

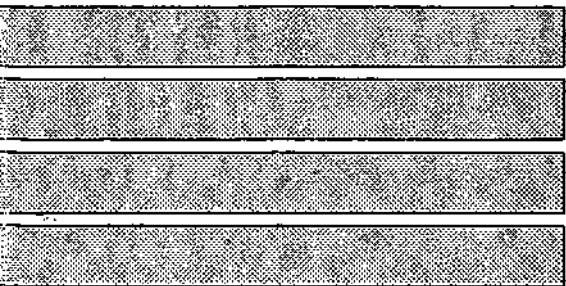
Contract Report 538

# Ground-Water Investigation at Hayes, Illinois

by Ellis W. Sanderson  
Office of Ground-Water Information  
and Adrian P. Visocky  
Office of Ground-Water Resources Evaluation and Management

Prepared for the  
City of Tuscola

October 1992



Illinois State Water Survey  
Hydrology Division  
Champaign, Illinois

A Division of the Illinois Department of Energy and Natural Resources

GROUND-WATER INVESTIGATION  
AT HAYES, ILLINOIS

by Ellis W. Sanderson  
and Adrian P. Visocky

Prepared for the  
City of Tuscola

Illinois State Water Survey  
2204 Griffith Drive  
Champaign, Illinois 61820-7495

October 1992

ISSN 0733-3927

*This report was printed on recycled and recyclable papers.*

# Final Report

## Ground-Water Investigation at Hayes, Illinois for the City of Tuscola

### CONTENTS

	Page
INTRODUCTION. . . . .	. 1
ACKNOWLEDGMENTS. . . . .	. 1
CONDUCT OF TESTING PROGRAM. . . . .	. 2
Objective. . . . .	. 2
Design of Tests. . . . .	. 2
Conduct of Tests. . . . .	. 4
STEP TEST. . . . .	. 5
Set-Up and Conduct of the Step Test. . . . .	. 5
Results. . . . .	. 6
AQUIFER TEST. . . . .	. 6
Set-Up and Conduct of the Aquifer Test. . . . .	. 6
ANALYSIS. . . . .	. 7
Type-Curve Method. . . . .	. 8
Jacob Straight-Line Method. . . . .	. 12
Results. . . . .	. 13
MODEL AQUIFER. . . . .	. 17
CONCLUSION. . . . .	. 20
REFERENCES. . . . .	. 20
APPENDICES. . . . .	. 22

ISSN 0733-3927

*This report was printed on recycled and recyclable papers.*

Ground-Water Investigation  
at  
Hayes, Illinois

by  
Ellis W. Sanderson, P.E., Senior Engineer  
Adrian P. Visocky, P.E., Senior Hydrologist

## **INTRODUCTION**

The city of Tuscola presently is furnished water by the Douglas Water Company. The company owns and operates a number of wells in Sections 26, 35, and 36, T. 16 N., R. 8 E., Douglas County, in the immediate vicinity of Tuscola. The wells furnish a significant fraction (approximately 40 to 60 percent) of the total water demand at Tuscola. The remainder of the supply is obtained by the company from the Quantum Chemical Company via pipeline from their industrial plant west of Tuscola. The wells owned by the water company tap a creviced limestone aquifer system and generally range from about 445 to 696 feet in depth. As the Quantum Chemical Company has issued notice that they no longer will continue to operate a public water supply system, the city of Tuscola and/or the Douglas Water Company must secure additional water supply to meet the present and future demands of the city residents. Previous use of the aquifer system at Tuscola in the 1960s and an accompanying study suggested that the yield of the aquifer in the vicinity of Tuscola was within about 25 percent of 300,000 gallons per day (gpd). There is local interest in expanding the use of the presently tapped limestone aquifer system. This interest is based primarily on the known areal extent of the aquifer system in this part of east-central Illinois and the yield information included in the driller's record for a well drilled in 1977 by C. F. Industries (CFI) at a site near Hayes located about four miles north of Tuscola.

## **ACKNOWLEDGMENTS**

Special thanks to Scott C. Meyer, Assistant Hydrologist, for his efforts in assisting with the field work during the step test and the aquifer test. His competence enabled the data collection efforts to be accomplished without complication.

Thanks also to Alan Gilmore, Superintendent of City Services, City of Tuscola; and to Michael R. Cline, P.E., Office Manager, Beam, Longest, and Neff, Inc., Consulting Engineers, Champaign, for their effort in coordinating the use of the well owned by C. F. Industries, Inc., and for their professional approach in investigating this water supply alternative.

Word processing of the camera-ready copy of this report was done by Pamela Lovett. The graphics were prepared by David C. Cox, and editing was done by Laurie Talkington.

## **CONDUCT OF TESTING PROGRAM**

### **Objective**

The principal objective of the study has been to estimate the potential for developing 200,000 to 400,000 gallons per day of ground water to supplement the existing well field in the vicinity of Tuscola. The target area for the study was in the vicinity of Hayes in the S14, Section 3, and the N½, Section 10, T.16 N., R.8 E., Douglas County, Illinois.

### **Design of Tests**

The study focused on conducting one aquifer test with a duration of 72 hours. The plan for the aquifer test consisted of pumping a test well at a constant, uninterrupted rate for the test duration while observing ground-water levels in the pumping test well and in three observation wells located at appropriate distances from the pumping test well. One of the observation wells was to be the existing well owned by C. F. Industries, located in the NW¼, SW¼, SE¼, Section 3, about 1,700 feet north of the test well. Two additional observation wells were drilled at locations about 265 feet southwest and 590 feet south-southeast of the test well (see figure 1).

Due to unknown conditions the pumping rate could not be maintained at a constant rate. During the test the pumping rate steadily declined, and the test pumping was terminated after 1,655 minutes (27.6 hours). Continuing to pump at ever-decreasing rates would not assist in the evaluation of the well field site. The decreasing pumping rate compromised the analysis of the extensive water-level data collected during the aquifer test and has not allowed a confident determination of the hydraulic properties of the creviced limestone aquifer. However, the hydraulic properties that were determined, reasonable assumptions, and accepted methods of resource evaluation have enabled an estimate of the yield of the aquifer from a selected number of wells.

Preliminary to the aquifer test, a step test was conducted on the pumping test well to attempt to determine an appropriate pumping rate for the aquifer test. The step test was to consist of pumping the test well at increasing increments of the full rate for a period of about 60 minutes for each rate. During the step test, water levels were observed in the pumping test well and in one observation well. The step-test data were seriously compromised

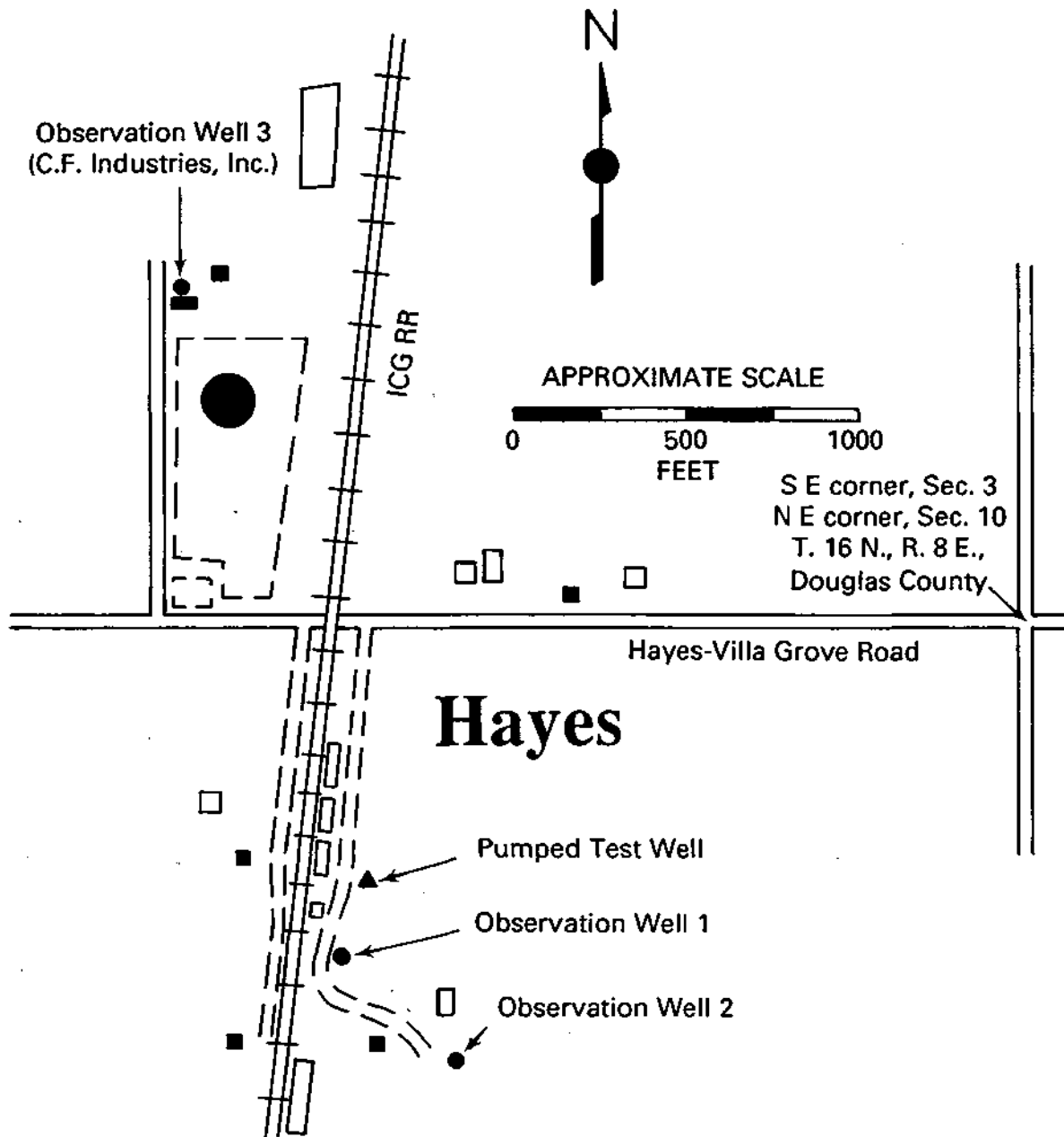


Figure 1. Aquifer test site



by decreasing pumping rates during each step and the inability to conduct the desired five to six steps.

## **Conduct of Tests**

Field work was conducted by Ellis W. Sanderson and Scott C. Meyer of the Illinois State Water Survey, assisted by Jernson Skouby and an aide from Layne-Western Company, the drilling contractor. The Layne-Western Company furnished and installed pumping equipment in the test well and discharge measuring equipment. The Water Survey furnished and installed water-level measuring and data logging equipment in the test well and in the observation wells.

The step test and the aquifer test were conducted on June 3, 1992, and June 5-7, 1992, respectively. Pumping equipment was changed on June 4, 1992, due to assumed problems (see later section), but all other discharge and ground-water level measurement equipment remained the same for both tests. Pumped ground water was conducted from the well head through about 100 feet of flexible hose 4 inches in diameter to an orifice tube 4 inches in diameter and discharged to a roadside ditch that efficiently conveyed the water to the area's surface drainage system.

The orifice tube and orifice caps used to measure the flow rates were previously calibrated by the Layne-Western Company. They furnished necessary discharge rate-pressure information. Ground-water level measuring equipment included the Water Survey's Micro-computer Data Acquisition System (referred to as McDAS), Omnidata logging equipment, and pressure transducers in each well.

The McDAS system was used during the step test to log water-level data in the pumped test well and in Observation Well 1 located 265 feet southwest of the test well. Although only the water-level information in the test well was needed, the observation well data would ensure that appropriate transducers had been chosen to provide the needed range and accuracy during the 72-hour aquifer test. Also, Omnidata logging equipment was installed in the existing well (Observation Well 3) owned by C. F. Industries. In addition to a transducer in the well, a second transducer was installed inside the pump column pipe to provide redundancy in case of the failure of one or the other. A barometer was also placed at the site of Observation Well (OW) 3 to monitor the barometric pressure preceding and during the 72-hour constant-rate aquifer test. When conducting a long-term test on an aquifer that is under artesian conditions, changes in barometric pressure can influence ground-water levels sufficiently to compromise the test data analysis. The test data can be corrected, if

needed, for this barometric pressure influence if the barometric pressure record is available.

## **STEP TEST**

### **Set-Up and Conduct of the Step Test**

The test equipment for the step test did not deviate from that described earlier. When installed, the submersible test pump was set at a depth of approximately 320 feet. After field discussion with Jernsen Skouby, the plan for the step test was to restrict the pumping rate for the first step to a rate of about 120 gallons per minute (gpm) and then to increase the rate in 20-gpm increments until the full capacity of the pump was being used or five to six steps had been conducted.

As the pumping started and the rate was being adjusted, excessive pressures on the pump column pipe were experienced. The approach to the test was then changed to allow the first step of the test to be at a high rate and then to decrease the rate in 20-gpm increments for the succeeding steps. The initial rate was set at about 240 gpm. After about 30 minutes, however, the rate began to decline and could not be maintained even with the valve full open. The response of the well and aquifer system was observed to be normal. That is, the ground-water level in the well recovered in response to the declining pumping rate. At the end of the first 40-minute step, the rate had declined to about 220 gpm, the rate intended for the second step of the test. The rate was instead adjusted by closing the valve until the pumping rate was about 200 gpm. Once again, the rate began to decline after about 20 minutes of pumping with the valve fully opened. After 40 minutes the pumping rate for the second step was about 170 gpm.

A third step was attempted by adjusting the valve until a rate of about 160 gpm was obtained. For the third time the pumping rate could not be maintained even with the valve fully opened, and it declined to about 125 gpm after 40 minutes. A fourth step was attempted but the rate could not be controlled, and the same pattern of declining pumping rate was observed. The step test was then terminated. A water sample was collected after a total pumping period of 132 minutes and the well pump was turned off.

Discussion during and after the step test about the declining pumping rates centered on a pump problem or a split column pipe. The pump was new and had not been used previously except for a four-hour period the previous night during an operational check. Mr. Skouby cited one or more technical reasons that might explain the problem with the pump.

## **Results**

For this investigation the primary purpose of the step test was to observe the response (ground-water levels) of the aquifer system to pumping. The response was to determine a pumping rate that could be maintained for the desired 72-hour constant-rate aquifer test, but at the same time stress the aquifer system sufficiently to provide meaningful data for analysis. The declining pumping rate and inability to control the pumping rates failed to provide the data or insight for an appropriate pumping rate for the constant-rate aquifer test that was scheduled to begin on June 5.

A second purpose of the step test was to determine the well loss coefficient of the well to enable calculation of the portion of observed drawdown that was due to well inefficiencies. Well loss is an additional component of observed drawdown in pumping wells and may or may not offer a significant disadvantage for a given development project. The collected data were severely compromised by the declining pumping rates during each of the three steps, but an analysis of the data was nonetheless attempted. The observed water-level data for each step were adjusted to chosen pumping rates of 230, 190, and 150 gpm. These rates were chosen because they represented an "average" rate for each of the steps. Accepted analytical methods were then applied to the adjusted water-level data.

The results of the analysis suggested that the test well had a very high well loss coefficient, probably in the range of 120 to 180  $\text{sec}^2/\text{ft}^5$ . Although high, such a value is common in wells tapping creviced limestone aquifers.

## **AQUIFER TEST**

### **Set-Up and Conduct of the Aquifer Test**

During the intervening day of June 4, the Layne-Western Company succeeded in removing the first test pump from the test well and installed another pump with somewhat less capacity. Due to the time restraints placed on the testing work by the consulting engineer, there was not sufficient time to check the operation of the substitute pump prior to the start of the 72-hour constant-rate aquifer test. All other equipment at the test well site remained the same as that used during the step test. At the observation wells, Omnidata logging and pressure transducers were installed. The same pressure transducer remained in OW 1. A pressure transducer and Omnidata logging equipment were installed in OW 2. The data logging, transducers, and barometric pressure equipment at OW 3 remained in operation as installed on June 3.

After field discussion with Jernsen Skouby regarding the installed pump capacity, a decision was made to conduct the constant-rate test at a pumping rate of 150 gpm. Pumping was started at 12:00 p.m. June 5. The pumping was quickly adjusted to the desired rate. As the time elapsed, the valve to control the pumping rate had to be opened further to try to maintain the desired rate. After about 60 minutes, the valve was full open and the 150-gpm pumping rate could not be sustained. These operational characteristics were the same as experienced two days previously during the step test. However, now there was confidence that the problem was not the pump itself. The hydraulic behavior of the well again suggested no problem with the well. Although we observed only occasional spurts of air in the discharge as the water exited the orifice tube, it was concluded that the pump was being "air locked," inhibiting its ability to lift water. It was also concluded that the pumping rate would continue to decline, although it could come to some "equilibrium rate" and not decline further.

After about 60 minutes of pumping, the rate was recorded frequently so that the water-level data could be adjusted to some "average" rate and the data analysis attempted. This data collection method continued for the duration of the test. The McDAS system was used to log the water-level data for the pumped well and OW 1 for about the first five hours of the aquifer test. The transducers in these wells were then connected to the Omnidata logging system for the overnight recording and the expected remainder of the aquifer test. The pumping operation was then left to Mr. Skouby and his helper.

On the afternoon of June 6 (Saturday) the test operation was visited by Scott Meyer. It was observed that the pumping rate had not come to some "equilibrium rate" and that the rate was less than 40 gpm after pumping about 26 hours. After discussion it was agreed that further pumping at ever-decreasing rates would have no value for the analysis of the test data and the evaluation of the test site. The McDAS system was reconnected to the transducers in the pumped well and OW 1 to log the recovery of the ground-water levels after the pump was turned off. The pumping operation ceased at 3:45 p.m. after pumping for 1,655 minutes. After about 100 minutes of logging recovery with the McDAS system, the Omnidata system was used to continue the monitoring of the water-level recovery during the night. All data logging and transducer equipment was removed the morning of June 7 (Sunday) after recording more than 1,000 minutes of recovery.

## **ANALYSIS**

The capacity of a formation to transmit ground water is expressed by the transmissivity, which is defined as the rate of flow of water, in gallons per day, through a vertical strip of the aquifer one foot wide and extending the full

saturated thickness under a hydraulic gradient of 100 percent (one foot per foot) at the prevailing temperature of the water. The transmissivity is the product of the saturated thickness of the aquifer and the hydraulic conductivity, which is defined as the rate of flow of water, in gallons per day, through a cross-sectional area of one square foot of the aquifer under a hydraulic gradient of 100 percent at the prevailing temperature of the water. The storage properties of an aquifer are expressed by the storage coefficient, which is defined as the volume of water released from storage per unit surface area of the aquifer per unit change in the water level. This parameter is dimensionless.

The hydraulic properties of an aquifer may be determined by means of an aquifer test, where the effect of pumping a well at a known constant rate is measured in the pumped well and at observation wells that penetrate the aquifer at various distances from the pumped well. Graphs of drawdown (the lowering of water levels in the wells) versus time after pumping starts and/or drawdown versus distance from the pumped well are used to solve equations that express the relation between the transmissivity, storage coefficient, pumping rate, and drawdown. Where appropriate, drawdown data must be adjusted to account for conditions that affect the observed rate of drawdown, such as variations in pumping rate, barometric pressure fluctuations, pumping in nearby wells, aquifer boundaries, significant dewatering (water-table conditions), or a partially penetrating pumped well. The two most common methods of analysis for field data under artesian conditions—the type-curve method and the Jacob straight-line method—are described below.

### **Type-Curve Method**

Theis (1935) introduced an analogy between the nonsteady flow of ground water and heat conduction. The nonequilibrium formula—popularly known as the Theis equation—describes radial flow toward a well pumping from an artesian aquifer as:

$$s = \frac{Q}{4\pi T} W(u) \quad (1)$$

or in commonly used units,

$$s = \frac{114.6Q}{T}W(u) \quad (2)$$

where:

$$W(u) = \int_u^\infty \frac{e^{-u}}{u} du = -0.5772 + \ln u + u - \frac{u^2}{2 \cdot 2!} + \frac{u^3}{3 \cdot 3!} - \frac{u^4}{4 \cdot 4!} + \dots \quad (3)$$

and

$$u = \frac{2693r^2S}{Tt} \quad (4)$$

where:

- s = drawdown at distance r from the pumped well, in ft
- Q = well discharge, in gpm
- T = transmissivity, in gpd/ft
- r = distance from pumped well to observation point, in ft
- S = storage coefficient, decimal fraction
- t = time since pumping began, in min

W(u) is referred to as the well function for nonleaky artesian aquifers and has been extensively tabulated.

This is devised a graphical procedure utilizing superposition to solve for the aquifer properties, T and S. Recall equations 2 and 4, inverting equation 4:

$$s = \frac{114.6Q}{T}W(u) \quad (5)$$

$$\frac{1}{u} = \frac{Tt}{2693r^2S} \quad (6)$$

Take the logarithm of both sides of these equations and expand:

$$\log s = \log \left[ \frac{114.6Q}{T} \right] + \log W(u) \quad (7)$$

$$\log \frac{1}{u} = \log \left[ \frac{T}{2693r^2S} \right] + \log t \quad (8)$$

In equation 7 the term  $\log [114.6Q/T]$  is a constant for a given pumping rate (hence, the need for a constant pumping rate during tests), so  $\log s$  is directly related to  $\log W(u)$ . Also, in equation 8, the term  $\log [T/2693r^2S]$  is a constant for a given distance  $r$  (a selected observation well), so  $\log 1/u$  is directly related to  $\log t$ . Thus,

$$\log s \propto \log W(u)$$

$$\log t \propto \log 1/u$$

From these relationships, one can construct a plot of the well function  $W(u)$  versus  $1/u$  on log-log graph paper (figure 2). Such a plot of a mathematical function is called a type curve. Likewise, one can plot on identical log-log paper a plot of drawdown  $s$  versus time  $t$  from the data collected at each observation well.

The type curve is then superposed over the field-data plot, keeping the corresponding ordinate and abscissa axes parallel, until a best fit is obtained. A convenient match point is chosen on the two graphs (usually one that includes the convenient type-curve match point of  $W(u) = 1$  and  $1/u = 10$ ). The corresponding coordinates of  $W(u)$ ,  $1/u$ ,  $s$ , and  $t$  are then substituted into equations 5 and 6 to solve for  $T$  and  $S$ .

In the same manner, one could make a type curve of  $W(u)$  versus  $u$ , noting the relationship between  $s$  versus  $W(u)$  and between  $u$  and  $r^2$ . For an aquifer test in which several observation wells were used, one could fit the new type curve to a field-data plot of  $s$  versus  $r^2$  for a given time, and follow the same procedure of fitting the type curve to the field-data plot and selecting a match point.

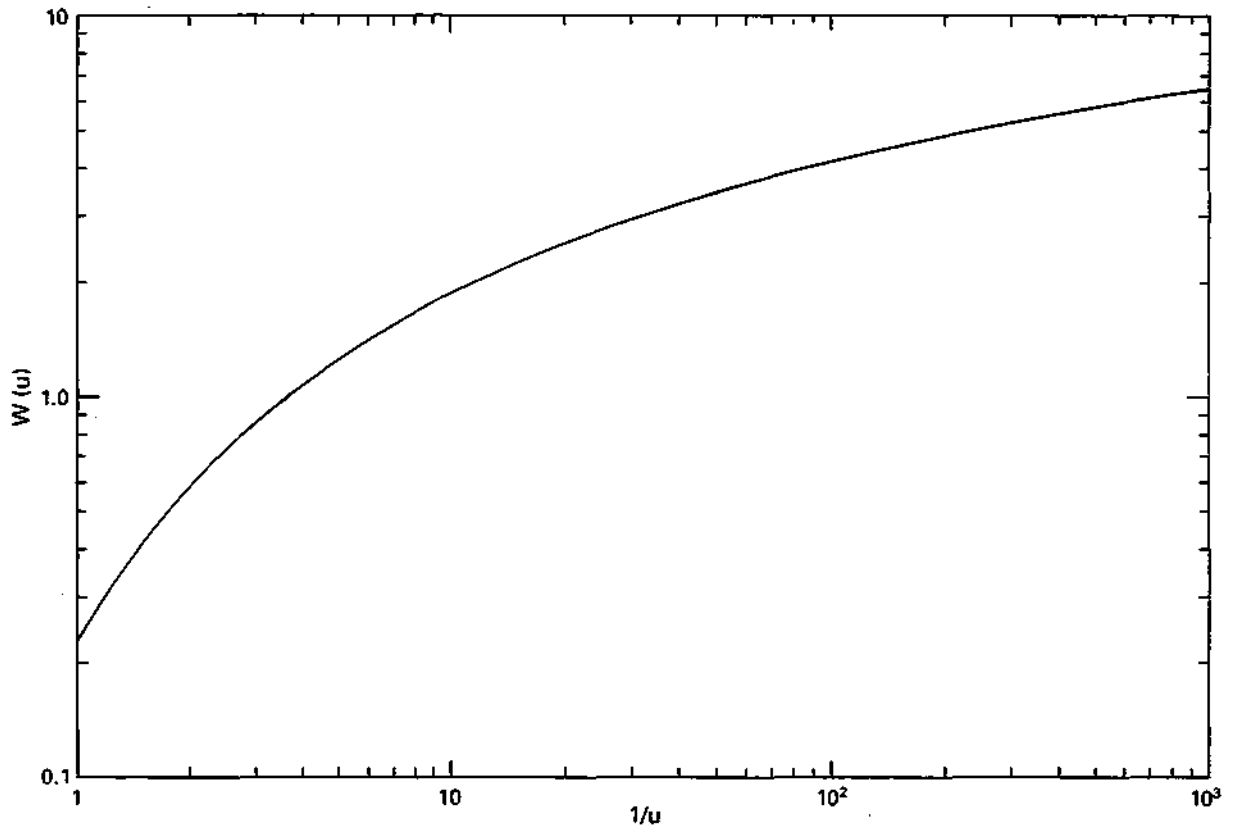


Figure 2. Nonleaky artesian type curve



## Jacob Straight-Line Method

A popular graphical method derived from the Theis method by Cooper and Jacob (1946) is referred to as the modified nonleaky artesian formula, or simply the Jacob straight-line method. The method is based on the fact that when values of  $u$  are small (less than, say, 0.01), the sum of the series terms in equation 3 beyond  $\ln u$  becomes insignificant. An examination of the terms in equation 4 shows that  $u$  becomes small when  $r$  becomes small (close-in observation wells) or  $t$  becomes large (long pumping periods).

When  $u < 0.01$ , field-data plots of drawdown versus log time on semi-log paper will yield a straight line. The straight-line portion of the  $s$  vs.  $t$  plot is extrapolated to its intersection with the zero-drawdown axis. The slope of the straight line (drawdown per log cycle) is used to solve for the transmissivity, and the zero-drawdown intercept is used to solve for the storage coefficient. Expressions for these computations, derived by Cooper and Jacob (1946) are:

$$T = \frac{264Q}{\Delta s} \quad (9)$$

$$S = \frac{Tt_0}{4790r^2} \quad (10)$$

where:

- T = transmissivity, in gpd/ft
- S = storage coefficient
- Q = well discharge, in gpm
- $s$  = drawdown difference per log cycle, in ft
- $r$  = distance from pumped well to observation point, in ft
- $t_0$  = intersection of straight-line slope with zero-drawdown axis, in min

The method can be extended also to plots of drawdown versus distance for given time values. Field-data plots of drawdown versus log distance on semilog paper will yield a straight line in the region where  $u < 0.01$ . The straight-line portion of the graph is extrapolated to its intersection with the zero-drawdown axis. The slope of the straight line is used to solve for  $T$ , and the zero-drawdown intercept is used to solve for  $S$ , using the following expressions:

$$T = \frac{528Q}{\Delta s} \quad (11)$$

$$S = \frac{Tt}{4790r_o^2} \quad (12)$$

where:

$r_o$  = intersection of straight-line slope with zero-drawdown axis, in ft

and all other terms are as defined above.

The Jacob straight-line method is popular because of its simplicity, however its use is restricted to field data that satisfy the "u-criterion" of  $u < 0.01$ . Deviation from a straight line becomes appreciable when  $u$  exceeds about 0.02 (Walton, 1962). The method should also be used to supplement, rather than supersede, the type-curve method.

## Results

Because of the failure of the pump to sustain a constant pumping rate during the aquifer test, the drawdown data were adjusted to a constant discharge rate of 110 gpm. This pumping rate was selected, since it was approximately the average discharge for the first six hours of the test. It was also a practical value on which to base drawdown adjustments, because turbulent well losses would have been significant at rates higher than 110 gpm, and well loss corrections would have been necessary as part of the adjustments. The other concern for adjustments in field data was the potential effect of changes in atmospheric pressure during the test. An examination of water-level and barometric pressure data collected prior to the test, however, indicated that barometric effects on water levels were negligible, especially in comparison to the severe effects of nonsteady pumping rates.

Time-drawdown data from the pumped well were analyzed by the Jacob straight-line method for transmissivity only. Because the effective radius of the pumped well cannot usually be determined accurately, it is impossible to determine the storage coefficient with pumped-well data, using either the Jacob method or the type-curve method. Data from the observation wells, however, were analyzed by both the type-curve and straight-line methods.

An example of the analysis is shown for the data from the second observation well ( $r = 590$  feet). The type-curve analysis indicated that the early data (less than about 100 minutes) deviated from the type curve (figure 3). One possible explanation for this early deviation is that the aquifer might have behaved as a layered aquifer during the test, with a nonuniform vertical distribution of aquifer yield in the pumped well. After about 120 minutes, however, a good fit was possible for the type curve when superposed on the remaining field data. Transmissivity and storage coefficient values of 3,820 gpd/ft and  $3.67 \times 10^{-4}$  were obtained. Although the u-criterion for the straight-line portion of the field-data plot was not satisfied (u ranged between 0.05 and 0.18), a Jacob straight-line analysis (figure 4) gave results consistent with the type-curve method: the slope of the line gave a T value of 3,806 gpd/ft, and the  $t_0$  value gave a value for S of  $3.3 \times 10^{-4}$ .

The results of the complete data analysis are given below:

	Semi-Log		Loa-Loa	
	Transmissivity (gpd/ft)	Storage	Transmissivity (gpd/ft)	Storage
Pumped well	3,820	--	--	--
OW 1	6,015	$4.2 \times 10^{-3}$	6,000	$5.2 \times 10^{-3}$
OW 2	3,806	$3.3 \times 10^{-4}$	3,820	$3.7 \times 10^{-3}$
OW 3	3,524	$2.0 \times 10^{-4}$	3,550	$3.2 \times 10^{-3}$
Average	4,291	$1.6 \times 10^{-3}$	4,457	$2.0 \times 10^{-3}$
Average w/o OW 1	3,717	$2.6 \times 10^{-4}$	3,685	$3.4 \times 10^{-4}$

Average transmissivity: ~ 3,700 gpd/ft  
 Average storage coefficient: ~  $3.0 \times 10^{-4}$

Note: Since water levels eventually fall below the top of the aquifer, ground-water flow is expected to convert to water-table conditions, resulting in higher values of storage coefficient. It was not possible to determine water-table storage coefficients during the abbreviated test. However, it is not unreasonable to assume that the higher values observed at OW 1 might reflect a storage coefficient under water-table conditions, inasmuch as conversion to water-table conditions had already taken place at the pumped well. Therefore, the long-term storage coefficient was assumed to be 0.005.

The hydraulic properties summarized above compare favorably with those of the aquifer in the vicinity of Tuscola.

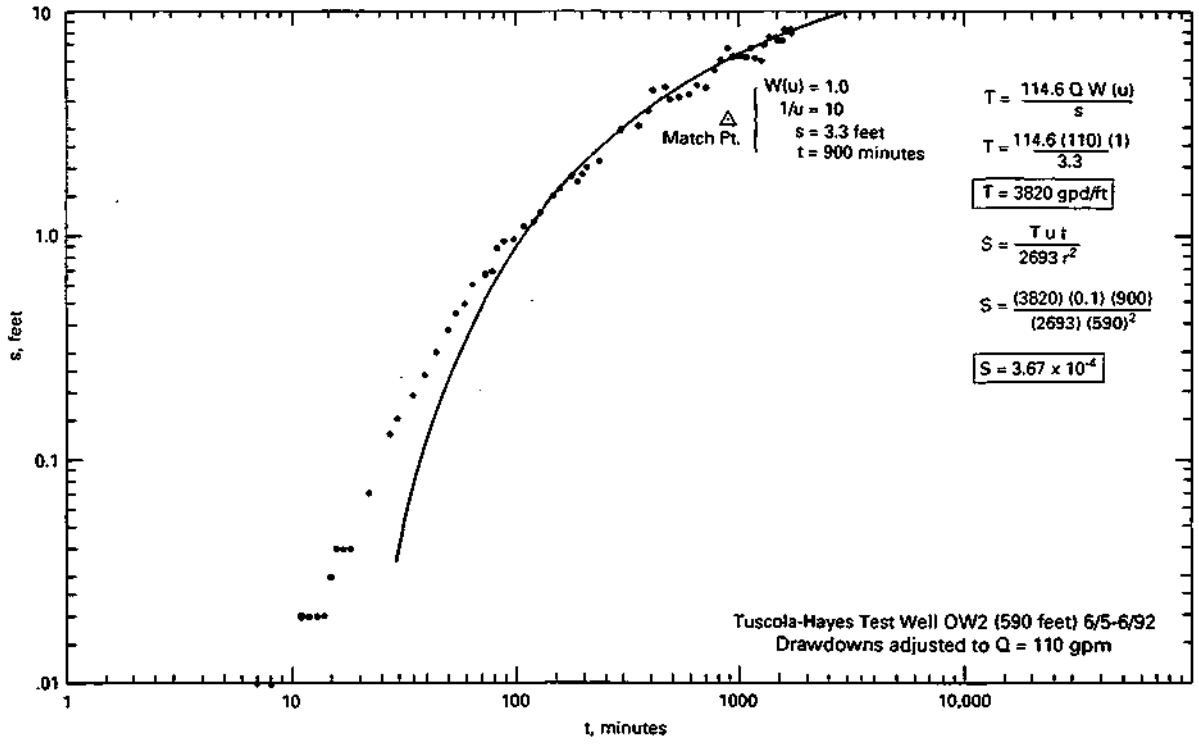


Figure 3. Type-curve analysis of OW2 data

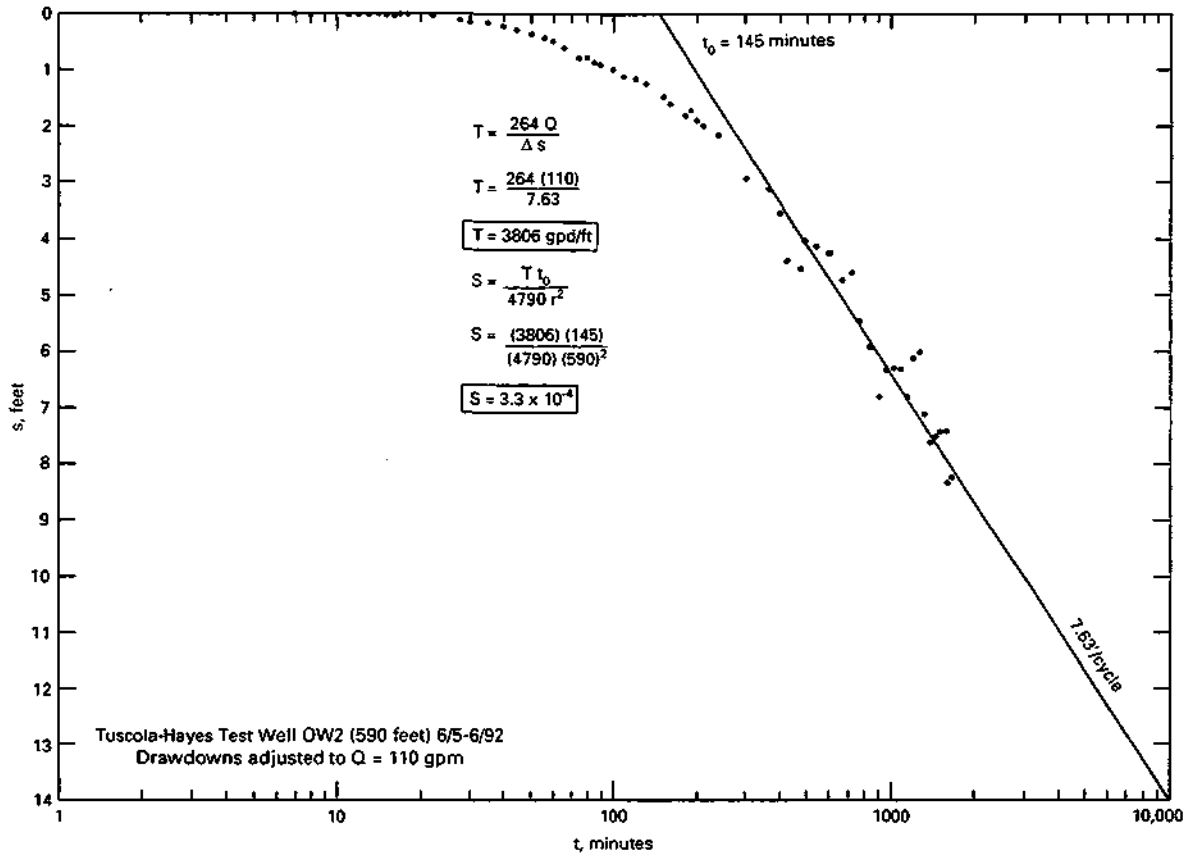


Figure 4. Straight-line analysis of OW2 data

## MODEL AQUIFER

To evaluate the quantity of water that might be developed from the test well site, it was necessary to formulate a conceptual model of the flow system within the Silurian aquifer from available hydrogeologic information. Analytical methods, using appropriate governing equations, were then employed to determine the effects of various schemes of ground-water development.

For the duration of the attempted constant-rate aquifer test, the aquifer operated as though it were effectively of "infinite" areal extent, that is, the aquifer boundaries were beyond the cone of depression developed by test pumping. Given the available geologic information about the Silurian dolomite, it is reasonable to assume that the aquifer will continue to operate as an "infinite" aquifer, even under long-term pumping conditions. In addition, although the aquifer is initially under artesian (confined) conditions, on a long-term basis the aquifer is expected to operate under water-table (unconfined) conditions.

In a multi-well system, the total yield is a function of not only the aquifer hydraulic properties but the available drawdown, that is, the drawdown from all sources at which water levels would be at some critical or limiting stage that should not be exceeded. In aquifers of uniform hydraulic properties, the critical level is at the midpoint, that is, dewatering of half of the saturated thickness of such aquifers is the maximum allowable drawdown. There is evidence from the Silurian dolomite in northeastern Illinois that, because of fracturing near the top of the aquifer, productivity in the upper third of the aquifer is much higher than in the lower two-thirds (Csallany and Walton, 1963). While the dolomite in the Douglas County area is reportedly as much as 800 feet thick (Willman et al., 1975), the wells at Tuscola do not penetrate below about 600 feet. It is not unreasonable, therefore, to assume a maximum thickness of the aquifer at the test site of about 700 feet. The test well was finished at a depth of 600 feet and penetrated about 475 feet of the dolomite, while the CFI well reportedly was 200 feet deeper. For computational purposes, therefore, it was assumed that the minimum effective thickness of the dolomite at the test site was 475 feet.

The range of allowable dewatering can be obtained by applying the 50 percent dewatering rule to the upper third of the range of aquifer thickness (475 to 700 feet). Thus, the minimum allowable dewatering is computed as:

$$\frac{1}{2} \times \quad \times 475 = 79 \text{ feet}$$

The maximum allowable dewatering is similarly derived as:

$$\frac{1}{2} \times \quad \times 700 = 117 \text{ feet}$$

Based on these considerations, therefore, the allowable dewatering at the test site would range from about 79 to 117 feet.

Under water-table conditions, gravity drainage of interstices decreases the saturated thickness and, therefore, the transmissivity of the aquifer. Accordingly, then, water-table drawdowns must be adjusted for the effect of dewatering, using a formula derived by Jacob (1944):

$$s' = s - (s^2/2m)$$

where:

- s' = drawdown that would occur in an equivalent nonleaky artesian aquifer, in ft
- s = observed drawdown under water-table conditions, in ft
- m = initial saturated thickness of aquifer, in ft

If one allows dewatering of 50 percent of the effective aquifer thickness, as described above, one can derive the corresponding adjusted (artesian) drawdown by applying the above formula to the range of allowable dewatering. In doing so we obtain an equivalent range of available artesian drawdown of 59 to 87 feet.

Adjusted values of the time-drawdown values observed during the aquifer test were extrapolated to determine a long-term pumping level for an average discharge rate of 110 gpm. The extrapolated drawdown was adjusted to a number of desired pumping rates. A comparison was then made of these adjusted levels with the range of "critical" levels discussed above to determine the remaining drawdown that would be available for interference from two additional pumping wells in the well field. In order to minimize interference, a well spacing of 1,000 feet was assumed. Interference was estimated by constructing theoretical distance-drawdown curves for various pumping rates, using an assumed storage coefficient of 0.005 and an average transmissivity of 3,700 gpd/ft. The distance-drawdown curve for a discharge rate of 100 gpm is shown in figure 5.

The minimum total pumpage from the three-well system was calculated by summing the long-term drawdown at the center well for a given pumping rate and the interference from the two additional wells flanking it and proportioning this total so that the result added up to 59 feet (the minimum available artesian drawdown). The extrapolated drawdown at the center well for a pumping rate of 110 gpm was determined to be about 107 feet. As shown in figure 5, the interference from each of the two additional wells at a pumping rate of 100 gpm each is about 14 feet, for a total interference of 28 feet. Thus, our allowable pumping rate for each of the three wells is:

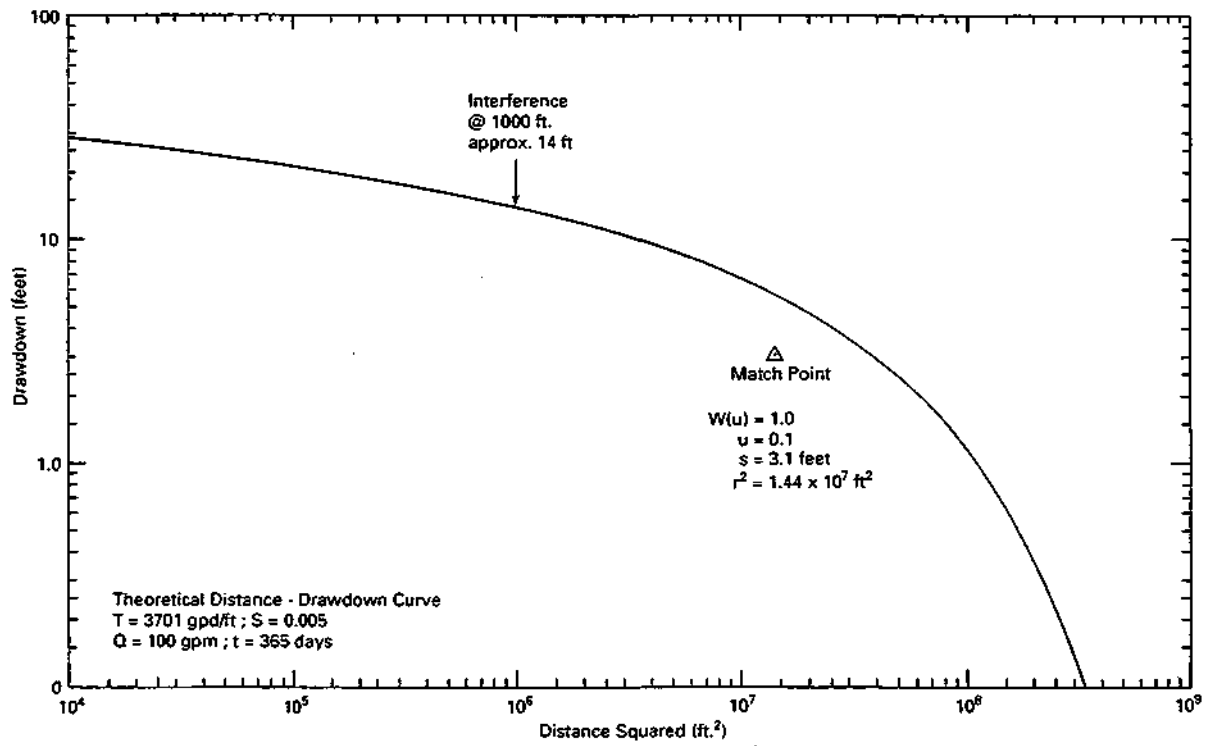


Figure 5. Theoretical distance-drawdown curve



$$(Q/110 \times 107) + (Q/100 \times 28) = 59$$

where Q is the individual pumping rate in gpm for each well. Solving for Q, one obtains:

$$Q = 47 \text{ gpm per well}$$

or:

$$Q = 141 \text{ gpm total (about 203,000 gpd)}$$

In a similar manner the maximum total pumpage from the three-well system was calculated as above by summing drawdowns and proportioning the total so that the result added up to 87 feet (the maximum available artesian drawdown). Thus,

$$(Q/110 \times 107) + (Q/100 \times 28) = 87 \text{ feet}$$

and solving for Q, one obtains:

$$Q = 70 \text{ gpm per well}$$

or:

$$Q = 210 \text{ gpm total (about 302,000 gpd)}$$

## **CONCLUSION**

Based on the above assumptions, which take into account a likely range of aquifer conditions and properties, it was determined that a water supply of between 200,000 and 300,000 gpd appears possible from a three-well system. Three wells would be necessary, located in a line and spaced about 1,000 feet apart.

If an air/gas mixture is encountered in production wells, some experimentation with pumping equipment may be needed to overcome the "air locking" and resulting decline in pumping capability experienced during this investigation.

## REFERENCES

- Cooper, H. H., Jr., and C. E. Jacob. 1946. A generalized graphical method for evaluating formation constants and summarizing well field history. *Trans. Am. Geophys. Union*, v.27(4).
- Csallany, S., and W. C. Walton. 1963. Yields of shallow dolomite wells in northern Illinois. *Illinois State Water Survey Report of Investigation 46*.
- Jacob, C. E. 1944. Notes on determining permeability by pumping tests under water-table conditions. Unpublished U.S. Geological Survey mimeo.
- Theis, C. V. 1935. The relation between the lowering of piezometric surface and the rate and duration of discharge of a well using ground-water storage. *Trans. Am. Geophys. Union*, 16th Annual Meeting, pt. 2.
- Walton, W. C. 1962. Selected analytical methods for well and aquifer evaluation. *Illinois State Water Survey Bulletin 49*.
- Willman, H. B., E. Atherton, T. C. Buschbach, C. Collinson, J. C. Frye, M. E. Hopkins, J. A. Lineback, and J. A. Simon. 1975. *Handbook of Illinois stratigraphy*. *Illinois State Geological Survey Bulletin 95*.

Appendix 1

CITY OF TUSCOLA  
Ground-Water Investigation at Hayes, Illinois

PUMPED TEST WELL INFORMATION

OBSERVATION WELL INFORMATION

WELL PRODUCTION TEST  
CITY OF TUSCOLA, TEST WELL AT HAYES  
DOUGLAS COUNTY, ILLINOIS

by

Ellis W. Sanderson, P.E., Senior Engineer  
Scott C. Meyer, Assistant Hydrologist  
Illinois State Water Survey

Well Owner:	City of Tuscola
Consulting Engineers:	Beam, Longest, and Neff, Inc.
Well Location:	Approximately 700 ft South and 2000 ft West of the NE/corner, Section 10, T.16 N., R.8 E., Douglas County, IL
Date Well Completed:	June 2, 1992
Date of Step Test:	June 3, 1992
Length of Step Test:	Three 40-minute steps
Date of Production Test:	June 5, 1992
Length of Production Test:	1665 minutes
No. of Observation Wells:	3
Aquifer:	Silurian limestone

PUMPED TEST WELL DATA

Well No.:	Test Well
Depth:	600 ft
Drilling Contractor:	Layne-Western Company, Inc.
Drill Cuttings:	to ISGS
Drilling Method:	Air rotary
Hole Record:	12¼-inch, 0-136 ft; 8-inch 136-600 ft
Casing Record:	8-inch, +0.8-136 ft
Screen Record:	None
Annulus and Gravel Pack Record:	None
Ground Elevation at Well:	Approximately 690 feet above msl, topographic map
Measuring Point:	Top of well casing, 0.8 ft above lsd
Nonpumping Water Level:	133.48 ft below MP, June 3, 1992 125.85 ft below MP, June 5, 1992

Measuring Equipment: Steel tape, electric dropline, McDAS w/pressure transmitters, Omnidata loggers w/pressure transmitters, 4-inch orifice tube

Test Pump and Power for Step Test: Crown 10 stage Submersible w/60 hp Franklin motor and generator

for Aquifer Test: Crown 5 stage Submersible w/20 hp Franklin motor and generator

Test Pump Setting: 320 ft

Time Water Sample Collected: 4:51 pm, June 5, 1992

Temperature of Water: 59° F

PUMPED TEST WELL  
DRILLERS LOG

<u>Formation</u>	<u>From</u>	<u>To</u>
Brown clay	0	34
Sand and gravel	34	78
Limestone w/ some shale	78	80.5
Mudstone and siltstone	80.5	86
Fractured limestone	86	88
Siltstone	86	88
Void	88	107
Mudstone	107	108
Mud void	108	114
Fractured limestone w/ mudstone	114	117
Limestone, buff to green in color	117	136
	136	600

## OBSERVATION WELL DATA

Observation Well No.:	1
Depth:	600 ft
Hole Record:	12¼-inch, 0-118 ft; 8-inch, 118-600 ft
Casing Record:	8-inch +1.4-118 ft
Screen Record:	None
Measuring Equipment:	Steel tape, electric dropline, McDAS w/pressure transmitter, Omnidata loggers w/pressure transmitter
Ground Elevation:	Approximately 690 feet above msl, topographic map
Measuring Point:	Top of casing, 1.4 ft above lsd
Nonpumping Water Level:	98.70 ft below MP, June 5, 1992
Distance and Direction from Pumped Well:	265 ft southwest

## DRILLERS LOG

<u>Formation</u>	<u>From</u>	<u>To</u>
Brown clay	0	34
Sand and gravel	34	76
Fractured limestone	76	78
Limestone w/shale stringers	78	81
Shale and mudstone stringers	81	131
Limestone, buff to green in color	131	600

## OBSERVATION WELL DATA

Observation Well No.: 2  
 Depth: 300 ft  
 Hole Record: 12¼-inch, 0-87 ft; 8-inch, 87-137.5 ft; 6-inch, 137.5-300 ft  
 Casing Record: 8-inch, +1.3-87 ft; 6-inch, + 1.3-137.5 ft  
 Screen Record: None  
 Measuring Equipment: Steel tape, electric dropline, Omnidata logger w/pressure transmitter  
 Ground Elevation: Approximately 690 ft above msl, topographic map  
 Measuring Point: Top of casing, 1.3 ft above lsd  
 Nonpumping Water Level: 113.94 ft below MP, June 5, 1992  
 Distance and Direction from Pumped Well: 590 ft south southeast

## DRILLERS LOG

<u>Formation</u>	<u>From</u>	<u>To</u>
Brown clay	0	23
Gray silty clay	23	47
Sand and gravel	47	62
Gray silty clay w/sand stringers	62	79
Fractured limestone, shale	79	81
Shale, mudstone	81	85
Sand and gravel	85	89
Mudstone	89	134.5
Fractured limestone	134.5	300

## OBSERVATION WELL DATA

Observation Well No.:	3 (C. F. Industries, Inc.)
Depth:	802 ft
Hole Record:	10-inch, 0-107 ft; 8-inch, 107-802 ft
Casing Record:	10-inch, 0-107 ft
Screen Record:	None
Measuring Equipment:	Steel tape, Omnidata logger w/pressure transmitter
Ground Elevation:	Approximately 688 ft above msl, topographic map
Measuring Point:	Top of well cover plate
Nonpumping Water Level:	88.69 ft below MP, June 2, 1992
Distance and Direction from Pumped Well:	Approximately 1700 ft north
Remarks:	Well produced methane gas when drilled in 1978

## DRILLERS LOG

<u>Formation</u>	<u>From</u>	<u>To</u>
Black dirt	0	5
Sandy yellow clay	5	20
Gray shale and gravel	20	45
Brown shale and gravel	45	55
Gray and green shale	55	70
Gray shale	70	75
Brown and gray shale	75	87
Dark gray sandy shale	87	90
Dark gray and red shale	90	95
Brownish red shale	95	107
Dark gray lime	107	115
Light brown lime	115	140
Brown lime	140	150
Dark gray lime	150	190
Light gray to white	190	225
Medium gray lime	225	275
Brown lime	275	300
Light brown lime	300	345
White lime very hard	345	350



<u>Formation</u>	<u>From</u>	<u>To</u>
Dark gray lime	350	370
Light gray lime hard	370	400
Light gray lime	400	410
Medium gray lime	410	420
Dark gray lime and shale breaks	420	630
Gray and brown lime	630	680
Brown lime, some pink in it	680	802

Sample Study 61461  
 Illinois State Geological Survey

Appendix 2

CITY OF TUSCOLA  
Ground-Water Investigation at Hayes, Illinois

STEP TEST

WATER-LEVEL MEASUREMENTS

CITY OF TUSCOLA  
Ground-Water Investigation at Hayes, IL

STEP TEST

WATER LEVEL MEASUREMENTS  
Pumped Test Well

Hour	Time (min)	Depth to water in test well (ft)	Adjusted depth to water in test well (ft)	Piez (in)	Pumping rate (crom)	Remarks
06/03/92						
09:02 am	0.0	133.52				Measured depth
09:04 am	0.0	133.48				Measured depth
10:33 am	0.0					McDAS started
						Early water level trend
						data lost due to error
11:53 am	0.0	132.53				Water level trend
	0.0	132.53				
11:55 am	0.0	132.53				
	0.0	132.63				
	0.0	132.53				
	0.0	132.53				
	0.0	132.53				
11:59 am	0.0	132.53				
	0.0	132.53				
12:00 pm	0.0	132.63				Pump On; Step 1
	1.0	207.08				
	2.0	211.20				
	3.0	216.98				
	4.0	229.83				
12:05 pm	5.0	236.69				
	6.0	242.07				
	7.0	246.35	*			
	7.2	248.12	242.84	37.0	241	* D/W values adjusted to 230 gpm
	8.0	253.10				
	9.0	256.48				
12:10 pm	10.0	259.27				
	11.0	260.80	257.01	36.0	237	
	11.4	261.44	255.56	37.0	241	
	12.0	262.57				
	12.6	263.37	257.40	37.0	241	
	13.0	263.75	257.76	37.0	241	Adjusted rate
	13.6	264.45	259.48	36.5	239	
	14.0	264.95	258.91	37.0	241	
12:15 pm	15.0	266.34	261.30	36.5	239	
	16.0	266.91				
	17.0	267.59	261.96	36.8	240	
	18.0	268.04				
	18.4	268.00				Adjusting rate
	19.0	268.60				
	19.2	268.69	263.56	36.5	239	
12:20 pm	20.0	269.27				
	20.6	269.82	264.65	36.5	239	
	22.0	270.08				
	24.1	269.28				
	24.9	269.46	265.98	35.5	236	Adjust rate

CITY OF TUSCOLA  
Ground-Water Investigation at Hayes, IL

STEP TEST

WATER LEVEL MEASUREMENTS (Continued)  
Pumped Test Well

Hour	Time (min)	Depth to water in test well (ft)	Adjusted depth to water in test well (ft)	Piez (in)	Pumping rate (apm)	Remarks
	26.1	270.55	264.25	37.0	241	
	27.1	271.75	267.64	36.0	237	Adjust rate
	27.5	271.51	269.13	35.0	234	Adjust rate
	28.1	270.88				
	28.5	270.48	269.29	34.5	232	
	29.5	268.60	270.40	33.0	227	Rate would not increase; just recording rate
12:30 pm	30.1	267.42	269.81	32.5	226	
	30.3	266.94	270.54	32.0	224	
	30.5	266.52	271.35	31.5	222	
	31.5	266.09	266.67	33.5	229	
	32.1	266.31	268.08	33.0	227	
	33.1	265.71	268.07	32.5	226	
	33.3	265.66	267.42	33.0	227	
	33.9	266.05	263.77	35.0	234	
	34.6	266.94	268.72	33.0	227	
	36.0	265.40	270.19	31.5	222	
	38.0	265.65	270.45	31.5	222	
	38.6	263.86	271.73	30.0	217	
	38.8	263.07	273.49	29.0	213	
	39.0	262.08				
	39.6	260.68				
12:40 pm	40.0					Change rate
12:41 pm	1.0	258.61	*			Step 2
	1.6	259.36	245.66	29.0	213	* D/W values adjusted to 190 gpm
	2.0	259.47				
	2.6	256.28	251.28	25.0	198	
	3.0	254.46				
	4.0	253.69	246.49	26.0	202	
	5.0	253.94	245.61	26.5	204	
	6.0	253.87	246.66	26.0	202	
	7.0	253.81				
	8.0	253.64				
	8.6	253.81	246.61	26.0	202	
	9.0	253.92				
12:50 pm	10.1	253.86				
	10.7	253.81	246.61	26.0	202	
	11.1	253.80				
	12.1	253.63	246.44	26.0	202	
	13.1	253.08				
	14.1	252.95				
	15.1	253.49	246.30	26.0	202	
	16.1	253.34				
	17.1	252.80				
	18.1	252.50	246.50	25.5	200	
	19.1	251.85				
01:00 pm	20.1	250.33				
	21.1	248.70	249.94	22.5	188	Adjust rate
	22.1	246.02				
	23.1	243.36	251.50	20.0	177	Valve full open
	24.1	241.23	250.55	19.5	175	

CITY OF TUSCOLA  
Ground-Water Investigation at Hayes, IL

STEP TEST

WATER LEVEL MEASUREMENTS (Continued)  
Pumped Test Well

Hour	Time (min)	Depth to water in test well (ft)	Adjusted depth to water in test well (ft)	Piez (in)	Pumping rate (qpm)	Remarks
	25.1	240.79	247.44	20.5	179	
	26.1	239.65				
	27.3	239.17	247.00	20.0	177	
	28.1	241.37	233.90	26.5	204	Rate increase w/o adj
	28.5	244.66	239.05	25.5	200	
	29.1	246.40	244.05	24.0	194	
	29.7	245.85	248.29	22.0	186	
01:10 pm	30.1	245.16				
	31.1	244.58	244.58	23.0	190	
	32.1	245.16	247.58	22.0	186	
	33.5	243.56	250.38	20.5	179	
	34.1	242.19				
	34.5	241.24	249.22	20.0	177	
	36.1	238.42	249.50	19.0	172	
	37.1	236.61	248.85	18.5	170	
	38.1	236.46				
	38.5	236.32	247.18	19.0	172	
	39.1	236.07				
	39.5	235.97				
01:20 pm	40.0					Change rate
01:21 pm	1.0	236.50	220.64	20.0	177	Step 3
	1.6	237.14	222.20	19.5	175	* D/W values adjusted to 150 gpm
	2.0	237.46				
	3.0	234.51				
	3.2	233.43	228.32	16.0	158	
	4.0	230.18	226.42	15.5	156	
	5.0	228.02				
	5.6	227.22	223.58	15.5	156	
	6.0	226.83				
	7.0	225.91				
	7.4	225.56	223.74	15.0	153	
	8.0	225.37				
	9.0	224.81	224.20	14.5	151	Adjust rate
01:30 pm	10.0	224.02				
	11.0	225.13	221.57	15.5	156	Air thru orifice tube
	12.0	226.69	221.92	16.0	158	
	13.0	228.05				
	14.0	227.92	223.09	16.0	158	
	15.0	226.97				
	16.1	226.06				
	17.0	225.18				Checking transducer at OW 1
	18.1	224.08				
	19.0	222.39				
01:40 pm	20.1	220.45	221.64	14.0	148	
	22.0	217.15				
	23.1	215.71	223.60	12.0	137	
	24.1	213.76				
	25.4	210.93	220.29	11.5	134	
	26.1	211.97				
	27.1	211.50	225.07	10.5	128	

CITY OF TUSCOLA  
Ground-Water Investigation at Hayes, IL

STEP TEST

WATER LEVEL MEASUREMENTS (Continued)  
Pumped Test Well

Hour	Time (min)	Depth to water in test well (ft)	Adjusted depth to water in test well (ft)	Piez (in)	Pumping rate (gpm)	Remarks
	28.0	211.21				
	29.1	211.18	218.64	12.0	137	
01:50 pm	30.1	213.21	222.84	11.5	134	
	31.1	211.63	225.23	10.5	128	
	31.5	210.98	226.67	10.0	125	
	32.1	210.10				
	33.5	208.59	226.05	9.5	122	
	34.1	208.05				
	35.5	207.63	224.87	9.5	122	
	36.1	207.68				
	36.9	207.54				
	37.9	207.38				
	38.9	207.52				
	39.8	207.89				
02:00 pm	40.0					Change rate
02:01 pm	1.0	207.87				Step 4
	2.0	208.37				
	2.6	209.06		10.0	125	
	3.0	207.50				
	3.6	199.88		6.5	101	
	4.0	197.63		5.0	88	
	5.0	199.14				
	5.2	199.53		9.5	122	
	6.0	202.95				
	6.6	197.73		6.0	97	
	7.0	193.33		4.5		
	8.0	185.53		3.5		
	9.0	180.93				
02:10 pm	10.0	178.53				
	11.0	181.43				
	12.0	182.73				Water sample collected;
	13.0	184.93				T= 59°F
	14.0	185.73				
	15.0	187.23				
	16.0	187.93				
	17.0	187.93				
	18.0	187.93				
	18.2	188.43				
02:19 pm	19.0					End of Test

Appendix 3

CITY OF TUSCOLA  
Ground-Water Investigation at Hayes, Illinois

AQUIFER TEST

WATER-LEVEL MEASUREMENTS

Appendix 3-1

CITY OF TUSCOLA  
Ground-Water Investigation at Hayes, Illinois

AQUIFER TEST

WATER-LEVEL MEASUREMENTS  
Pumped Test Well



CITY OF TUSCOLA  
Ground-Water Investigation at Hayes, IL

AQUIFER TEST

WATER LEVEL MEASUREMENTS  
Pumped Test Well

Hour	Time (min)	Depth to water (ft)	Observed drawdown (ft)	Drawdown at 110 gpm (ft)	Piez (in)	Rate (gpm)	Remarks
06/05/92							
	0.0	125.85					Measured depth
11:31 am	0.0	125.85					McDAS started
	0.2	125.85					Water level trend
	0.4	125.85					
	0.6	125.85					
	0.8	125.85					
	1.0	125.85					
	2.0	125.85					
	3.0	125.85					
	4.0	125.75					
	4.8	125.75					
	5.6	125.75					
	6.0	125.75					
	7.0	125.75					
	8.0	125.75					
11:40 am	9.0	125.75					
	10.0	125.75					
	11.0	125.75					
	12.0	125.75					
	13.0	125.75					
	14.0	125.75					
	15.0	125.75					
	16.0	125.75					
	17.0	125.75					
	18.0	125.75					
11:50 am	19.0	125.75					
	20.0	125.75					
	21.0	125.75					
	22.0	125.75					
	23.0	125.75					
	24.0	125.75					
	25.0	125.75					
	26.0	125.75					
	27.0	125.75					
11:59 am	28.0	125.75					
	28.2	125.75					
12:00 pm	0.000						Pump On
	0.010	125.85	0.10				
	0.015	128.45	2.70				
	0.016	136.45	10.70				
	0.016	135.55	9.80				
	0.017	141.55	15.80				
	0.018	144.55	18.80				
	0.018	145.15	19.40				
	0.019	148.45	22.70				
	0.020	148.25	22.50				
	0.020	149.65	23.90				
	0.025	142.05	16.30				
	0.031	134.45	8.70				
	0.040	130.65	4.90				

CITY OF TUSCOLA  
Ground-Water Investigation at Hayes, IL

AQUIFER TEST

WATER LEVEL MEASUREMENTS (Continued)  
Pumped Test Well

Hour	Time (min)	Depth to water (ft)	Observed drawdown (ft)	Drawdown at 110 gpm (ft)	Piez (in)	Rate (gpm)	Remarks
	0.051	130.25	4.50				
	0.060	132.15	6.40				
	0.070	133.75	8.00				
	0.080	135.15	9.40				
	0.091	136.15	10.40				
	0.101	137.45	11.70				
	0.12	139.65	13.90				
	0.14	141.85	16.10				
	0.16	143.65	17.90				
	0.18	145.75	20.00				
	0.20	147.85	22.10				
	0.25	151.75	26.00				
	0.30	155.15	29.40				
	0.35	158.65	32.90				
	0.40	161.35	35.60				
	0.45	163.85	38.10				
	0.50	166.45	40.70				
	0.61	171.05	45.30				
	0.70	174.75	49.00				
	0.80	178.55	52.80				
	0.90	181.95	56.20				
12:01 pm	1.0	185.45	59.70				
	1.1	187.85	62.10				
	1.2	190.75	65.00				
	1.3	192.59	66.84				
	1.4	194.97	69.22				
	1.5	195.72	69.97				
	1.6	196.44	70.69				
	1.8	196.70	70.95	49.40	16.0	158	
	2.0	196.70	70.95				
	2.2	196.39	70.64	52.50	14.0	148	
	2.5	196.30	70.55	50.72	15.0	153	
	2.6	196.39	70.64	49.81	15.5	156	
	3.0	196.27	70.52	52.06	14.3	149	
	3.1	196.21	70.46	52.02	14.3	149	
	3.4	196.33	70.58	51.42	14.5	151	
	3.7	196.50	70.75				
	3.9	196.75	71.00	51.72	14.5	151	Cloudy discharge
	4.0	196.83	71.08				
12:05 pm	5.0	197.91	72.16				
	6.1	198.25	72.50				
	7.0	198.40	72.65	55.11	13.5	145	
	7.5	198.56	72.81	54.12	14.0	148	
	7.8	198.77	73.02	53.19	14.5	151	
	8.0	198.92	73.17	52.95	14.8	152	
	9.0	200.20	74.45				
12:10 pm	10.1	201.22	75.47				
	10.5	201.23	75.48				
	11.0	201.23	75.48	58.06	13.0	143	Discharge still cloudy
	11.5	201.01	75.26				
	12.1	200.82	75.07				
	12.3	200.78	75.03	57.72	13.0	143	

CITY OF TUSCOLA  
Ground-Water Investigation at Hayes, IL

AQUIFER TEST

WATER LEVEL MEASUREMENTS (Continued)  
Pumped Test Well

Hour	Time (min)	Depth to water (ft)	Observed drawdown (ft)	Drawdown at 110 gpm (ft)	Piez (in)	Rate (gpm)	Remarks
	12.6	201.13	75.38	57.98	13.0	143	
	12.9	201.63	75.88	56.40	14.0	148	
	13.2	202.34	76.59	56.93	14.0	148	
	13.5	202.94	77.19	57.37	14.0	148	
	13.8	203.05	77.30	57.45	14.0	148	
	14.1	203.29	77.54				
	14.5	203.94	78.19	56.96	14.5	151	
	14.8	204.27	78.52				
12:15 pm	15.1	204.35	78.60	57.64	14.3	150	Discharge less cloudy
	15.9	204.66	78.91	58.65	14.0	148	Sediment present in discharge
	16.2	204.62	78.87	58.62	14.0	148	
	16.6	205.22	79.47	57.51	14.8	152	
	17.0	205.86	80.11	57.97	14.8	152	
	17.4	205.70	79.95	59.42	14.0	148	
	18.2	205.71	79.96	58.25	14.5	151	
12:20 pm	19.9	205.12	79.37				
	20.8	204.58	78.83				
	21.3	204.57	78.82	59.79	13.5	145	
	25.0	206.60	80.85				
	26.8	205.77	80.02	60.70	13.5	145	
	27.4	205.76	80.01	58.29	14.5	151	
	28.7	206.84	81.09	60.27	14.0	148	
	29.4	206.94	81.19	60.34	14.0	148	
12:30 pm	30.1	206.75	81.00				
	30.8	206.39	80.64	58.74	14.5	151	
	33.0	207.13	81.38				
	33.8	206.68	80.93	60.15	14.0	148	
	34.5	207.79	82.04	59.76	14.5	151	
	35.3	207.41	81.66	60.69	14.0	148	
	37.0	208.59	82.84	60.35	14.5	151	
	37.9	208.42	82.67	61.44	14.0	148	
	38.8	208.28	82.53	62.61	13.5	145	
12:40 pm	39.7	207.67	81.92	59.68	14.5	151	
	40.6	208.54	82.79	61.53	14.0	148	
	41.5	208.16	82.41	62.52	13.5	145	
	42.5	209.16	83.41	60.76	14.5	151	
	43.5	209.62	83.87	61.10	14.5	151	
	44.5	210.18	84.43				
	45.5	209.69	83.94	62.39	14.0	148	Valve full open
	46.6	208.72	82.97	62.94	13.5	145	Monitoring discharge rate
	47.7	207.42	81.67	62.82	13.0	143	
	48.8	208.74	82.99	59.67	15.0	153	
12:50 pm	49.9	206.96	81.21	63.81	12.5	140	
	51.1	206.04	80.29	61.76	13.0	143	
	52.3	205.59	79.84	62.73	12.5	140	
	53.5	204.54	78.79	61.91	12.5	140	
	54.8	203.67	77.92	62.56	12.0	137	
	56.0	203.03	77.28	63.44	11.5	134	
	57.3	202.64	76.89	63.12	11.5	134	
	58.7	201.84	76.09	62.46	11.5	134	
01:00 pm	60.0	201.43	75.68	60.76	12.0	137	
	61.4	199.46	73.71	63.34	10.5	128	

CITY OF TUSCOLA  
Ground-Water Investigation at Hayes, IL

AQUIFER TEST

WATER LEVEL MEASUREMENTS (Continued)  
Pumped Test Well

<u>Hour</u>	<u>Time (min)</u>	<u>Depth to water (ft)</u>	<u>Observed drawdown (ft)</u>	<u>Drawdown at 110 gpm (ft)</u>	<u>Piez (in)</u>	<u>Rate (gpm)</u>	<u>Remarks</u>
	64.4	198.78	73.03	62.76	10.5	128	
	65.9	198.40	72.65	63.93	10.0	125	Water clear
	67.4	197.00	71.25	64.24	9.5	122	
	70.6	194.93	69.18				
	72.2	193.36	67.61	62.50	9.0	119	
	75.7	191.22	65.47	62.62	8.5	115	
	79.2	193.61	67.86	59.72	10.0	125	
	81.1	194.37	68.62	61.87	9.5	122	
	83.0	192.47	66.72	63.82	8.5	115	
	84.9	191.38	65.63	62.78	8.5	115	
01:29 pm	88.9	190.45	64.70	61.89	8.5	115	
	93.1	190.15	64.40	61.60	8.5	115	
	97.5	192.93	67.18	60.57	9.5	122	
	99.7	194.24	68.49	61.75	9.5	122	
	102	194.27	68.52	61.78	9.5	122	
	104	194.12	68.37	61.65	9.5	122	
	107	192.00	66.25	63.37	8.5	115	
	109	192.58	66.83	63.92	8.5	115	
	114	191.58	65.83	62.97	8.5	115	
	117	191.80	66.05	63.18	8.5	115	
02:00 pm	120	193.11	67.36	62.27	9.0	119	
	122	192.83	67.08	64.16	8.5	115	
	125	192.18	66.43	63.54	8.5	115	
	128	191.45	65.70	62.84	8.5	115	
	131	191.14	65.39	63.10	8.3	114	
	137	191.47	65.72	64.55	8.0	112	
	143	188.85	63.10	61.97	8.0	112	
	150	188.35	62.60	63.76	7.5	108	
	154	190.45	64.70	63.54	8.0	112	
	161	188.05	62.30	65.27	7.0	105	
	164	186.05	60.30	63.17	7.0	105	
	172	185.75	60.00	65.35	6.5	101	
03:00 pm	180	183.65	57.90	63.06	6.5	101	
	184	185.05	59.30	63.33	6.8	103	
	189	186.55	60.80	60.80	7.3	110	
	197	188.35	62.60	62.60	7.3	110	
	202	186.75	61.00	63.90	7.0	105	
	211	183.75	58.00	63.17	6.5	101	
	221	187.65	61.90	64.85	7.0	105	
	226	186.65	60.90	63.80	7.0	105	
03:57 pm	237	184.15	58.40	63.60	6.5	101	
	248	181.85	56.10	63.62	6.0	97	
	266	177.05	51.30	62.70	5.3	90	
	272	177.75	52.00	69.50	11.0	82.3	Changed to 254" orifice
	278	179.05	53.30	71.24	11.0	82.3	Correcting tube position
	284	175.85	50.10	66.96	11.0	82.3	
04:51 pm	291	175.85	50.10	66.96	11.0	82.3	Water sample collected
05:05 pm	306	175.75	50.00	66.83	11	82.3	Omni data loggers
05:30 pm	330	291.05	165.30				started
06:00 pm	360	175.95	50.20	67.10	11	82.3	
06:40 pm	400	169.65	43.90	64.82	9	74.5	
07:00 pm	420	166.65	40.90	74.49	16	60.4	Changed to 2" orifice

CITY OF TUSCOLA  
Ground-Water Investigation at Hayes, IL

AQUIFER TEST

WATER LEVEL MEASUREMENTS (Continued)  
Pumped Test Well

Hour	Time (min)	Depth to water (ft)	Observed drawdown (ft)	Drawdown at 110 gpm (ft)	Piez (in)	Rate (gpm)	Remarks
08:00 pm	480	166.75	41.00	75.80	15.5	59.5	
08:20 pm	500	166.25	40.50	66.79	19.5	66.7	
09:00 pm	540	169.45	43.70	73.05	19	65.8	
10:00 pm	600	169.65	43.90	73.39	19	65.8	
11:00 pm	660	167.35	41.60	74.65	16.5	61.3	
11:40 pm	700	167.55	41.80				
06/06/92							
12:00 am	720	166.15	40.40	69.33	18	64.1	
01:00 am	780	164.05	38.30	77.44	13	54.4	
01:20 am	800	163.95	38.20				
02:00 am	840	162.25	36.50	80.14	11	50.1	
03:00 am	900	158.55	32.80	82.00	8.5	44	
04:00 am	960	158.75	33.00	78.06	9.5	46.5	
04:40 am	1000	159.45	33.70				
05:00 am	1020	159.35	33.60	79.48	9.5	46.5	
06:00 am	1080	158.65	32.90	77.83	9.5	46.5	
06:20 am	1100	158.85	33.10				
07:00 am	1140	157.65	31.90	82.18	8	42.7	
08:00 am	1200	159.85	34.10	78.47	10	47.8	
09:00 am	1260	159.45	33.70	75.81	10.5	48.9	
09:40 am	1300	157.15	31.40				
10:00 am	1320	156.75	31.00	82.37	7.5	41.4	
11:00 am	1380	155.05	29.30	83.71	6.5	38.5	
11:20 am	1400	154.95	29.20				
12:00 pm	1440	155.15	29.40	84.00	6.5	38.5	
01:00 pm	1500	155.25	29.50	84.29	6.5	38.5	
01:59 pm	1560	154.95	29.20	83.43	6.5	38.5	
02:39 pm	1600	153.05	27.30				
03:00 pm	1620	152.65	26.90	87.54	5	33.8	
03:29 pm	1650	152.15	26.40				
03:35 pm	1655	152.15	26.40				McDAS Started
	1656	152.25	26.50				
	1657	152.35	26.60				
	1658	152.15	26.40				
	1659	152.25	26.50				
	1660	152.25	26.50				
	1661	152.15	26.40				
	1662	152.15	26.40				
	1663	152.15	26.40				
	1664	152.15	26.40				
03:45 pm	1665	152.15					Pump Off
	0.0	152.25					Recovery
	0.2	141.55					
	0.4	136.85					
	0.6	136.65					
	0.8	138.35					
	1.0	139.35					
	1.2	140.05					
	1.4	140.55					
	1.6	140.75					
	1.8	140.95					
	2.0	141.15					

CITY OF TUSCOLA  
Ground-Water Investigation at Hayes, IL

AQUIFER TEST

WATER LEVEL MEASUREMENTS (Continued)  
Pumped Test Well

<u>Hour</u>	<u>Time (min)</u>	<u>Depth to water (ft)</u>	<u>Observed drawdown (ft)</u>	<u>Drawdown at 110 gpm (ft)</u>	<u>Piez (in)</u>	<u>Rate (gpm)</u>	<u>Remarks</u>
	2.4	141.25					
	3.0	140.05					
	4.0	139.25					
03:50 pm	5.0	140.05					
	6.0	140.35					
	7.0	140.35					
	8.0	140.25					
	9.0	140.15					
03:55 pm	10.0	139.85					
	12.0	139.65					
	14.0	139.65					
	16.0	139.25					
	18.0	139.15					
04:05 pm	20.0	139.05					
	22.0	138.95					
	25.0	138.75					
04:15 pm	30.0	138.55					
	35.1	138.35					
04:25 pm	40.0	138.25					
	45.0	138.05					
04:35 pm	50.1	138.05					
	54.9	138.35					
04:45 pm	60.0	138.95					
	65.1	138.75					
04:55 pm	70.1	138.75					
	75.1	138.55					
05:05 pm	80.1	138.45					
	85.0	138.35					
05:15 pm	90.0	138.25					
	95.1	138.15					
05:25 pm	100	138.05					
	105	137.95					
05:35 pm	110	137.95					
05:45 pm	120	135.85					Omnidata started
05:55 pm	130	135.65					
06:05 pm	140	135.55					
06:15 pm	150	135.35					
06:25 pm	160	135.25					
06:35 pm	170	135.15					
06:45 pm	180	134.95					
06:55 pm	190	134.85					
07:05 pm	200	134.75					
07:15 pm	210	134.65					
07:25 pm	220	134.55					
07:45 pm	240	134.35					
08:15 pm	270	134.15					
08:45 pm	300	133.85					
09:45 pm	360	133.45					
10:25 pm	400	132.95					
10:45 pm	420	132.85					
11:45 pm	480	132.35					

CITY OF TUSCOLA  
Ground-Water Investigation at Hayes, IL

AQUIFER TEST

WATER LEVEL MEASUREMENTS (Continued)  
Pumped Test Well

<u>Hour</u>	<u>Time (min)</u>	<u>Depth to water (ft)</u>	<u>Observed drawdown (ft)</u>	<u>Drawdown at 110 gpm (ft)</u>	<u>Piez (in)</u>	<u>Rate (gpm)</u>	<u>Remarks</u>
06/07/92							
	12:05 am	500	132.25				
	12:45 am	540	132.05				
	01:45 am	600	131.85				
	02:45 am	660	131.55				
	03:25 am	700	131.35				
	03:45 am	720	131.25				
	04:45 am	780	130.95				
	05:05 am	800	130.85				
	05:45 am	840	130.75				
	06:45 am	900	130.55				
	07:45 am	960	130.35				
	08:25 am	1000	130.15				
	08:45 am	1020	130.35				End of Test

Appendix 3-2

CITY OF TUSCOLA  
Ground-Water Investigation at Hayes, Illinois

AQUIFER TEST

WATER-LEVEL MEASUREMENTS  
Observation Well 1



CITY OF TUSCOLA  
Ground-Water Investigation at Hayes, IL

AQUIFER TEST

WATER LEVEL MEASUREMENTS  
Observation Well 1

<u>Hour</u>	<u>Time (min)</u>	<u>Depth to water (ft)</u>	<u>Observed drawdown (ft)</u>	<u>Drawdown at 110 gpm (ft)</u>	<u>Piez (in)</u>	<u>Rate (gpm)</u>	<u>Remarks</u>
06/05/92							
11:31 am	0.0	98.70					Measured depth McDAS started Water level trend
	0.2						
	0.4	98.72					
	0.6	98.72					
	0.8	98.72					
	1.0	98.72					
	2.0	98.72					
	3.0	98.72					
	4.0	98.72					
	4.8	98.72					
	5.6	98.71					
	6.0	98.72					
	7.0	98.70					
	8.0	98.69					
11:40 am	9.0	98.69					
	10.0	98.69					
	11.0	98.69					
	12.0	98.69					
	13.0	98.69					
	14.0	98.68					
	15.0	98.69					
	16.0	98.67					
	17.0	98.67					
	18.0	98.68					
11:50 am	19.0	98.68					
	20.0	98.68					
	21.0	98.71					
	22.0	98.68					
	23.0	98.68					
	24.0	98.68					
	25.0	98.68					
	26.0	98.68					
	27.0	98.68					
11:59 am	28.0	98.68					
	28.2	98.68					
12:00 pm	0.000						Test Well Pump On
	0.010	98.72	0.02				
	0.015	98.70	0.00				
	0.016	98.68	-0.02				
	0.016	98.70	0.00				
	0.017	98.70	0.00				
	0.018	98.68	-0.02				
	0.018	98.70	0.00				
	0.019	98.70	0.00				
	0.020	98.72	0.02				
	0.020	98.68	-0.02				
	0.025	98.68	-0.02				
	0.031	98.68	-0.02				
	0.040	98.70	0.00				
	0.051	98.70	0.00				

CITY OF TUSCOLA  
Ground-Water Investigation at Hayes, IL

AQUIFER TEST

WATER LEVEL MEASUREMENTS (Continued)  
Observation Well 1

Hour	Time (min)	Depth to water (ft)	Observed drawdown (ft)	Drawdown at 110 gpm (ft)	Piez (in)	Rate (gpm)	Remarks
	0.060	98.70	0.00				
	0.070	98.70	0.00				
	0.080	98.70	0.00				
	0.091	98.70	0.00				
	0.101	98.70	0.00				
	0.12	98.70	0.00				
	0.14	98.70	0.00				
	0.16	98.70	0.00				
	0.18	98.70	0.00				
	0.20	98.70	0.00				
	0.25	98.72	0.02				
	0.30	98.72	0.02				
	0.35	98.68	-0.02				
	0.40	98.68	-0.02				
	0.45	98.69	-0.01				
	0.50	98.70	0.00				
	0.61	98.69	-0.01				
	0.70	98.69	-0.01				
	0.80	98.68	-0.02				
	0.90	98.69	-0.01				
12:01 pm	1.0	98.68	-0.02				
	1.1	98.69	-0.01				
	1.2	98.69	-0.01				
	1.3	98.69	-0.01				
	1.4	98.69	-0.01				
	1.5	98.69	-0.01				
	1.6	98.69	-0.01				
	1.8	98.69	-0.01	-0.007	16.0	158	
	2.0	98.69	-0.01				
	2.2	98.69	-0.01	-0.007	14.0	148	
	2.5	98.70	0.00	0.000	15.0	153	
	2.6	98.70	0.00	0.000	15.5	156	
	3.0	98.70	0.00	0.000	14.3	149	
	3.1	98.70	0.00	0.000	14.3	149	
	3.4	98.69	-0.01	-0.007	14.5	151	
	3.7	98.70	0.00				
	3.9	98.70	0.00	0.000	14.5	151	
	4.0	98.70	0.00				
12:05 pm	5.0	98.71	0.01				
	6.1	98.71	0.01				
	7.0	98.71	0.01	0.008	13.5	145	
	7.5	98.71	0.01	0.007	14.0	148	
	7.8	98.72	0.02	0.015	14.5	151	
	8.0	98.71	0.01	0.007	14.8	152	
	9.0	98.72	0.02				
12:10 pm	10.1	98.73	0.03				
	10.5	98.73	0.03				
	11.0	98.74	0.04	0.031	13.0	143	
	11.5	98.73	0.03				
	12.1	98.74	0.04				
	12.3	98.74	0.04	0.031	13.0	143	
	12.6	98.73	0.03	0.023	13.0	143	

CITY OF TUSCOLA  
Ground-Water Investigation at Hayes, IL

AQUIFER TEST

WATER LEVEL MEASUREMENTS (Continued)  
Observation Well 1

Hour	Time (min)	Depth to water (ft)	Observed drawdown (ft)	Drawdown at 110 gpm (ft)	Piez (in)	Rate (qpm)	Remarks
	12.9	98.74	0.04	0.030	14.0	148	
	13.2	98.74	0.04	0.030	14.0	148	
	13.5	98.73	0.03	0.022	14.0	148	
	13.8	98.74	0.04	0.030	14.0	148	
	14.1	98.74	0.04				
	14.5	98.74	0.04	0.029	14.5	151	
	14.8	98.75	0.05				
12:15 pm	15.1	98.74	0.04	0.029	14.3	150	
	15.9	98.75	0.05	0.037	14.0	148	
	16.2	98.76	0.06	0.045	14.0	148	
	16.6	98.76	0.06	0.043	14.8	152	
	17.0	98.75	0.05	0.036	14.8	152	
	17.4	98.76	0.06	0.045	14.0	148	
	18.2	98.76	0.06	0.044	14.5	151	
12:20 pm	19.9	98.76	0.06				
	20.8	98.77	0.07				
	21.3	98.76	0.06	0.046	13.5	145	
	25.0	98.78	0.08				
	26.8	98.79	0.09	0.068	13.5	145	
	27.4	98.80	0.10	0.073	14.5	151	
	28.7	98.79	0.09	0.067	14.0	148	
	29.4	98.80	0.10	0.074	14.0	148	
12:30 pm	30.1	98.81	0.11				
	30.8	98.81	0.11	0.080	14.5	151	
	33.0	98.81	0.11				
	33.8	98.82	0.12	0.089	14.0	148	
	34.5	98.82	0.12	0.087	14.5	151	
	35.3	98.82	0.12	0.089	14.0	148	
	37.0	98.83	0.13	0.095	14.5	151	
	37.9	98.83	0.13	0.097	14.0	148	
	38.8	98.84	0.14	0.106	13.5	145	
12:40 pm	39.7	98.85	0.15	0.109	14.5	151	
	40.6	98.85	0.15	0.111	14.0	148	
	41.5	98.84	0.14	0.106	13.5	145	
	42.5	98.85	0.15	0.109	14.5	151	
	43.5	98.86	0.16	0.117	14.5	151	
	44.5	98.85	0.15				
	45.5	98.87	0.17	0.126	14.0	148	
	46.6	98.87	0.17	0.129	13.5	145	
	47.7	98.87	0.17	0.131	13.0	143	
	48.8	98.88	0.18	0.129	15.0	153	
12:50 pm	49.9	98.89	0.19	0.149	12.5	140	
	51.1	98.89	0.19	0.146	13.0	143	
	52.3	98.89	0.19	0.149	12.5	140	
	53.5	98.90	0.20	0.157	12.5	140	
	54.8	98.90	0.20	0.161	12.0	137	
	56.0	98.91	0.21	0.172	11.5	134	
	57.3	98.90	0.20	0.164	11.5	134	
	58.7	98.91	0.21	0.172	11.5	134	
01:00 pm	60.0	98.91	0.21	0.169	12.0	137	
	61.4	98.92	0.22	0.189	10.5	128	
	64.4	98.93	0.23	0.198	10.5	128	

CITY OF TUSCOLA  
Ground-Water Investigation at Hayes, IL

AQUIFER TEST

WATER LEVEL MEASUREMENTS (Continued)  
Observation Well 1

Hour	Time (min)	Depth to water (ft)	Observed drawdown (ft)	Drawdown at 110 gpm (ft)	Piez (in)	Rate (gpm)	Remarks
	65.9	98.93	0.23	0.20	10.0	125	
	67.4	98.93	0.23	0.21	9.5	122	
	70.6	98.95	0.25				
	72.2	98.95	0.25	0.23	9.0	119	
	75.7	98.96	0.26	0.25	8.5	115	
	79.2	98.98	0.28	0.25	10.0	125	
	81.1	98.98	0.28	0.25	9.5	122	
	83.0	98.99	0.29	0.28	8.5	115	
	84.9	98.99	0.29	0.28	8.5	115	
01:29 pm	88.9	99.01	0.31	0.30	8.5	115	
	93.1	99.02	0.32	0.31	8.5	115	
	97.5	99.04	0.34	0.31	9.5	122	
	99.7	99.04	0.34	0.31	9.5	122	
	102	99.06	0.36	0.32	9.5	122	
	104	99.06	0.36	0.32	9.5	122	
	107	99.07	0.37	0.35	8.5	115	
	109	99.07	0.37	0.35	8.5	115	
	114	99.09	0.39	0.37	8.5	115	
	117	99.09	0.39	0.37	8.5	115	
02:00 pm	120	99.10	0.40	0.37	9.0	119	
	122	99.12	0.42	0.40	8.5	115	
	125	99.12	0.42	0.40	8.5	115	
	128	99.13	0.43	0.41	8.5	115	
	131	99.13	0.43	0.41	8.3	114	
	137	99.16	0.46	0.45	8.0	112	
	143	99.17	0.47	0.46	8.0	112	
	150	99.19	0.49	0.50	7.5	108	
	154	99.20	0.50	0.49	8.0	112	
	161	99.23	0.53	0.56	7.0	105	
	164	99.24	0.54	0.57	7.0	105	
	172	99.25	0.55	0.60	6.5	101	
03:00 pm	180	99.27	0.57	0.62	6.5	101	
	184	99.28	0.58	0.62	6.8	103	
	189	99.30	0.60	0.60	7.3	110	
	197	99.31	0.61	0.61	7.3	110	
	202	99.33	0.63	0.66	7.0	105	
	211	99.34	0.64	0.70	6.5	101	
	221	99.37	0.67	0.70	7.0	105	
	226	99.38	0.68	0.71	7.0	105	
03:57 pm	237	99.40	0.70	0.76	6.5	101	
	248	99.42	0.72	0.82	6.0	97.0	
	266	99.44	0.74	0.90	5.3	90.0	
	272	99.45	0.75	1.00	11.0	82.3	
	278	99.46	0.76	1.02	11.0	82.3	
	284	99.48	0.78	1.04	11.0	82.3	
04:51 pm	291	99.49	0.79	1.06	11.0	82.3	
05:05 pm	306	99.49	0.79	1.06	11	82.3	Omni data loggers
05:30 pm	330	99.50	0.80				
06:00 pm	360	99.55	0.85	1.14	11	82.3	
06:40 pm	400	99.60	0.90	1.33	9	74.5	
07:00 pm	420	99.63	0.93	1.69	16	60.4	
08:00 pm	480	99.68	0.98	1.81	15.5	59.5	

CITY OF TUSCOLA  
Ground-Water Investigation at Hayes, IL

AQUIFER TEST

WATER LEVEL MEASUREMENTS (Continued)  
Observation Well 1

Hour	Time (min)	Depth to water (ft)	Observed drawdown (ft)	Drawdown at 110 gpm (ft)	Piez (in)	Rate (gpm)	Remarks
08:20 pm	500	99.71	1.01	1.67	19.5	66.7	
09:00 pm	540	99.76	1.06	1.77	19	65.8	
10:00 pm	600	99.84	1.14	1.91	19	65.8	
11:00 pm	660	99.89	1.19	2.14	16.5	61.3	
11:40 pm	700	99.93	1.23				
06/06/92							
12:00 am	720	99.93	1.23	2.11	18	64.1	
01:00 am	780	99.96	1.26	2.55	13	54.4	
01:20 am	800	99.97	1.27				
02:00 am	840	100.00	1.30	2.85	11	50.1	
03:00 am	900	100.00	1.30	3.25	8.5	44.0	
04:00 am	960	100.02	1.32	3.12	9.5	46.5	
04:40 am	1000	100.03	1.33				
05:00 am	1020	100.03	1.33	3.15	9.5	46.5	
06:00 am	1080	100.05	1.35	3.19	9.5	46.5	
06:20 am	1100	100.05	1.35				
07:00 am	1140	100.05	1.35	3.48	8	42.7	
08:00 am	1200	100.01	1.31	3.01	10	47.8	
09:00 am	1260	100.01	1.31	2.95	10.5	48.9	
09:40 am	1300	99.99	1.29				
10:00 am	1320	99.98	1.28	3.40	7.5	41.4	
11:00 am	1380	99.97	1.27	3.63	6.5	38.5	
11:20 am	1400	99.97	1.27				
12:00 pm	1440	99.97	1.27	3.63	6.5	38.5	
01:00 pm	1500	99.96	1.26	3.60	6.5	38.5	
01:59 pm	1560	99.97	1.27	3.63	6.5	38.5	
02:39 pm	1600	99.96	1.26				
03:00 pm	1620	99.95	1.25	4.07	5	33.8	
03:29 pm	1650	99.95	1.25				
03:35 pm	1655	99.95	1.25				McDAS Started
	1656	99.95	1.25				
	1657	100.02	1.32				
	1658	99.96	1.26				
	1659	99.97	1.27				
	1660	99.96	1.26				
	1661	99.95	1.25				
	1662	99.95	1.25				
	1663	99.94	1.24				
	1664	99.97	1.27				
03:45 pm	1665	99.95	1.25				Test Well Pump Off Recovery
	0.0	99.99					
	0.2	100.00					
	0.4	99.98					
	0.6	99.98					
	0.8	99.99					
	1.0	99.98					
	1.2	99.98					
	1.4	99.98					
	1.6	99.98					
	1.8	99.98					
	2.0	99.98					
	2.4	99.99					

CITY OF TUSCOLA  
Ground-Water Investigation at Hayes, IL

AQUIFER TEST

WATER LEVEL MEASUREMENTS (Continued)  
Observation Well 1

Hour	Time (min)	Depth to water (ft)	Observed drawdown (ft)	Drawdown at 110gpm (ft)	Piez (in)	Rate (gpm)	Remarks
	3.0	99.97					
	4.0	99.95					
03:50 pm	5.0	99.94					
	6.0	99.95					
	7.0	99.95					
	8.0	99.96					
	9.0	99.98					
03:55 pm	10.0	99.93					
	12.0	99.87					
	14.0	99.93					
	16.0	99.87					
	18.0	99.88					
04:05 pm	20.0	99.90					
	22.0	99.90					
	25.0	99.91					
04:15 pm	30.0	99.92					
	35.1	99.89					
04:25 pm	40.0	99.94					
	45.0	99.92					
04:35 pm	50.1	99.96					
	54.9	100.12					
04:45 pm	60.0	100.40					
	65.1	100.39					
04:55 pm	70.1	100.39					
	75.1	100.39					
05:05 pm	80.1	100.38					
	85.0	100.38					
05:15 pm	90.0	100.38					
	95.1	100.37					
05:25 pm	100	100.36					
	105	100.36					
05:35 pm	110	100.36					
05:45 pm	120	100.35					Omnidata started
05:55 pm	130	100.34					
06:05 pm	140	100.33					
06:15 pm	150	100.32					
06:25 pm	160	100.31					
06:35 pm	170	100.31					
06:45 pm	180	100.29					
06:55 pm	190	100.28					
07:05 pm	200	100.27					
07:15 pm	210	100.26					
07:25 pm	220	100.24					
07:45 pm	240	100.21					
08:15 pm	270	100.18					
08:45 pm	300	100.19					
09:45 pm	360	100.19					
10:25 pm	400	100.15					
10:45 pm	420	100.12					
11:45 pm	480	100.03					
06/07/92							
12:05 am	500	100.01					

CITY OF TUSCOLA  
Ground-Water Investigation at Hayes, IL

AQUIFER TEST

WATER LEVEL MEASUREMENTS (Continued)  
Observation Well 1

<u>Hour</u>	<u>Time (min)</u>	<u>Depth to water (ft)</u>	<u>Observed drawdown (ft)</u>	<u>Drawdown at 110 gpm (ft)</u>	<u>Piez (in)</u>	<u>Rate (gpm)</u>	<u>Remarks</u>
12:45 am	540	99.96					
01:45 am	600	99.91					
02:45 am	660	99.84					
03:25 am	700	99.82					
03:45 am	720	99.80					
04:45 am	780	99.77					
05:05 am	800	99.75					
05:45 am	840	99.74					
06:45 am	900	99.71					
07:45 am	960	99.67					
08:25 am	1000	99.67					
08:45 am	1020	99.76					End of Test

Appendix 3-3

CITY OF TUSCOLA  
Ground-Water Investigation at Hayes, Illinois

AQUIFER TEST

WATER-LEVEL MEASUREMENTS  
Observation Well 2



CITY OF TUSCOLA  
Ground-Water Investigation at Hayes, IL

AQUIFER TEST

WATER LEVEL MEASUREMENTS  
Observation Well 2

<u>Hour</u>	<u>Time (min)</u>	<u>Depth to water (ft)</u>	<u>Observed drawdown (ft)</u>	<u>Drawdown at 110 gpm (ft)</u>	<u>Piez (in)</u>	<u>Rate (gpm)</u>	<u>Remarks</u>
06/05/92							
09:05 am	0	113.94					Measured depth
10:10 am	0	113.93					Omnidata started
10:15 am	5	113.93					Water level trend
10:20 am	10	113.92					
10:25 am	15	113.91					
10:30 am	20	113.90					
10:40 am	30	113.89					
10:50 am	40	113.88					
11:00 am	50	113.87					
11:10 am	60	113.86					
11:20 am	70	113.84					
11:30 am	80	113.83					
11:40 am	90	113.82					
11:50 am	100	113.81					
11:55 am	105	113.80					
11:59 am	109	113.80					
12:00 pm	0	113.80	0.00				Test Well Pump On
12:01 pm	1	113.80	0.00				
12:02 pm	2	113.80	0.00	0.00	14.0	148	
12:03 pm	3	113.80	0.00	0.00	14.3	149	
12:04 pm	4	113.80	0.00	0.00	14.5	151	
12:05 pm	5	113.80	0.00				
12:06 pm	6	113.80	0.00				
12:07 pm	7	113.81	0.01	0.01	13.5	145	
12:08 pm	8	113.81	0.01	0.01	14.8	152	
12:09 pm	9	113.81	0.01				
12:10 pm	10	113.81	0.01				
12:11 pm	11	113.82	0.02	0.02	13.0	143	
12:12 pm	12	113.82	0.02	0.02	13.0	143	
12:13 pm	13	113.83	0.03	0.02	14.0	148	
12:14 pm	14	113.83	0.03	0.02	14.0	148	
12:15 pm	15	113.84	0.04	0.03	14.3	150	
12:16 pm	16	113.85	0.05	0.04	14.0	148	
12:17 pm	17	113.85	0.05	0.04	14.8	152	
12:18 pm	18	113.86	0.06	0.04	14.5	151	
12:19 pm	19	113.87	0.07				
12:20 pm	20	113.88	0.08				
12:22 pm	22	113.90	0.10	0.07	14.5	151	
12:24 pm	24	113.93	0.13				
12:26 pm	26	113.95	0.15				
12:28 pm	28	113.97	0.17	0.13	14.0	148	
12:30 pm	30	114.00	0.20	0.15	13.5	145	
12:35 pm	35	114.06	0.26	0.19	14.0	148	
12:40 pm	40	114.13	0.33	0.24	14.5	151	
12:45 pm	45	114.20	0.40	0.30	14.0	148	
12:50 pm	50	114.28	0.48	0.38	12.5	140	
12:55 pm	55	114.35	0.55	0.44	12.0	137	
01:00 pm	60	114.41	0.61	0.49	12.0	137	
01:05 pm	65	114.48	0.68	0.60	10.0	125	
01:10 pm	70	114.54	0.74				
01:15 pm	75	114.60	0.80	0.77	8.5	115	
01:20 pm	80	114.66	0.86	0.78	9.5	122	

CITY OF TUSCOLA  
Ground-Water Investigation at Hayes, IL

AQUIFER TEST

WATER LEVEL MEASUREMENTS (Continued)  
Observation Well 2

<u>Hour</u>	<u>Time (min)</u>	<u>Depth to water (ft)</u>	<u>Observed drawdown (ft)</u>	<u>Drawdown at 110 gpm (ft)</u>	<u>Piez (in)</u>	<u>Rate (gpm)</u>	<u>Remarks</u>
01:25 pm	85	114.71	0.91	0.87	8.5	115	
01:30 pm	90	114.77	0.97	0.93	8.5	115	
01:35 pm	95	114.81	1.01				
01:40 pm	100	114.86	1.06	0.96	9.5	122	
01:50 pm	110	114.95	1.15	1.10	8.5	115	
02:00 pm	120	115.04	1.24	1.15	9.0	119	
02:10 pm	130	115.12	1.32	1.27	8.3	114	
02:20 pm	140	115.21	1.41				
02:30 pm	150	115.28	1.48	1.51	7.5	108	
02:40 pm	160	115.35	1.55	1.62	7.0	105	
02:50 pm	170	115.42	1.62				
03:00 pm	180	115.48	1.68	1.83	6.5	101	
03:10 pm	190	115.54	1.74	1.74	7.3	110	
03:20 pm	200	115.59	1.79	1.88	7.0	105	
03:30 pm	210	115.65	1.85	2.01	6.5	101	
03:58 pm	238	115.78	1.98	2.16	6.5	101	
04:58 pm	298	116.00	2.20	2.94	11.0	82.3	
05:58 pm	358	116.13	2.33	3.11	11.0	82.3	
06:38 pm	398	116.20	2.40	3.54	9.0	74.5	
06:58 pm	418	116.21	2.41	4.39	16.0	60.4	
07:58 pm	478	116.24	2.44	4.51	15.5	59.5	
08:18 pm	498	116.25	2.45	4.04	19.5	66.7	
08:58 pm	538	116.27	2.47	4.13	19.0	65.8	
09:58 pm	598	116.35	2.55	4.26	19.0	65.8	
10:58 pm	658	116.43	2.63	4.72	16.5	61.3	
11:38 pm	698	116.45	2.65				
11:58 pm	718	116.47	2.67	4.58	18.0	64.1	
12:58 am	778	116.50	2.70	5.46	13.0	54.4	
06/06/92							
01:18 am	798	116.50	2.70				
01:58 am	838	116.51	2.71	5.95	11.0	50.1	
02:58 am	898	116.51	2.71	6.78	8.5	44.0	
03:58 am	958	116.47	2.67	6.32	9.5	46.5	
04:58 am	1018	116.45	2.65	6.27	9.5	46.5	
05:58 am	1078	116.45	2.65	6.27	9.5	46.5	
06:58 am	1138	116.45	2.65	6.83	8.0	42.7	
07:58 am	1198	116.44	2.64	6.08	10.0	47.8	
08:58 am	1258	116.47	2.67	6.01	10.5	48.9	
09:58 am	1318	116.48	2.68	7.12	7.5	41.4	
10:58 am	1378	116.46	2.66	7.60	6.5	38.5	
11:58 am	1438	116.42	2.62	7.49	6.5	38.5	
12:58 pm	1498	116.40	2.60	7.43	6.5	38.5	
01:58 pm	1558	116.39	2.59	7.40	6.5	38.5	
02:58 pm	1618	116.36	2.56	8.33	5.0	33.8	
03:30 pm	1650	116.34	2.54	8.27	5.0	33.8	
03:40 pm	1660	116.33	2.53				
03:45 pm	1665	116.33	2.53	8.23	5.0	33.8	Test Well Pump Off
03:46 pm	1	116.33					Recovery
03:47 pm	2	116.33					
03:48 pm	3	116.33					
03:49 pm	4	116.33					
03:50 pm	5	116.33					
03:51 pm	6	116.33					

CITY OF TUSCOLA  
Ground-Water Investigation at Hayes, IL

AQUIFER TEST

WATER LEVEL MEASUREMENTS (Continued)  
Observation Well 2

Hour	Time (min)	Depth to water (ft)	Observed drawdown (ft)	Drawdown at 110 gpm (ft)	Piez (in)	Rate (gpm)	Remarks
03:52 pm	7	116.33					
03:53 pm	8	116.33					
03:54 pm	9	116.32					
03:55 pm	10	116.32					
03:56 pm	11	116.32					
03:57 pm	12	116.32					
03:58 pm	13	116.31					
03:59 pm	14	116.31					
04:00 pm	15	116.31					
04:01 pm	16	116.31					
04:02 pm	17	116.30					
04:03 pm	18	116.30					
04:04 pm	19	116.30					
04:05 pm	20	116.29					
04:07 pm	22	116.29					
04:09 pm	24	116.28					
04:11 pm	26	116.27					
04:13 pm	28	116.26					
04:15 pm	30	116.25					
04:20 pm	35	116.23					
04:25 pm	40	116.21					
04:30 pm	45	116.18					
04:35 pm	50	116.16					
04:40 pm	55	116.14					
04:45 pm	60	116.11					
04:50 pm	65	116.09					
04:55 pm	70	116.07					
05:00 pm	75	116.05					
05:05 pm	80	116.03					
05:10 pm	85	116.01					
05:15 pm	90	115.99					
07:45 pm	240	115.41					
08:15 pm	270	115.33					
08:45 pm	300	115.25					
09:45 pm	360	115.09					
10:25 pm	400	114.99					
10:45 pm	420	114.94					
11:45 pm	480	114.81					
06/07/92							
12:45 am	540	114.69					
01:45 am	600	114.58					
02:45 am	660	114.49					
03:35 am	700	114.41					
03:45 am	720	114.40					
04:45 am	780	114.31					
05:05 am	800	114.29					
05:45 am	840	114.24					
06:45 am	900	114.16					
07:45 am	960	114.08					
08:25 am	1000	114.04					
08:45 am	1020	114.02					
09:25 am	1060	113.98					
09:35 am	1070	113.97					

End of Test

Appendix 3-4

CITY OF TUSCOLA  
Ground-Water Investigation at Hayes, Illinois

AQUIFER TEST

WATER-LEVEL MEASUREMENTS  
Observation Well 3 (CFI)

CITY OF TUSCOLA  
Ground-Water Investigation at Hayes, IL

AQUIFER TEST

WATER LEVEL MEASUREMENTS  
Observation Well 3 (C.F.I.)

<u>Hour</u>	<u>Time (min)</u>	<u>Depth to water (ft)</u>	<u>Observed drawdown (ft)</u>	<u>Drawdown at 110gpm (ft)</u>	<u>Piez (in)</u>	<u>Rate (gpm)</u>	<u>Remarks</u>
06/02/92							
	01:20 pm	88.69					Measured depth
06/03/92							
	11:11 am	88.69					Omnidata started
	11:12am	88.69					
	11:13 am	88.69					
	11:14am	88.69					
	11:15am	88.69					
	11:16 am	88.69					
	11:17am	88.69					
	11:18 am	88.69					
	11:19 am	88.69					
	11:20 am	88.69					
	11:30 am	88.69					
	11:40 am	88.70					
	11:50 am	88.71					
	12:00 pm	88.71					Test Well Pump On
	12:01 pm	88.71					Step Test Started
	12:10 pm	88.71					
	12:20 pm	88.72					
	12:30 pm	88.72					
	12:40 pm	88.73					
	12:50 pm	88.73					
	01:00 pm	88.73					
	01:10 pm	88.73					
	01:20 pm	88.73					
	01:30 pm	88.74					
	01:40 pm	88.75					
	01:50 pm	88.75					
	02:00 pm	88.76					
	02:10 pm	88.76					
	02:20 pm	88.77					Step Test End
	02:30 pm	88.77					Water level trend
	02:40 pm	88.77					
	02:50 pm	88.78					
	02:55 pm	88.79					
	02:56 pm	88.79					
	03:10 pm	88.80					
	03:30 pm	88.81					
	03:40 pm	88.82					
	03:50 pm	88.82					
	04:00 pm	88.83					
	04:30 pm	88.84					
	05:00 pm	88.86					
	06:00 pm	88.89					
	07:00 pm	88.92					
	08:00 pm	88.95					
	09:00 pm	88.98					
	10:00 pm	89.02					
	11:00 pm	89.04					
06/04/92							
	12:00 am	89.06					
	01:00 am	89.07					

CITY OF TUSCOLA  
Ground-Water Investigation at Hayes, IL

AQUIFER TEST

WATER LEVEL MEASUREMENTS (Continued)  
Observation Well 3 (C.F.I.)

<u>Hour</u>	<u>Time (min)</u>	<u>Depth to water (ft)</u>	<u>Observed drawdown (ft)</u>	<u>Drawdown at 110 gpm (ft)</u>	<u>Piez (in)</u>	<u>Rate (gpm)</u>	<u>Remarks</u>
02:00 am		89.09					
03:00 am		89.10					
04:00 am		89.12					
05:00 am		89.15					
06:00 am		89.17					
07:00 am		89.18					
08:00 am		89.21					
09:00 am		89.22					
10:00 am		89.23					
11:00 am		89.22					
12:00 pm		89.25					
01:00 pm		89.28					
02:00 pm		89.30					
03:00 pm		89.30					
04:00 pm		89.30					
05:00 pm		89.31					
06:00 pm		89.31					
07:00 pm		89.33					
08:00 pm		89.36					
09:00 pm		89.39					
10:00 pm		89.42					
11:00 pm		89.43					
06/05/92							
12:00 am		89.44					
01:00 am		89.46					
02:00 am		89.47					
03:00 am		89.48					
04:00 am		89.50					
05:00 am		89.52					
06:00 am		89.56					
07:00 am		89.59					
08:00 am		89.60					
09:00 am		89.62					
10:00 am		89.63					
11:00 am		89.66					
11:10 am		89.66					
11:20 am		89.67					
11:30 am		89.67					
11:40 am		89.67					
11:50 am		89.67					
12:00 pm	0	89.68	0.00				Constant Rate Test
12:10 pm	10	89.68	0.00				Test Well Pump On
12:20 pm	20	89.69	0.01	0.007	14.5	151	
12:30 pm	30	89.69	0.01	0.008	13.5	145	
12:40 pm	40	89.69	0.01	0.007	14.5	151	
12:50 pm	50	89.70	0.02	0.016	12.5	140	
01:00 pm	60	89.70	0.02	0.016	12.0	137	
01:10 pm	70	89.70	0.02				
01:20 pm	80	89.69	0.01	0.009	9.5	122	
01:30 pm	90	89.70	0.02	0.019	8.5	115	
01:40 pm	100	89.71	0.03	0.027	9.5	122	
01:50 pm	110	89.71	0.03	0.029	8.5	115	
02:00 pm	120	89.72	0.04	0.037	9.0	119	

CITY OF TUSCOLA  
Ground-Water Investigation at Hayes, IL

AQUIFER TEST

WATER LEVEL MEASUREMENTS (Continued)  
Observation Well 3 (C.F.I.)

Hour	Time (min)	Depth to water (ft)	Observed drawdown (ft)	Drawdown at 110 gpm (ft)	Piez (in)	Rate (gpm)	Remarks
02:10 pm	130	89.72	0.04	0.039	8.3	114	
02:20 pm	140	89.73	0.05				
02:30 pm	150	89.73	0.05	0.051	7.5	108	
02:40 pm	160	89.74	0.06	0.063	7.0	105	
02:50 pm	170	89.75	0.07				
03:00 pm	180	89.76	0.08	0.087	6.5	101	
03:10 pm	190	89.76	0.08	0.080	7.3	110	
03:20 pm	200	89.77	0.09	0.094	7.0	105	
03:30 pm	210	89.77	0.09	0.098	6.5	101	
03:40 pm	220	89.78	0.10				
03:50 pm	230	89.78	0.10				
04:00 pm	240	89.79	0.11	0.120	6.5	101	
05:00 pm	300	89.82	0.14	0.187	11.0	82.3	
06:00 pm	360	89.85	0.17	0.227	11.0	82.3	
06:40 pm	400	89.87	0.19	0.281	9	74.5	
07:00 pm	420	89.89	0.21	0.382	16	60.4	
08:00 pm	480	89.93	0.25	0.462	15.5	59.5	
08:20 pm	500	89.94	0.26	0.429	19.5	66.7	
09:00 pm	540	89.96	0.28	0.468	19	65.8	
10:00 pm	600	90.01	0.33	0.552	19	65.8	
11:00 pm	660	90.05	0.37	0.664	16.5	61.3	
11:40 pm	700	90.07	0.39				
06/06/92							
12:00 am	720	90.08	0.40	0.686	18	64.1	
01:00 am	780	90.11	0.43	0.869	13	54.4	
01:20 am	800	90.12	0.44				
02:00 am	840	90.15	0.47	1.032	11	50.1	
03:00 am	900	90.17	0.49	1.225	8.5	44.0	
04:00 am	960	90.21	0.53	1.254	9.5	46.5	
04:40 am	1000	90.22	0.54				
05:00 am	1020	90.23	0.55	1.301	9.5	46.5	
06:00 am	1080	90.26	0.58	1.372	9.5	46.5	
06:20 am	1100	90.28	0.60				
07:00 am	1140	90.30	0.62	1.597	8	42.7	
08:00 am	1200	90.34	0.66	1.519	10	47.8	
09:00 am	1260	90.37	0.69	1.552	10.5	48.9	
09:40 am	1300	90.38	0.70				
10:00 am	1320	90.39	0.71	1.886	7.5	41.4	
11:00 am	1380	90.41	0.73	2.086	6.5	38.5	
11:20 am	1400	90.42	0.74				
12:00 pm	1440	90.43	0.75	2.143	6.5	38.5	
01:00 pm	1500	90.44	0.76	2.171	6.5	38.5	
02:00 pm	1560	90.46	0.78	2.229	6.5	38.5	
02:40 pm	1600	90.46	0.78				
03:00 pm	1620	90.47	0.79	2.571	5	33.8	
03:40 pm	1660	90.47	0.79				
03:45 pm	1665						Test Well Pump Off
03:50 pm	5	90.48					Recovery
04:00 pm	15	90.48					
04:10 pm	25	90.48					
04:20 pm	35	90.48					
04:30 pm	45	90.49					
04:40 pm	55	90.49					

CITY OF TUSCOLA  
Ground-Water Investigation at Hayes, IL

AQUIFER TEST

WATER LEVEL MEASUREMENTS (Continued)  
Observation Well 3 (C.F.I.)

<u>Hour</u>	<u>Time (min)</u>	<u>Depth to water (ft)</u>	<u>Observed drawdown (ft)</u>	<u>Drawdown at 110 gpm (ft)</u>	<u>Piez (in)</u>	<u>Rate (gpm)</u>	<u>Remarks</u>
04:50 pm	65	90.49					
05:00 pm	75	90.49					
05:10 pm	85	90.49					
05:20 pm	95	90.49					
05:30 pm	105	90.49					
05:40 pm	115	90.49					
05:50 pm	125	90.49					
06:00 pm	135	90.50					
06:10 pm	145	90.50					
06:20 pm	155	90.50					
06:30 pm	165	90.50					
06:40 pm	175	90.50					
06:50 pm	185	90.50					
07:00 pm	195	90.51					
07:10 pm	205	90.51					
07:20 pm	215	90.51					
07:30 pm	225	90.52					
07:50 pm	245	90.52					
08:20 pm	275	90.53					
08:50 pm	305	90.55					
09:50 pm	365	90.59					
10:30 pm	405	90.59					
10:50 pm	425	90.59					
11:50 pm	485	90.60					
06/07/92							
12:10 am	505	90.60					
12:50 am	545	90.60					
01:50 am	605	90.59					
02:50 am	665	90.60					
03:30 am	705	90.61					
03:50 am	725	90.61					
04:50 am	785	90.62					
05:10 am	805	90.63					
05:50 am	845	90.64					
06:50 am	905	90.67					
07:50 am	965	90.68					
08:30 am	1005	90.71					
08:50 am	1025	90.72					
09:30 am	1065	90.74					
10:10 am	1105	90.75					End of Test



Appendix 4

CITY OF TUSCOLA  
Ground-Water Investigation at Hayes, Illinois

WATER SAMPLE ANALYSES

PUMPED TEST WELL



Chemistry Division
2204 Griffith Drive
Champaign, Illinois 61820-7495
Telephone (217) 333-9321
Telefax (217) 333-6540

WATER SAMPLE DATA
LABORATORY SAMPLE NUMBER: 225858

SOURCE: TEST WELL
OWNER: CITY OF TUSCOLA
LOCATION: NORTH OF TUSCOLA
COUNTY: DOUGLAS TOWNSHIP: 16N RANGE: 8E SECTION: 10.3G
DATE COLLECTED: 06/03/92 DATE RECEIVED: 06/03/92
WELL DEPTH (Ft.): 600. TEMPERATURE REPORTED (F): 59.
TREATMENT: NONE
COMMENTS: SAMPLE COLLECTED AFTER PUMPING AT RATES OF 241 - 88 GPM FOR 132 MINUTES.

Table with 4 columns: PARAMETER, mg/L, PARAMETER, mg/L. Rows include Iron (Total Fe), Manganese (Mn), Calcium (Ca), Magnesium (Mg), Sodium (Na), Barium (Ba), Turbidity (Lab), Color, Odor, pH (in Lab), Fluoride (F), Nitrate (as NO3), Chloride (Cl), Sulfate (SO4), Alkalinity (as CaCO3), Hardness (as CaCO3), Total Dissolved Minerals.

< = Below detection limit (i.e. <1.0 = less than 1.0 mg/L)
mg/L = milligrams per liter mg/L x 0.0584 = grains per gallon
uS/cm = microsiemens per centimeter
ND = Not determined/Information not available

IEPA Certified Environmental Laboratory, Number 100202

Lauren F. Sievers

Analyst: Lauren F. Sievers
Assistant Chemist



Chemistry Division
2204 Griffith Drive
Champaign, Illinois 61820-7495
Telephone (217) 333-9321
Telefax (217) 333-6540

WATER SAMPLE DATA
LABORATORY SAMPLE NUMBER: 225874

SOURCE: TEST WELL
OWNER: CITY OF TUSCOLA
LOCATION: NORTH OF TUSCOLA
COUNTY: DOUGLAS TOWNSHIP: 16N RANGE: 8E SECTION: 10.3G
DATE COLLECTED: 06/05/92 DATE RECEIVED: 06/08/92
WELL DEPTH (Ft.): 600. TEMPERATURE REPORTED (F): 59.
TREATMENT: NONE
COMMENTS: SAMPLE COLLECTED AFTER PUMPING AT RATES OF 158 - 82 GPM FOR 291 MINUTES.

Table with 4 columns: PARAMETER, mg/L, PARAMETER, mg/L. Rows include Iron (Total Fe), Manganese (Mn), Calcium (Ca), Magnesium (Mg), Sodium (Na), Barium (Ba), Turbidity (Lab), Color, Odor, pH (in Lab), Fluoride (F), Nitrate (as NO3), Chloride (Cl), Sulfate (SO4), Alkalinity (as CaCO3), Hardness (as CaCO3), Total Dissolved Minerals.

< = Below detection limit (i.e. <1.0 = less than 1.0 mg/L)
mg/L = milligrams per liter mg/L x 0.0584 = grains per gallon
uS/cm = microsiemens per centimeter
ND = Not determined/Information not available

IEPA Certified Environmental Laboratory, Number 100202

Lauren F. Sievers
Analyst: Lauren F. Sievers
Assistant Chemist

