinklers off	9	53.2 - 3.75 =	49.45	151106 (450)
	1025	12,900					29.45	3.13			
	1043	12,917	34.67								
	1045	12,920			37.60						
	11:00	12935	pump off - end of drawdown test !!						49.50		152160 450
	Δ		6.1		9.3		7.6/1.4		23.6		

DWR 133 (REV. 12-64)

STATE OF CALIFORNIA | DEPARTMENT OF WATER RESOURCES | THE RESOURCES AGENCY

COMPUTATION SHEET

Project WILLITS RECOVERY TEST | Sheet

Feature | Designed | Date

Item 4/2/87 - 4/3/87 (49.50) | Checked | Date

DATE	TIME	min	CITY WELL (static 25.9)		Munson (28.32)		Fish (21.9)		Giese (28.58)			
1/2	11:25	00	~~53.25~~ (3.45)		37.60		29.45/3.13		34.67		hr meter = 709.0	152300 cf
	11:26:30	+ 1.5	44.4									
	11:27:30	+ 2.5	43.9									
	11:30	5	43.0									
	11:37	12	41.7									
	11:40	15	41.35									
	11:45	20	40.90									
	11:55	30	40.25								began to rain	
	12:08	43							34.66			
	12:13	48			37.10		sprinkler on					
	12:25	60					30.5/3.14					
	12:33	68	39.1									
	12:50	85	38.7								ptly overcast	
	12:55	90							34.64			
	13:00	95			36.74							
	13:30	125					29.24/3.13				~~Fish stopped sprinklers~~ will run every other nite	
	13:45	140	33.98 tape / 37.90 sonic (-3.92)								begin meas w/ tape -	
	14:10	165	33.77								re-calculated probe difference	
	15:00	215	33.37									
	15:09	224			36.13							
	15:25	240					28.67/3.12					
	15:38	253							34.44			
	18:00	395	32.52									
1/3	00:24	779							33.94			
	00:30	785	31.57									
	:40	795					27.32/3.13					
	01:00	815			34.63							
	08:25	1260					26.77/3.15					
	10:10	1365 / 1370			~~33.90~~				33.48			
	10:40	1395	pumping for WQ test									

DWR 133 (REV. 12-64)

(Original) reduced 12%

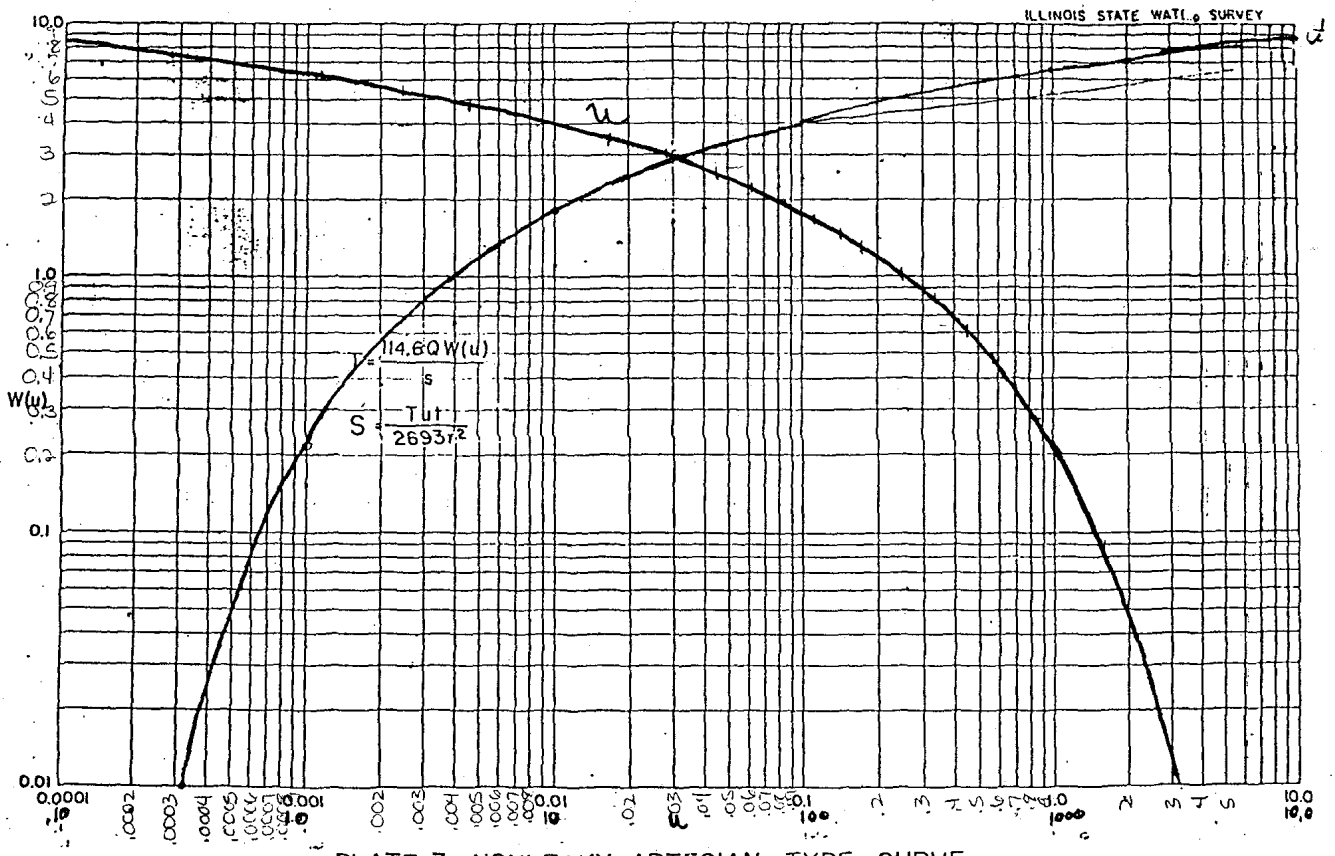

PLATE 3. NONLEAKY ARTESIAN TYPE CURVE

APPENDIX C. Lab Analysis of Park Well

DEPARTMENT OF WATER RESOURCES

WATER ANALYSIS (MINERAL)

5 | G | N058 07

CARD-1

BASIN	STATE WELL NO./STATION NO.	YR.	MO.	DAY	TIME (PST)	CO.	FIELD TEMP.
		86	09	04	1000		

CARD-2

FIELD EC	FIELD PH	DO	DISCHARGE (CFS)	G.H. (FT.)	DEPTH (FT.)	SAMPLER	LK. CARD	CODE
						5050	1	A

TYPE OF ANALYSIS: 1

W.O. 1210-0671

DISSOLVED HARDNESS	DISSOLVED CALCIUM	DISSOLVED MAGNESIUM	DISSOLVED SODIUM	DISSOLVED POTASSIUM
ml	0 35 ml	meq/L Na 6.16	DEC 1 0 1986	DEC 1 0
1 ml mg $CaCO_3$	1 ml mg Ca 55.5	meq/L Ca 2.79	dil.	dil.
		meq/L Mg 3.37	% A	% A
		41.3	Curve 26.3	0.7
as $CaCO_3$ mg/L 3.08	Ca mg/L 5.6	Mg mg/L 4.1	Na mg/L 2.6	K mg/L 0.7

DISSOLVED TOTAL ALKALINITY	DISSOLVED SULFATE	DISSOLVED CHLORIDE	DISSOLVED NITRATE
50 ml 1 ml 1.002 mg $CaCO_3$ 12/8/86 35	FEB 1 3 1987 ml M. Spears	FEB 1 3 1987 ml 1 ml = M. Spears mg Cl	FEB 1 8 1987 ml M. Spears
17.08	4.4	< 4	0.69-007 N: 0.683
as $CaCO_3$ mg/L 3.44	SO_4 mg/L 4	Cl mg/L 8	NO_3 mg/L 3.0

pH 8.4

DISSOLVED FLUORIDE	DISSOLVED BORON	CALC. DIS. SOLIDS	DISSOLVED SOLIDS	SPECIFIC CONDUCTANCE
ml	FEB 1 0 1987 ml	345	100 ml 180 C = 8 105 C = 5	25° C
	A M. Spears	TURBIDITY CODE: Candle = C, Hach = A, Hellige = E, Hach Colorimeter = B	37.5300 62 4921 379	R (Std) 718
	Factor			R (sam) 609
	A (sam) 0.22			Factor
F mg/L	B mg/L 0.2	Turb. CODE R	T.D.S. mg/L 379 T	Micromhos/cm 609

CARD-3

DISSOLVED SILICA: ml; A C; Factor; A (sam); SiO_2 mg/L

OWNER NAME ADDRESS COPY TO OWNER

CITY ZIP CODE

DETAILED LOCATION Willits Park Well Post Pump Test

POINT OF COLLECTION PPG

REF. POINT Cl RESID. COLOR

DEPTH TO WATER FT. SECCHI M ODOR

DEPTH OF WELL FT. WIND FOAM

USE % CLOUD COVER

Na	6.87 Alk		
Ca 2.79	0.08 SO_4		
Mg 3.37	0.22 Cl		
Na 1.13	0.05 NO_3		
K 0.02	F		
7.31 meq/L sum	7.22 meq/L sum		

LAB. 5050 OV 3

DATE TO LAB. SEP 2 0 1986

DATE STARTED

DATE COMPLETED ~~FEB 1 6 1987~~

CHEMIST Ted Meyers

CHECKED

PERF. INTER. ALGAE TURBID.

REMARKS

SAMPLER OF

DWR 2241 a (Rev. 8/78)

DEPARTMENT OF WATER RESOURCES

WATER ANALYSIS (MINOR ELEMENTS)

5 | 6 | N.0.5.8.0.7

BASIN	STATE WELL NO./STATION NO.	YR	MO.	DAY	TIME (PST)	CO	FIELD TEMP
		8.6	0.9	0.4	1.0.0.0		

FIELD EC	FIELD PH	DO	DISCHARGE (CFS)	G.H. (FT.)	DEPTH (FT.)	SAMPLER	LK	CARD CODE
						5.0.5.0		1 A

TYPE OF ANALYSIS: Total 11, 13, 15, 16, 17, 19, 20, 21, 23, 25 | W.O. 1210-0671

ARSENIC (10/100) 25 ml
A ____ C ____
Factor DEC 04 1986
A(sam) 23.4 → 48.7
48.7 x 0.25/1000 x 10 →
As mg/L: 0.1.2.2 (.122 mg/L) D/T: T

BARIUM ____ ml
A ____ C ____
Factor ____
A(sam) ____
Ba mg/L ____ D/T ____

CADMIUM BK 0.0 ml
A 1.00(ABS 0.153) C 1.0
Factor NOV 1 0 1986
A(sam) -0.03 -0.01
250/25
Cd mg/L: 0.00 D/T: T

CHROMIUM (all) BK 0.0 ml
A 1.00(ABS 0.075) C 1.0
Factor NOV 1 0 1986
A(sam) 0.00 0.01
250/25
Cr mg/L: 0.000 D/T: T

CHROMIUM (+6) ____ ml
A ____ C ____
Factor ____
A(sam) ____
Cr+6 mg/L ____ D/T ____

COPPER BK 0.0 ml
A 2.50(ABS 0.15) C 2.5
Factor NOV 1 0 1986
A(sam) 0.05 0.04
250/25
Cu mg/L: 0.0045 D/T: T

IRON BK 0.0 ml
A 2.50(ABS 0.121) C 2.5
Factor NOV 1 0 1986
A(sam) 1.99 1.69
250/25 X 2/12 1.84 X 6/10 = 1.104
Fe mg/L: 1.1 D/T: T

LEAD BK 0.0 ml
A 2.50(ABS 0.04) C 2.5
Factor NOV 1 0 1986
A(sam) -0.08 -0.10
250/25
Pb mg/L: 0.0 D/T: T 2

MANGANESE BK 0.0 ml
A 2.50(ABS 0.233) C 2.5
Factor NOV 1 0 1986
A(sam) 2.65 2.47
250/25 X 2/12 X 5/10 (= 3.21)
Mn mg/L: 3.2 D/T: T

MERCURY NOV 1 0 1986 ml
A BK 0. Std 17.6 C 0.001
Factor 0.0000568
A(sam) 2
(0.0001)
Hg mg/L: 0.000 D/T: T

SELENIUM 25 ml
A ____ C ____
Factor NOV 1 9 1986
A(sam) 0.0 → 0.0
0.0 → .00000
Se mg/L: 0.0.0.0 D/T: T

SILVER ____ ml
A ____ C ____
Factor ____
A(sam) ____
Ag mg/L ____ D/T ____

ZINC BK 0.0 ml
A 1.00(ABS 0.153) C 1.0
Factor NOV 1 0 1986
A(sam) 0.15 0.15
250/25
Zn mg/L: 0.02 D/T: T

CARD - 2

CARD - 3

AX

NOV 1 0 1986

LAB 5.0.5.0

OV pH EC 3

OWNER ____ NAME ____ ADDRESS ____ COPY TO OWNER ____

CITY ____ ZIP CODE ____

DETAILED LOCATION Willits Park Well
Post Pump Test

POINT OF COLLECTION ____ PPG ____

REF. POINT ____ Cl RESID. ____ COLOR ____

DEPTH TO WATER ____ FT. SECCHI ____ M ODOR ____

DEPTH OF WELL ____ FT. WIND ____ FOAM ____

USE ____ % CLOUD COVER ____

PERF. INTER. ____ ALGAE ____ TURBID. ____

REMARKS ____

SAMPLER ____ OF ____

DATE TO LAB SEP 2 6 1986

DATE STARTED NOV 1 0 1986

DATE COMPLETED NOV 1 0 1986

CHEMIST ____

CHECKED ML

DWR 2241 d (Rev. 1/76)