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LOCKHEED MARTIN

INTERPRETATION OF WELL HYDROGRAPHS IN THE KARSTIC MAYNARDVILLE LIMESTONE AT THE OAK RIDGE Y-12 PLANT

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June 1996

Prepared for the
Environmental Management Department
Health, Safety, Environment, and Accountability Organization
Oak Ridge Y-12 Plant
Oak Ridge, Tennessee 38731

managed by
LOCKHEED MARTIN ENERGY SYSTEMS, INC.
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Prepared by:

Lisa Shevenell[1] and Bruce McMaster[2]

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Environmental Management Department
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EXECUTIVE SUMMARY

The Maynardville Limestone in Oak Ridge, Tennessee underlies the southern portion of Bear Creek Valley (BCV), and is considered to be the primary pathway for groundwater leaving the Y-12 Plant boundaries. Sixty-seven percent of all wells drilled into the Maynardville Limestone have intersected at least one cavity, suggesting karst features may be encountered throughout the shallow (<200 ft) portions of the Limestone. Because waste facilities at the Y-12 Plant are located adjacent to the Maynardville Limestone, contaminants could enter the karst aquifer and be transported rapidly in the conduit system.

As part of an overall hydrologic characterization effort of this karst aquifer, 41 wells in the Maynardville Limestone were instrumented with pressure transducers to monitor water level changes (hydrographs) associated with rain events. Wells at depths between approximately 20 and 750 ft were monitored over the course of at least two storms in order that variations with depth could be identified. The wells selected were not exclusively completed in cavities but were selected to include the broad range of hydrologic conditions present in the Maynardville Limestone. Cavities, fractures and diffuse flow zones were measured at a variety of depths. The water level data from the storms are used to identify areas of quickflow versus slower flowing water zones. The data are also used to estimate specific yields and continuum transmissivities in different portions of the aquifer.

Typically, hydrographs are obtained from streams and springs, and a quantitative evaluation of the hydrograph can be obtained because data are cast in terms of total discharge (a volume flow per time, i.e., m^3/s) for which hydrograph analysis techniques have been developed and applied for many years. The data obtained from well hydrographs provide water level versus time; hence, a method of hydrograph analysis is required for situations in which only water level data are available. The shape of the rising limb of a hydrograph is mainly determined by the character of a storm event, whereas the recession limb shape is largely independent of the storm. Recession limb analysis often leads to two or more line segments representing responses in different portions of the aquifer. Other investigators have demonstrated that stream flow recessions can be approximated by three straight lines on a semilogarithmic plot with the lines representing three different types of storage: stream channels, surface soil, and groundwater. It is hypothesized here that three segments on a recession curve from wells in a karst aquifer also represent drainage from three types of storage: conduit, fracture, and matrix portions of the aquifer. With this assumption, this report describes the development of a method to quantitatively analyze well hydrographs in order to obtain estimates of non-conduit transmissivities, and specific yields associated with karst dominated portions of an aquifer.

Hydrograph data from the 41 wells indicate that some wells are dominated by conduit flow, whereas others are not. Sixteen wells have recession curves with three line segments. Other wells show no evidence of quickflow. Delay times between initiation of precipitation and water level rises in the wells are used to qualitatively identify portions of the aquifer subject to quickflow versus diffuse flow. Water level responses are not well correlated to total depth of well, screen length or the height of the water column above the monitoring interval. However, all deeper wells (>300 ft deep) with large water columns in the wells show diffuse flow behavior, and all wells exhibiting flashy, conduit flow are at depths of <200 ft (although not all wells at depths <200 ft exhibit quickflow characteristics).

The hydrographs from wells completed in cavities and experiencing quickflow show three discrete line segments on recession curves. These segments are believed to represent successive drainage from the conduit, fracture and matrix dominated portions of the aquifer in the vicinity of the well bore. Using the slopes of these lines, a continuum transmissivity and the specific yields for the conduit, fracture and matrix parts of the aquifer are calculated for all wells which exhibit quickflow through cavities. Wells which do not intersect cavities do not have three discrete slopes on their recession curves, and hence, transmissivities and specific yields can not be calculated for these wells using the method described here. Recession curves with a single slope represent drainage from only the lower transmissivity matrix. Those with two slopes have an additional, more rapid response segment on the recession curve which represents drainage from the higher transmissivity, lower S_y, fractures in the system.

Calculated transmissivity divided by the storage coefficient (T/S; after Rorabaugh, 1964), and ratios of specific yield (S_y) for the three types of drainage obtained from the well hydrographs, are used to estimate these aquifer parameters for different portions of the system. Data from three short injection tests at one well indicate continuum T at this well bore is ≈5 m^2/d, and tests at numerous other wells in the aquifer yield results between 1 and 7 m^2/d. The T estimated with well hydrographs from two storms indicates a T of 6.2 m^2/d, and specific yields of 3×10^{-4}, 1×10^{-3}, and 3×10^{-3} for the conduit, fracture, and matrix components, where the matrix S_y was held constant for all calculations based on the average value obtained from numerous, previous tests in the aquifer. Well-developed conduit systems in the Y-12 area in which water levels in wells show a flashy response typically have shown S_y's of 1×10^{-4}, 1×10^{-3}, and 3×10^{-3} for conduit, fracture, and matrix. Less well developed conduit areas show more nearly equal S_y's (8.6×10^{-4}, 1.3×10^{-3}, 3×10^{-3}). Areas with no evidence for the presence of conduits have only one, or in some cases two, slopes on the recession curve. Using easily obtainable and relatively inexpensive hydrograph data with the method described here provides reliable estimates of continuum T, and S_y of conduit, fracture and matrix intervals in many portions of the aquifer. Such information will be useful in identifying heterogeneity in the aquifer and in constructing numerical groundwater flow models.

INTRODUCTION

Profound effects on contaminant transport rates may result when waste disposal facilities are located on or adjacent to karst aquifers. Several waste disposal sites are located adjacent to a karst aquifer comprised of the Cambrian Maynardville Limestone (Cmn) and Copper Ridge Dolomite (Ccr) at the U.S. Department of Energy Y-12 Plant in Oak Ridge, TN (Figure 1). Hence, studies on the behavior of this karst system were initiated (Geraghty and Miller, 1990).

The Maynardville Limestone is recognized throughout eastern Tennessee and is the youngest formation of the Conasauga Group (Miller and Fuller, 1954). The Maynardville Limestone underlies the southern portion of Bear Creek Valley (BCV), and is considered to be the primary pathway for groundwater leaving the Y-12 Plant boundaries. Sixty-seven percent of all wells drilled into the Maynardville Limestone have intersected at least one cavity suggesting karst features may be encountered throughout the shallow (<200 ft) portions of the Limestone.

In 1992, an extensive drilling program was completed which was designed to locate and evaluate different karst features as a function of location, lithology, depth, elevation, and topography. Results of various portions of the study appear in Shevenell et al. (1992), Shevenell and Beauchamp (1994), Shevenell (1994), Shevenell (1996), Goldstrand (1995), and Goldstrand et al. (1995). Following completion of preliminary analysis, additional testing of the individual wells was deemed appropriate. Many cavities were intersected by wells, but it is necessary to determine the interconnection and trends of these features in order to evaluate potential flow paths. Two of the methods selected for evaluation of the karst features are (1) continuous monitoring of water levels, specific conductance and temperature (discussed here), and (2) pulse train analyses (discussed in Shevenell et al., 1995).

The data from the types of tests discussed here provide water level hydrographs from the wells. Typically, hydrograph analysis techniques are developed for hydrographs obtained from discharge rates at spring and streams locations (i.e., Padilla et al., 1994). Few studies (Atkinson, 1977; Rorabaugh, 1960) have been conducted which yield quantitative data on aquifer parameters using well hydrographs. The first purpose of this report is to develop a scheme to quantitatively analyze well hydrographs in karst terranes when corresponding stream or spring discharge rates are not available. Quantitative evaluation of possible transmissivities and storage coefficients in different portions of the flow regime are obtained with the use of water level hydrographs.

METHODS

Data Collection

Hydrographs were obtained from 41 wells within the Cmn, mostly during the winter months of 1993 through 1995. Hydrograph data are preferably obtained during the wetter winter months when sufficiently large storm pulses will be observed with minimal interference from evapotranspiration. Hence, the wells were preferably monitored between the months of November and March when rainfall is higher and water demand from vegetation is lowest, although one transect (Picket A) was monitored between April and June, 1995. Rapid water level responses are expected in conduits (cavities or fractures), in comparison to those in the more diffuse flow portion of the aquifer. Because conduit systems have little hydraulic resistance in comparison to porous media, recharged water is expected to drain quickly. The much lower hydraulic conductivity porous media portion of the system responds more slowly to transient events, and does not remain in phase with the conduit system (White, 1988).

Pressure transducers were installed in up to 10 monitor wells in a particular Picket area (see Figure 1 for Picket locations), and Hydrolab probes were also installed, measuring temperature and specific conductance, in up to five monitor wells. All data loggers were set to the same time, or as close as practicable, in order that responses from different wells could be directly compared. Numbers were assigned to all Hydrolab probes, pressure transducers and data loggers, and probes matched up with specific data loggers. When installing probes in the wells, Hydrolab probes were installed first, and pressure transducers second to avoid transducer probe damage by the larger Hydrolab probe.

In general, pressure transducers were placed ≈3 to 5 ft below the static water level. Hydrolab probes were placed at the depth of the completion intervals in each of the wells for which temperature and specific conductance measurements were desired. The maximum depth of deployment of the Hydrolab probes was 300 ft. When the probes were installed into or removed from a well, they were checked for proper operation and calibration, and recalibrated if necessary. Periodically during the monitoring (e.g., every other week), the batteries were checked, and the water levels were field checked with an electronic water level indicator. The pressure transducer and Hydrolab probes were decontaminated each time they were moved into different wells. The probes were washed with a laboratory detergent, rinsed with tap water, and then rinsed with deionized water and dried. Cables were wiped dry as they were retrieved from the wells.

The data loggers were programmed to include the well identification number and elevation. Generally, the readings on pressure transducers were scanned every 2 minutes and recorded every 30 minutes during the monitoring period. The pressure measurements were automatically converted into water level above mean sea level and recorded in the data logger file. The minimum, maximum, and instantaneous water level measurements were also recorded. The measurements from the Hydrolab probes were recorded each time the pressure was recorded, though no minimum and maximum scans were possible from these probes. The data loggers in the monitored wells were operational during a minimum of two precipitation events, with up to six storms being monitored in some wells. Field notes from the tests included well numbers, static water level, date, time, transducer depth below top of casing (or elevation above mean sea level), Hydrolab depth or elevation, notes on calibration (transducer water level versus manually measured water level), battery conditions, weather, the identification number of the data logger, transducer and Hydrolab assigned to the particular well.

The weather station from which precipitation data were obtained for all storm events is located in the town of Oak Ridge. The approximate distances between the weather station and the individual picket locations follows: Picket W = 4.8 miles, Picket A = 4.0 miles, Picket B = 3.3 miles, Picket C = 2.7 miles, and Picket J = 1.0 miles.

Hydrograph Analysis Technique

A hydrograph consists of a rising limb, a peak, and a recession curve. The shape of the rising limb is largely dictated by the characteristics of the storm event, whereas the shape of the recession limb is mainly independent of the character of the storm (Linsley et al., 1982). In large basins, in which runoff may occur over different parts of the basin during different storm events, the recession curve may vary between storm events. Recession limb analysis often leads to two or more line segments which represent responses in the different portions of the groundwater system: (1) a fast response to conduit flow; (2) slower responses due to flow through fractured and unfractured porous media (White, 1988).

The most useful hydrographs are those obtained during abrupt, intense storm events in which a sharp pulse is transmitted to the karst system. In an ideal system, the recession limb of a hydrograph decreases exponentially until the water level reaches the pre-storm water level, assuming no other precipitation events interfere with the water level decline. A system with a well-developed conduit system will exhibit rapid responses to precipitation events (flashy), whereas responses in aquifers with poorly developed, or nonexistent, conduits will be more subdued. Because conduit systems have little hydraulic resistance, water levels in conduits will also decline more rapidly than those in regions without conduits (White, 1988).

Short lag times between initiation of precipitation and water level rise in monitored areas may be suggestive of quickflow if other aspects of the hydrographs support the conclusion. However, the lag time between storm impulse and water level rise is not the time for water to flow to the monitoring point, but the time required to transmit an impulse (i.e., a pressure pulse) in the aquifer. The response time t_R is determined by fitting the recession limb of the hydrograph to an exponential function;

$$Q = Q_o e^{-\varepsilon t}$$

where, ε is the exhaustion coefficient, which is the slope of the recession curve of ln(Q) vs time, and $t_R = 1 / \varepsilon$ (Burdon and Papakis, 1963). The coefficient ε represents the capability of the aquifer to release water. This value decreases as the underground retardation of water release increases. When ε is large, the underground has poor retardation capability (Milanovic, 1981).

In well-developed karst systems, three straight line segments with different values of ε occur in the recession. Greater or less than three slopes may be observed depending on the complexity of the system (Milanovic, 1981). The first and steepest slope represents the dominant effects of drainage of the larger karst features, whereas the second, intermediate slope characterizes the emptying of well connected and partially karstified fractures. The third slope represents drainage of the porous portion of the aquifer. The first slope encompasses the effects of all three flow regimes, yet is dominated by the flow through the conduit portion of the aquifer.

Typically, hydrographs are obtained from streams and springs from which a measure of the total discharge (i.e., m^3/day) can be obtained, and a quantitative evaluation of the hydrograph can be conducted. Stream flow recession curves can be approximated by three straight lines on a semilogarithmic plot with the lines representing three different types of storage: stream channels, surface soil, and groundwater (Barnes, 1940; Linsley et al., 1982). It is suggested here that three segments on a recession curve from wells in a karst aquifer also represent three types of storage: conduit, fracture, and matrix portions of the aquifer. The data presented in this report do not include fluid discharge rates, hence, a method of hydrograph analysis is developed for situations in which only water level data are available.

As an example, a hydrograph for the GW-734 well is used to illustrate the hydrograph analysis technique. The recession portion of the hydrograph from the first storm event shows two inflection points, and this is more clearly illustrated on a plot of the natural logarithm of the water level versus time (Figure 2). Data (Figure 2) show that water levels decline almost immediately after the maximum water level is achieved, and the recession data suggest three line segments. The first segment is interpreted to represent rapid drainage of the main conduits intersected by this well. Water levels decrease more slowly after about 30 hours. The second segment apparently suggests drainage is dominated by the intermediate permeability features (fractures), whereas the third segment illustrates the slower hydrologic response as the matrix intervals are drained and water levels return to baseflow conditions throughout the continuum. Note that the rock matrix on the ORR is believed to contain microscopic and larger, mostly disconnected pores and vugs that do not completely drain under the influence of gravity. When matrix is referenced in this report, it is assumed that this portion of the aquifer system is composed of pores, small fractures and vugs that are not included in the categories represented by rapid drainage through open conduits or the larger fractures in the system.

Each of the three segments of the hydrograph (Figure 2) has a characteristic slope (λ) for any given storm event, and the slope is defined by the following equation (Moore, 1992):

$$\frac{\ln (Y_1 / Y_2)}{(t_2 - t_1)} = \lambda = \frac{\ln (Q_1 / Q_2)}{(t_2 - t_1)}, \tag{1}$$

where, Y_1 and Y_2 are water levels, and Q_1 and Q_2 are the associated flows (discharges) corresponding to the water levels Y_1 and Y_2 at times t_1 and t_2, and Y and Q vary as storage changes between t_1 and t_2. Solving for Q_1/Q_2 in equation (1), the ratios of the theoretical discharges can be calculated, where values of Q_1 to Q_2 represent conduit dominated drainage, values of Q_2 to Q_3 represent fracture dominated drainage, and values of Q_3 to Q_4 represent diffuse, matrix dominated drainage.

Hydrograph data give information on the changes in groundwater storage. At peak discharge, storage in the aquifer is at a maximum and this storage volume decreases at a given rate. The changes in subsurface storage associated with conduit flow will be more rapid than those associated with drainage from matrix or fractured zones. The relationship of baseflow conditions to changes in groundwater storage volume has been expressed by Moore (1992), after Fetter (1988, p.52), as

$$V_1 = Q_1 (t_2 - t_1) / \ln(Q_1 / Q_2). \tag{2}$$

Combining with equation 1 yields

$$V_t = Q_t / \lambda \tag{3}$$

where V_t is the volume of water in storage at any time t, and Q_t is the flow rate produced by the stored water at time t during the recession. It is assumed that the flow rate Q_t from storage is reflected in the well hydrograph by the hydraulic head Y_t, and the two are related by equation 1. Using the discharge (Q) ratios above, the volumes (V_t) can be cast in terms of one Q (e.g., Q_1). The volume of storage related to each segment on a well hydrograph can be expressed as a function of each of the individual Q values, where both Q and the storage volume change with time, decreasing as water levels decrease. The change in storage volume can be expressed as (Moore, 1992)

$$(V_1 - V_2) = (Q_1 - Q_2) / \lambda \tag{4}$$

or equivalently as

$$(V_1 - V_2) = A\, S_y\, (Y_1 - Y_2). \tag{5}$$

where A is the drainage area, and S_y is the specific yield.

Using equation 4 to obtain $(V_1 - V_2)$ as a function of the Q associated with the segment of the hydrograph being considered, and substituting this value as a function of Q into equation 5 (ie. $(Q_1 - Q_2)/\lambda = AS_y (Y_1 - Y_2)$)) allows determination of a value for the ratio AS_{y_t}/Q_t for each segment of the hydrograph. Using the ratios of Q_1/Q_2, etc. obtained previously, the specific yields for each portion of the hydrograph (conduit, fracture, matrix regions) can be expressed as a function of one of the Q values. For instance, expressions of the following form will be obtained:

$$\frac{AS_{y_1}}{Q_1} = X_1 \neq \frac{AS_{y_2}}{Q_1} = X_2 \neq \frac{AS_{y_3}}{Q_1} = X_3 \qquad (6)$$

where $X_1 \neq X_2 \neq X_3$ are numerical values. If it is assumed that the drainage area corresponding to volume changes represented by the three line segments are the same, than the $AS_{y_t} / Q_1 = X_t$ expressions can be solved for Q_1 and equated. The resulting expressions yield numerical values for the ratios of specific yields associated with each segment of the hydrograph.

In order to conduct a meaningful, quantitative hydrologic analysis, estimates for the values of transmissivity (T) and storativity (storage coefficient) must be obtained. In estimating the average non-conduit transmissivity of an unconfined aquifer from a baseflow recession curve, Atkinson (1977) presented the following expression (after Rorabaugh, 1960; 1964):

$$\log(Q_1/Q_2) = \frac{T}{S}\,(t_2 - t_1)\,\frac{1.071}{L^2} \qquad (7)$$

where L is the distance from discharge to groundwater divide, T is transmissivity, and S is the storage coefficient, which is equal to the S_y for unconfined aquifers. This expression was obtained by solving a heat flow equation for a uniform homogeneous, isotropic, thick aquifer, underlain by impermeable material, with side boundaries being fully penetrating. Although T will change with a rise in water level in the unconfined, fractured conditions investigated here, it is assumed that this change is relatively small relative to the thickness of the aquifer. Inserting the Q ratios obtained previously, and an assumed distance from recharge area, estimates for the ratios of T/S can be obtained from equation 7. The previous analysis estimates T in base flow conditions which are more representative of the slower diffuse (continuum) flow than the more rapid conduit flow.

RESULTS

Testing the Applicability of Hydrograph Analysis Technique

Table 1 lists the data and calculated slopes (λ from equation 1) for the three line segments from the 1992 storms I and III in GW-734. The values for t and Y in Table 1 are from the first point (the maximum water level) in each line segment listed. From equation (1), the ratios of the theoretical flows can be calculated, where Q_1 represents the conduit flow at position Y_1 and time t_1, Q_2 represents fracture flow, and Q_3 represents dominantly diffuse, matrix flow. From the data from the first storm in GW-734 in 1992, $Q_1/Q_2 = 1.284$, $Q_2/Q_3 = 1.308$, $Q_3/Q_4 = 1.174$, $Q_1/Q_4 = 1.972$,

Next, equations 2 through 6 are used to calculate the AS_y/Q ratios, and these ratios are calculated and reported in reference to Q_1 in Table 1. The value of AS_y/Q_1 in the first column refers to the value of AS_{y_1}/Q_1 for the first storm, the value in the second column refers to the value of AS_{y_2}/Q_1 for the first storm, etc. If recharge to all three flow domains (conduit, fracture, matrix) occurs over the same area, then a constant drainage area can be assumed. The ratios of S_y values can be found by solving each of the AS_y/Q_1 expressions for Q_1 and equating the expression. If drainage area A (equations 5 and 6) is constant, it can be eliminated from the expression. The resulting specific yield ratios between the individual segments appears in Table 1.

An estimate of the distance between the well (discharge area) and the groundwater divide is required to obtain a value of T/S from equation 7 for the continuum, which includes the slow flow, diffuse portion of the system. The distance between GW-734 and the crest of Chestnut Ridge to the south is ≈1520 ft. Note that strike parallel flow in the conduit is likely to dominate as the cavity appears to be aligned approximately parallel to strike. Also, note that there is a possibility of a sinkhole in the Copper Ridge Dolomite at the approximate distance of 1520 ft to the south which is the location of the Chestnut Ridge Sediment Disposal Basin (CRSDB). Water level contours at the CRSDB suggest groundwater generally flows from three directions (west, south, north) toward the location of the CRSDB (Shevenell and Switek, 1992). This suggests relatively direct recharge through a sinkhole may occur to the water table in the Copper Ridge Dolomite. The presence of a sinkhole suggests the possibility of rapid flow from a recharge area on Chestnut Ridge, perhaps toward the GW-734 area. However, it is not known if the conduits intersected in GW-734 are connected to conduits in the Copper Ridge Dolomite which may be partially fed by a sinkhole at CRSDB. Values for the T/S ratios are obtained from equation 7 by substituting values for the Q ratios obtained previously and the distance (L) to the groundwater divide (Table 1).

The average continuum S_y for the Knox aquifer (which includes both the Ccr and the Cmn) is 3.3×10^{-3} (Moore and Toran, 1992). The continuum value is most appropriately associated with combined flow conditions represented by the baseflow (segment 3) portion of the hydrograph. The first listings of T (m^2/d) values in Table 1 are calculated by multiplying the T/S ratios of Table 1 by the assumed value of $S_y = 3 \times 10^{-3}$. The estimated T value for the third segment of the hydrograph of 4 to 5 m^2/d (44 to 58 ft^2/d) is nearly equal to that calculated for the continuum transmissivity of 7.3 m^2/d (78.5 ft^2/d) for the Knox aquifer (Moore and Toran, 1992). This suggests that segment 3 is representative of the behavior of the continuum whereas the other two segments show greater influence from fractures and conduits. Assuming that the S_y value of 3×10^{-3} is reasonable for the continuum, the values of apparent S_y for the other portions of the hydrograph can be estimated using the previously obtained S_y ratios (Table 1). Using these S_y values necessarily results in the T for each portion of the hydrograph being set equal to the value of the continuum T (second listing of T, Table 1).

The previous procedure was used to calculate T/S, S_y and T from three storm hydrographs in GW-734 in 1992 and 1994, and these values appear in Table 2. Three storms were monitored in 1994, yet two of them had incomplete recession curves and data from the third line segment are unavailable. Hence, the two 1992 storms previously discussed, and the second storm from 1994 are used to determine the values for T in the continuum near GW-734. Table 2 shows results of the calculations of T. The 1992 storms indicate a value of $T = 9.8 \pm 0.6$ m^2/d, similar to that obtained in previous studies of the Knox aquifer (Moore and Toran, 1992). However, the values of T3/Sy2, T, and K from the 1994 storm are 3.8, 2.4 and 2.4 times greater, respectively, than those in 1992. The values for the 1994 storm are probably higher because this storm was a less sharp pulse than those in 1992, had a higher total precipitation (2.33 inches, versus 1.44 and 0.92 inches in 1992), and resulted in a larger water level rise in the well (10.56 ft, versus 5.3 and 2.24 in 1992). Because the T in an unconfined aquifer is a function of the changing thickness of the aquifer, and the aquifer thickness during the 1994 storm was larger, it is reasonable to assume that the calculated T from the 1994 storm would be slightly larger than that obtained in 1992. Based on the data that follow, the T value of 37.4 m^2/d is probably an upper estimate for the

GW-734 well area.

Three short duration injection tests were conducted at GW-734 in 1994, and these data are used to calculate T and S_y by more traditional means. The computer model AQTESOLV (Duffield and Rumbaugh, 1991) was used to calculate T and S_y from unconfined solutions for slug tests (Bouwer and Rice, 1976), recovery tests (Theis, 1935), and pumping tests (Theis, 1935; Cooper and Jacob, 1946). The T and S_y values obtained from these various solution techniques represent the values for the continuum, and not any single component of the aquifer. Values of T from the slug test solutions are $5.87 \times 10^{-4} \pm 1.93 \times 10^{-4}$ m^2/s (assuming a 325 ft aquifer thickness), those from the recovery tests $4.9 \times 10^{-5} \pm 2.18 \times 10^{-5}$ m^2/s, and those from the traditional pumping tests $6.12 \times 10^{-5} \pm 1.7 \times 10^{-5}$ m^2/s. The slug test results are probably not as reliable as the others noted given that the water level responses used in the solution were not produced by a sharp, instantaneous injection or withdrawal of water as is required for slug tests. Hence, taking the average of the other results leads to an estimated T for the continuum of $5.81 \times 10^{-5} \pm 1.75 \times 10^{-5}$ m^2/s (or 5.0 m^2/d). This value compares well with previous data (1 to 7 m^2/d) obtained from pumping tests at other localities in the Knox aquifer (Moore and Toran, 1992). The estimated continuum transmissivity based on the new hydrograph analysis technique is 9.8 m^2/d (Table 2), indicating that realistic values can be obtained with this method. This value, which corresponds to a hydraulic conductivity (K) of 7.2×10^{-5} m/s, is within the lower to middle of the range expected for typical karst limestones (Freeze and Cherry, 1979).

Also note that Table 2 lists T/S_y, and estimated S_y values based on assumptions that the continuum S_y value is 0.003 (based on Moore and Toran, 1992). These data show that the S_y of the conduit portion of the aquifer ($\approx$0.0006) is less than that consisting of fractures ($\approx$0.0014), which is less than the matrix, or continuum value of 0.003. Greater amounts of storage in intergranular porosity are expected when compared to the storage in conduits. In addition, T/S_y values for the line segments assumed to represent the conduit dominated portion of the recession curves are the greatest, and the third line segment is the least. This is reasonable given that T is much higher and S_y is much lower in conduit dominated portions of an aquifer than in portions of the aquifer dominated by porous flow.

Well Hydrographs

Hydrographs were obtained from several wells, some of which were dominated by conduit flow, and others were not. Summary data on monitored well depths, elevations and water zones in the completion intervals appear in Table 3. Precipitation and water level data are illustrated in Figures A-1 through A-46 in Appendix A for each well monitored, and selected data from each well are tabulated in Tables B-1 through B-44 in Appendix B. Responses from all of the wells are summarized in Table 4. This table indicates if one, two or three slopes were seen on the recession curve and also lists delay times between precipitation and water level responses. Example responses from three different monitoring zone types are discussed in detail below, and highlights from the wells in specific Pickets are summarized based on the data in Appendices A and B, and these other wells are discussed only briefly. Only the responses which vary from the detailed discussions of the three wells of Figure 3 are noted in the Picket discussions below.

In the 'Comment' row of the Appendix B tables, 'WL drop' indicates that the water level continued to drop after the precipitation began for a particular storm. In most cases, the water level at the time just prior to initiation of precipitation is used as the "WL before Precip. (ft)' value. However, some wells showed a relatively dramatic water level drop following initiation of precipitation. For instance, in GW-710 storms 5 and 6, the WL before precipitation is taken as the level just before the water level began to rise in this well. This value was selected for these storms because relatively large water level declines occurred for a considerable period of time. A 0.28 ft decline occurred over 11 hours before storm 5 resulted in water level rises, and a 0.29 ft decline occurred over 22.5 hrs before storm 6 resulted in water level rises. In other cases where 'WL drop' is noted in the tables, only a slight (<0.1 ft) decline occurred over a relatively short time period.

The data in the Appendix B tables also include information on the slopes of the recession curves. Recession curves were plotted for each storm response. From the plots, breaks in slopes could be identified, with one, two and three slopes being noted depending on the well, storm event, and whether recession was complete before the next storm event. Other data in these tables include delay to water level rise from the start of precipitation, duration of the peak water level, and total water level change as a result of a storm. These data are useful to qualitatively determine if the well taps a quickflow zone. Long delays in water level rises, and long, broad peaks suggest a well does not monitor a quickflow water zone within a cavity.

Figure 3 illustrates example hydrographs from three different types of monitoring zones. Figure 3A illustrates the response in GW-715 which is completed in a cavity and is assigned to Group 1 wells in this work. Figure 3B illustrates the response in GW-604 which is completed in water-bearing intervals in a fractured aquifer and is assigned to Group 2 wells in this work. Figure 3C illustrates the response in GW-710 which is a deep well completed in water-bearing intervals in a fractured aquifer and is assigned to Group 3 wells. The responses in these wells are clearly quite different with Group 1 wells showing very rapid water level rises and declines, and three distinct slopes on the recession curve. Group 3 wells, on the other hand, show very slow, broad responses and only one or two nearly equal slopes on their recession curves. Group 2 wells show intermediate responses between Groups 1 and 3 wells. Although three slopes occur on the recession curve (Figure 3B), they are more nearly equal to one another than in Group 1 wells, suggesting conduit development in these wells is less pronounced and the differences in storage between the fracture, conduit and matrix portions of the aquifer are less than in the Group 1 wells. Nevertheless, Group 2 wells respond much more rapidly to rain events than Group 3 wells, indicating there is a component of quickflow in these wells.

Rapid water level responses are expected in conduits (cavities or fractures), in comparison to those in the more diffuse flow portion of the aquifer. Because conduit systems have little hydraulic resistance in comparison to porous media, recharged water is expected to drain quickly. The much lower hydraulic conductivity porous media portion of the system responds more slowly to transient events. A detailed description of the example wells in Figure 3 follows and addresses these differences between types of flow near each wells in each grouping.

GW-715, Group 1 Example

Precipitation and water level data are illustrated in Figure A-6, specific conductance (specific conductance) and temperature (Temp) data are plotted in Figure A-7, and selected data are tabulated in Table B-6. Water level changes during storms 1 through 5 ranged from 2.58 to 6.6 ft, which are the largest changes observed in this picket. GW-715 is a shallow well (TD = 43.1 ft) and is known to contain cavities in its completion (open or screened) interval. Delays to the start of water level rises from the initiation of precipitation varied from 1.0 to 23.5 hours. The longest delay of 23.5 hours occurred during storm 3 in which the beginning of the precipitation event was of very low intensity. Hence, at the beginning of storm 3, insufficient precipitation occurred to produce a water level rise, which is reasonable given that cavities are associated with this well. Cavities respond rapidly to precipitation, yet there must be a sufficiently large volume of water introduced into the aquifer for noticeable pressure pulses to be observed. Small rains (e.g., at time = 140 hours in Figure 3) are not large enough to cause water levels to rise in these conduit dominated ares.

The timing and magnitude of water level rises correlate with precipitation amount, duration, and intensity. The highest precipitation (1.0 inches, storm 4) corresponds with the largest water level change (4.98 ft), whereas the smallest precipitation (0.67 inches) corresponds to the smallest water level change (1.29 ft). As in the other wells in this picket (see Appendices A and B), storm 4 produced the larger water level rise. The duration of the peaks during all storms was short (0.0 to 1.5 hrs). This is indicative of very rapid drainage of the conduit portion of the aquifer following cessation of precipitation. Responses to the storms are more rapid than in any of the other wells in this picket, all of which belong to Group 3. This is reasonable given that this well is considerably shallower and intersects cavities.

The time delay between peak precipitation and peak water levels varies between 5.5 to 33 hours; however, there is no correlation between these lag times and precipitation amount or intensity. For instance, the longest delay is associated with storm 4 which had the highest intensity. Except for storm 1, the storms had recessions which were probably not complete prior to the initiation of the next storm event. Table B-6 lists slopes for the recession curves. Plots suggest storms 1, 2 and 3 exhibit three distinct slopes, suggesting that conduits drain rapidly (slope 1), fractured portions (slope 2) may drain less rapidly than the the conduits, but more rapidly than the intervening matrix blocks (slope 3). Data from storm 1 appear to be the most reliable because this storm appears to have a complete recession curve.

Peaks in specific conductance and temperature also occurred as a result of the four storms. Modest increases in temperature occurred (between 0.12 and 0.16 °C), whereas decreases in specific conductance varied from 8 to 39 μmhos/cm, with the largest change occurring during storm 4. These parameters began to change between 1 and 25 hours following the initiation of precipitation, with the fastest response occurring during the most intense storm (storm 4; Table B-7). The beginning of change in these parameters began 0 to 9.5 hrs following the beginning of water level rise, depending on the storm. During intense storms, such as storm 4, precipitated water may undergo rapid recharge and flow to the position of GW-715 in as little time as one hour indicating flow can be quite rapid in the zone intersected by GW-715. Water level peaks (i.e., pressure responses) precede those of temperature and specific conductance, as expected, showing that the pressure pulse arrives at GW-715 prior to the recharge water. Temperature began to increase before specific conductance began to decrease for each of the monitored storms. This phenomenon likely results because of the different gradients in specific conductance and temperature. Higher temperature recharge water is introduced into lower temperature aquifer waters, and the driving gradient is from the recharge water to the aquifer water (i.e., in the direction of flow). The total dissolved solids of the recharge water is less than that in the aquifer, resulting in a concentration gradient from aquifer waters toward recharge waters (i.e., opposite the direction of recharging flow). Hence, in less intense storms in which flow rates are slower or in storms in which recharge is from a greater distance, the specific conductance is expected to lag the temperature pulse at a particular monitoring point.

Another feature of importance to note from the GW-715 data is that each storm exhibited two peaks in water level. Two peaks in specific conductance and temperature were also observed during storms 1, 2, and 3, with the temperature peaks being more distinct. Storms 2, 3, and 4 each had two periods of relatively high precipitation separated by a short period of low precipitation. The double peaks from these wells may reflect very rapid changes in the well's water level in response to rapid changes in precipitation conditions. However, storm 1 does not exhibit any lull in precipitation during the storm, yet two water level, Temp and specific conductance peaks also appear for this storm (Figures A-6 and A-7). These double peaks likely result because the water level in the conduit intersected by GW-715 is responding to water level changes occurring at different times in two upgradient conduits which feed into the one at GW-715 (for example, see Ashton, 1966).

Given the previous observations, it is clear that GW-715 taps a quickflow water zone which responds rapidly to precipitation. The conduit drains rapidly following a storm, and additional water level declines are a result of slower drainage from surrounding fractures and matrix blocks which likely have higher storage coefficients, but much lower transmissivities. Temperature and specific conductance recessions are much more rapid than WL recessions because the changes in these parameters reflect conditions in the conduits only, whereas those of WL show the combined effect of conduits, fractures, and matrix intervals.

GW-604, Group 2 Example

Precipitation and water level data are illustrated in Figure A-39 and selected data are tabulated in Table B-38. Water level changes during storms 1 through 3 ranged from 0.78 to 5.09 ft. Delays to the start of water level rises from the initiation of precipitation varied from 7.5 to 12 hours, which is identical to that observed in nearby well GW-603. The storm (storm 2) with the highest total precipitation and greatest intensity, had the most rapid initiation of WL rise in GW-604 as well as the largest water level increase. The duration of the peaks was relatively short (0.5 to 1.5 hrs). Because no recession occurred for storm 1, an artificially long peak is indicated. Responses to the storms are somewhat slower than in the shallower wells in Picket J (e.g., GW-220), which is reasonable given that this well is deeper (TD = 112.4 ft) than GW-220. The responses in GW-603 and GW-604 are nearly identical suggesting these two wells intersect zones with similar hydrologic characteristics and may be hydrologically connected.

The time delay between peak precipitation and peak water levels varies between 15 to 25 hours; however, there is no correlation between these lag times and precipitation amount or intensity. Each storm had recessions which were probably not complete prior to the initiation of the next storm event. Table B-38 lists slopes for the recession curves. Plots suggest that only storm 2 exhibits 3 distinct slopes, suggesting conduits or solutionally enlarged fractures may be draining rapidly and that poorly fractured portions (slope 2) may drain more rapidly than the intervening matrix blocks (slope 3). Other recessions may not have been sufficiently long to identify two slopes. Conduit flow, or flow through larger fractures, is indicated in this well (and in GW-603) by the hydrograph data, yet the importance of this type of flow is less than that in GW-715 in light of the relatively long delay times observed in these wells and the similarity of the slope values in comparison to the greater divergence of slope values in GW-715.

GW-710, Group 3 Example

Precipitation and water level data are illustrated in Figure 3, and selected data are tabulated in Table B-1. Water level changes during storms 1 through 5 ranged from 0.49 to 3.29 ft for precipitations between 0.67 and 1.14 inches. Delays to the start of water level rises from the initiation of precipitation varied from 8.0 to 11.5 hours. The timing and magnitude of water level rises correlate with precipitation amount, duration, or intensity. The highest precipitation (1.14 inches) corresponds with the largest water level change (3.29 ft), whereas the smallest precipitation (0.67 inches) corresponds to the smallest water level change (0.49 ft). Two storms (2 and 4) each had a total of 1 inch of precipitation, although that in storm 2 occurred over 21 hours, and that in storm 4 occurred in only 10 hours. The storm with the higher intensity (storm 4) caused the larger water level rise and a longer duration in peak water level. Similarly, precipitation was highest and the duration of the peak water level was the longest during storm 5.

All responses to storms are relatively slow, and plot as broad, smooth curves reflecting a pressure pulse being transmitted through a unit with relatively low transmissivity. The time delay between peak precipitation and peak water levels varies between 44.5 to 49 hours, with the shortest time occurring during the largest precipitation event (storm 5). Each storm had relatively long recessions, which in most cases were not complete prior to the initiation of the next storm event. Table B-1 lists slopes for the recession curves. Plots suggest slight changes in slopes, yet as can be seen on Table B-1, the differences between slopes 1 and 2 are minimal (i.e., -5.22×10^{-6} and -6.21×10^{-6}, storm 1) and are not likely to be significant. Hence, the recessions suggest only one slope and not three as would be expected in wells exhibiting a quickflow component through fractures or conduits. In light of the previous observations, it is believed that the water level responses in GW-710 reflect increases in pressures in overlying rocks as the water table rises during precipitation. It is not likely that the pressure responses in GW-710 are a result of direct fluid movement from the surface to this deep zone.

Picket W

During monitoring of wells at Picket W, seven storms occurred between December 20, 1993 and January 17, 1994. The last storm between 1/25/93 and 1/28/93 is not discussed here because insufficient water level data were collected. Figure 3 identifies each of the six storms considered. The data loggers used have a deficiency in that they stop logging for 24 hours on January 1 of each year. Hence, there are data missing from the hydrographs of all six wells in this picket during the second storm. In addition, pressure transducer malfunctions in three of the wells (GW-713, GW-714, and GW-715) caused the logger to stop logging data during the fourth storm event. Hence, data for storms 5 and 6 in these wells are not available. In the wells for which data are available, little or no response to storm 6 was recorded, and data from storm 6 will not be considered in general comments because of insufficient data. All available data are plotted and tabulated in Appendices A (Figures A-1 through A-6) and B (Tables B-1 through B-7).

One well in this picket (GW-715, Figures A-6 and A-7, Tables B-6 and B-7) belongs to the Group 1 category of wells and exhibits rapid water level responses because this well is completed in a cavity. A detailed description of the response in this well appears at the beginning of the RESULTS section. None of the other wells in this Picket are completed in cavities, and their water level responses are slow indicating that slower, diffuse flow dominates near the wells. Similar to GW-710 (Figure A-1, Table B-1) discussed previously, GW-711, GW-712, GW-713 and GW-714 (Figures A-2 through A-5, Tables B-2 through B-5) all belong to the Group 3 well category indicating that these wells monitor portions of the aquifer which are not subject to quick flow through solutionally enlarged fractures and cavities.

Daily fluctuations in water levels were observed in GW-711, GW-712 and GW-713 throughout the monitoring period, although some were masked by water level rises during storm events. The fluctuations in GW-711 occur every 24 hours, and with very few exceptions, the peak water level occurs at 2:30 PM each day. It is believed that these peaks are an artifact of the data logging equipment, and not a result of natural variations which might be expected from moon tides, which would occur twice daily. However, the water level fluctuations in GW-712 and GW-713 occur twice every 24 hours and have magnitudes of up to 0.1 and 0.07 ft, respectively. This behavior suggests that water levels are responding to earth tides. Tidal responses are less efficient in wells monitoring an unconfined aquifer than ones which tap confined aquifers (Bredehoeft, 1967). Other wells on the ORR exhibit daily water level variations on the order of 0.5 ft which is considered to be indicative of confined conditions (Nativ and Hunley, 1993). However, variations on the order of 0.06 ft have been attributed to tidal fluctuations in an unconfined well on the ORR (Richardson, 1956). Given that the aquifers on the ORR are considered to be increasingly confined with depth (Solomon et al., 1992; Moore and Toran, 1992), the water level fluctuations in GW-712 and GW-713 may suggest partial confinement.

Plots of GW-711 suggest storm 5 exhibits 2 distinct slopes, suggesting that poorly fractured portions (slope 1) may drain more rapidly than the intervening matrix blocks (slope 2). Other recessions were not sufficiently long to identify these two slopes. In light of the previous observations, it is believed that a small amount of water entering small fractures results in a rapid pressure pulse in the very low storage fractures near this well. Quickflow of the magnitude as would be experienced in the shallower, conduit portion of the aquifer is unlikely, though more rapid flow in the fractures, relative to matrix intervals, is possible near this well.

The recessions in GW-712 and GW-713 may not have been sufficiently long to identify two slopes. Storms 1 and 2 indicate slopes with much lower values than those of storms 3, 4, and 5. Responses in other wells which are believed to be influenced by conduit flow (ie. GW-715 in Picket W, and GW-220 and GW-734, Picket J) often show slope values progressively decreasing from slope 1 to 3, with values of $\approx 10^{-4}$ for slope 1, of 10^{-5} for slope 2, and of 10^{-6} for slope 3. Values for storms 1 and 2 at GW-712 and GW-713 are reminiscent of values expected for slope 3 which is considered to represent drainage from matrix intervals when considering the 3 slopes encountered in conduit influenced wells. Each recession only exhibits one slope; some with values typical of slope 2 and some with values typical of slope 3, In light of the previous observations, it is believed that both GW-712 and GW-713 tap slow flow water zones responding to pressure changes in the overlying water table. No quickflow to this part of the aquifer is expected.

Water level responses in GW-714 are more rapid than in most other wells in the Picket (GW-710 through GW-713). This is reasonable given that this well is considerably shallower (TD =145 ft) than GW-710 through GW-713 (TD = 744.5 to 315.2 ft). In GW-714, each storm had recessions which were probably not complete prior to the initiation of the next storm event. Table B-5 lists slopes for the recession curves. Storm 1 has two distinct slopes on a plot of water level versus time (Figure A-5), suggesting that poorly fractured portions (slope 1) may drain more rapidly than the intervening matrix blocks (slope 2). It is believed that GW-714 also taps a relatively slow flow water zone responding to pressure changes in the overlying water table. Responses in this well are more rapid than in GW-710 through GW-713 because this well is shallower than others previously discussed. However, no quickflow to this part of the aquifer is expected, and this well also belongs to Group 3.

Picket A

During monitoring of wells at Picket A, several storms occurred between April and June of 1995. No significant water level responses were observed during the storm on 4/12/95; hence, storm 1 is identified as the storm beginning on 4/17/95. Storm 2a occurred on 4/21, with an additional amount of rain on 4/23/95 (storm 2b) which masks the recession of storm 2a. There was a sufficient time lag between precipitation events between storm 3 (5/1/95) and storm 4a (5/9/95) for the recession of storm 3 to be nearly complete in most wells. A second precipitation event on 5/10/95 (storm 4b) during storm 4 which with the recession of storm 4a. The main rain event producing the response of storm 5 occurred on 5/14/95, with the smaller event on 5/16/95 producing only a minor secondary peak during the recession. A sufficient amount of time followed storm 6 (on 5/18/95) before another rain storm, and hence, most wells have complete recessions for this storm also. These storms are identified on Figure A-8.

In GW-054, GW-056 and GW-057 (Figures A-8, A-9 and A-10, and Tables B-8, B-9 and B-10), delays to the start of water level rise from initiation of precipitation are all short (<4 hours), and all had short peak durations (≤1 hr). Most of the storms had recessions that were not complete prior to the initiation of the next storm event, hence there was interference in the recession curve. However, three slopes are observed on most of the recession curves in these three wells suggesting that these are Group 3 wells and that larger, well-connected fractures (or cavities) are draining more rapidly than more poorly fractured portions and the intervening matrix blocks. In light of the previous observations, it is believed that GW-054, GW-056, and GW-057 tap relatively rapidly flowing water zones which is reasonable given their shallow depths (37, 55, and 23 ft, respectively) and locations within the floor of BCV.

GW-683 is a somewhat deeper well (197 ft) in picket A which is located on Chestnut Ridge, and the results from ambient monitoring of this well appear in Table B-11 and Figure A-11. The duration of the peaks during the storms was somewhat longer than for the shallow wells previously discussed in Picket A (0 to 5.5 hrs). All of the storms had recessions which were not complete prior to the initiation of the next storm event, hence there was interference in the recession curve, and only storm 3 shows three slopes on the recession curve. This suggests this well monitors larger, well connected fractures (or cavities) that are draining more rapidly than more poorly fractured portions and the intervening matrix blocks. However, the differences in the slopes between the first and second segment of the recession are not very large, indicating the difference in the size between the most transmissive features (larger fractures or conduits) and the size of the next lower transmissive features is probably relatively small.

Data are missing from the GW-684 hydrograph curve (Figure A-12, Table B-12) because the equipment malfunctioned during monitoring of this well. Nevertheless, sufficient data appear to have been collected in this well to determine that the response was quite surprising. This well is completed in a cavity that produces significant amounts of water. Even so, delay times were quite long for some precipitation events, and responses were not flashy as has been observed in many other wells completed in conduits. Rapid responses and rapid recession were seen in all other wells in this picket, both shallower wells and deeper wells. None of the storms indicate three slopes on the recession curve for GW-684, which is typical in wells monitoring conduits. This well should show flashy, conduit behavior. The fact that it did not during this particular storm suggests discrete flow paths. For instance, if this well monitored the same conduit as any of the other wells in this picket, similar water level changes should be observed. Recharge to this well is likely at slightly greater distances and through relatively slow percolation through porous material rather than rapid recharge through fractures or cavities.

Other data suggest that there may be a hydraulic connection between GW-684 and GW-683 (Shevenell et al., 1995). Cross borehole tests, where water was injected under pressure in GW-684, resulted in a sharp pressure response in GW-683. These seemingly conflicting data are interpreted as follows. The two wells are not connected via a large conduit as confirmed by the hydrograph data, but by a low storage fracture. This fracture showed a rapid pressure response because water injected in GW-684 rapidly filled the low storage fracture. The rapid recession on the GW-683 response results because GW-684 is completed in a cavity (not connected to GW-683) which drains rapidly after cessation of injection, releasing the pressure on the small fracture between the two wells.

The duration of the peaks in GW-685 (Figure A-13, Table B-13) during the storms was slightly longer than for the shallow wells previously discussed in Picket A (0.5 to 3.5 hrs). All of the storms had recessions which were not complete prior to the initiation of the next storm event, hence there was interference in the recession curve. However, four storms show three slopes on the recession curve, indicative of drainage of three types (sizes) of porosity. Erratic specific conductance changes occurred (Figure A-14, Table B-14), yet it is not clear if the changes are associated with the storms.

The duration of the peaks in GW-728 (Figure A-15, Table B-15) during the storms was similar to that for the shallow wells previously discussed in Picket A (0 to 1.5 hrs). Most of the storms had recessions which were not complete prior to the initiation of the next storm event. However, storms 3 and 6 had complete recessions and show three slopes on the recession curve, indicative of drainage of three types (sizes) of porosity. This well is completed in a large cavity, hence the three slopes on the recession curve are expected. Changes in both temperature and specific conductance were observed during the storms, yet the changes were very erratic and possibly a result of instrument drift (Figure A-16). Hence, no conclusions related to the hydrology near this well were made based on these data.

Picket B

Water levels were monitored in 10 wells in the Picket B area between 1/18/95 and 3/1/95 during which time several storms occurred. The plots that appear in the appendix begin on 1/18/95, although a storm on 1/15/95 is responsible for the first water level recession on the plots. Hence, this 1/15/95 storm is considered storm 1, although it is not depicted on the plots because no water level rise data are available for that time period. Figure A-17 shows how the storms were labeled, and some of the smaller storms are not considered here because they did not result in any changes in water levels in the wells. Only two of the storms showed a complete water level rise and recession in the wells. However, the partial hydrograph associated with the first storm resulted in a nearly complete recession. Incomplete or no recessions were seen at any of the wells for the fourth storm. In addition, at several of the wells, considerable interference in the recession response occurred due to repeated, small storm events during the larger storm 2 recession.

GW-059 is located near GW-058 in the valley floor, and the same data logger was used to record data from both wells. The responses in the two wells are nearly identical (Figures A-17 and A-18, Tables B-15 and B-16). The timing of water level rise does not correspond with precipitation amount or intensity. The most rapid initiation of water level rise occurred for storm 2 which had intermediate total precipitation and intensity, yet the slowest initiation of water level rise occured during storm 4 which had the lowest total precipitation and intensity. Hence, the character of the storm and the location of precipitation on the ground are very important in dictating the speed with which water levels begin to rise in a particular well after initiation of precipitation.

Both storms 1 and 3 resulted in three slopes on the recession curve indicating drainage from three different portions of the aquifer with different storage coefficients. Although there are three distinct slopes on the recession curve in both GW-058 and GW-059, they are more nearly equal to one another than in other portions of the aquifer (i.e., GW-734 and GW-715) indicating the conduit development may not be as important at GW-058 and GW-059, and conduits may be smaller and less well developed at these wells than at wells such as GW-734 and GW-715. Nevertheless, these wells tap a relatively quick flow zone as can be seen by the rapid responses to precipitation, particularly during storm 2. During this storm, a 10 hour lull in precipitation occurred, and water levels began to decrease relatively rapidly during this time, and it appears as if two slopes were forming during this recession. However, too many precipitation events occurred during the second recession for the third slope to be distinct. After the first major storm of 1.26 inches, eight additional small storms occurred during the recession. Except for minor water level rises during this recession, the recession appeared to proceed along one slope.

GW-225 and GW-226 (Figures A-19 and A-20) were monitored using the same data logger for recording water level data. The water level responses in GW-226 (Figure A-20, Table B-19) are similar to those in GW-225 (Figure A-19, Table B-18), yet the responses are slightly less broad, and water level changes are greater in GW-226. On 1/25/95, the logging was halted temporarily in order replace the transducer being used at GW-226. This resulted in a slight gap in data, and a change in the GW-226 recession curve due to calibration of the new transducer in this well.

Minor water level increases occur in GW-225 (Figure A-19) during storms 2 and 3, although the magnitude of the increases are very small (<0.08 ft) and often masked by decreases in water level during the recession, and are not distinct. Hence it is difficult to determine the period of the cyclic variations, but it appears to be <24 hours, indicating this well may be partially confined. In addition, the hydrograph for this well is very broad, and not flashy as would be expected in a well dominated by quickflow. Only one or two slopes were observed on the recession curves for both GW-225 and GW-226 indicating there is likely to be a component of fracture flow near these well. However, the values of the two slopes do not differ appreciably, indicating the difference in storage between the two components of the aquifer near these wells is not large. Note that the recession from storm 2 was taken after 2/4/95 (6:30 AM) when a second bump in the hydrograph occurred due to additional rain.

The water level responses in GW-621 (Figure A-21, Table B-20) are relatively flashy with water levels beginning to decline shortly after the cessation of precipitation (e.g., storm 3). Small peaks on the recession curves were recorded during parts of storm 1 and 2 recessions. These peaks do not represent responses to secondary, smaller precipitation events because they are not associated with all of the rain storms, particularly not the larger one which occurred during the storm 1 recession. In addition, the peaks on the storm 1 recession occur 23.5 to 24 hours apart. The peak water level occurs at 2:30 to 3:00 PM each day. It is believed that these peaks are an artifact of the data logging equipment, and not a result of natural variations which might be expected from moon tides, which would occur twice daily. This same behavior was observed during monitoring at GW-711 in Picket W. It is unknown if the same logger was used during monitoring of both of these wells, but both showed peak water levels at 2:30 in the afternoon. GW-621 is near a power line, whereas GW-711 is not. Following monitoring at GW-621, the logger used in the GW-621 well failed during attempts to monitor a well in Picket A. Hence it is believed that the cyclic variations observed in GW-711 and GW-621 are a result of a malfunctioning data logger.

Three slopes were distinguishable on the storm 1 and 3 recession curves in GW-621, although the differences in the values between the slopes are relatively small (Table B-20). The recession slopes suggest there are probably three types of storage being drained, yet the differences are small. Slope 1 might represent drainage of fractures which have been partially solutionally enlarged. Slope 2 might represent drainage from intermediate sized fractures, whereas slope 3 may represent drainage from micro-fractures or porous media portions of the aquifer.

Somewhat irregular changes in specific conductance occurred as a result of the storms monitored in GW-621. Specific conductance apparently increased during the storms as the water levels increased. Numerous cavities occur in the completion interval in this well between depths of 24.8 and 40.5 ft (Table 3). Perhaps entrainment of particulate matter in the flow through the cavities results in an elevated specific conductance, or perhaps an increased velocity near the well bore is responsible for the increasing specific conductance. It is possible that the irregular shape of the specific conductance curve in comparison to that observed in GW-694 results because there is more mixing and sloshing around of fluid in cavities than there are in fractures where flow may be more discreet (slug flow). However, this possibility is speculative.

The water level responses in GW-694 (Figure A-22, Table B-21) are also relatively flashy, with rapid rises in water levels and responses to changes in precipitation during a storm (Storm 2 and 3 have short hiatuses in precipitation), yet rounded peaks are depicted for these two storms (Figure A-22). Small peaks on the recession curves were recorded during parts of storm 1, 2, and 3 recessions. The peaks do not occur at regular intervals as they do in GW-621 indicating the peaks are likely to be related to the rain events in GW-694, rather than being an artifact of an equipment malfunction as in GW-621.

Only two slopes were distinguishable on the storm 1 and 3 recession curves, although the differences in the values between the slopes are relatively small (Table B-21). The recession slopes suggest there are probably two types of storage being drained. Slope 1 might represent drainage of fractures which have not been solutionally enlarged, whereas slope 2 may represent drainage from microfractures or porous media portions of the aquifer.

Very distinct and regular changes in specific conductance occurred in GW-694 as a result of the storms monitored Table B-22 and Figure A-23. Specific conductance increased dramatically by 79 to 143 μmhos/cm during the storms as the water levels increased. A fracture is noted in records from this well in the completion interval at a depth of 202 feet. It is likely, based on the water level and specific conductance responses observed, that a discrete fracture occurs within the completion interval which allows rapid transmission of water, perhaps as slug flow. The rapid specific conductance rise followed by a decrease to levels lower than pre-storm values suggests that the initial pulse may be a result of displacement of higher TDS pore waters during the early stages of the storm followed by flushing of the water in the fracture by lower TDS recharge water. No changes in temperature were observed during any of the monitored storms in this well.

The water level responses in GW-695 (Figure A-24, Table B-23) are not flashy as would be expected in wells intersecting rapid flow zones in discrete fractures or cavities such as in GW-621 and GW-694. Rounded peaks are depicted for the storms (Figure A-24). Small rain events appear to have little or no impact on the shape of the recession curves and produce secondary peaks in only one case (recession curve of storm 2). Only two slopes were distinguishable on the storm 1, 2 and 3 recession curves, although the differences in the values between the slopes are relatively small (Table B-23), and the values are similar to those calculated for GW-694 recessions. No specific conductance or temperature changes occurred in this well during the storms. The similarity of the slopes between GW-694 and GW-695, in spite of their very different response times, may indicate that similar types of fracture networks are located in the vicinity of each well bore in their completion intervals. GW-695 is much shallower (completed between 52.4 and 62.4 ft) than GW-694, yet no water production was noted in the GW-695 completion interval. The differences between the two wells in their water level and specific conductance responses are probably not related to aquifer conditions near the well bore, but are related to the connection of the portion of the aquifer with the recharge area, or the ground surface. Presumably, based on the WL and specific conductance responses in the wells, GW-694 is more directly connected via fractures to the recharge area than is GW-695, thus resulting in GW-695 showing slower water level responses (even though it is shallower) indicative of more diffuse flow, with little or no slug (piston) flow component to this well. The recession slopes suggest there are probably two types of storage being drained in GW-695, the features of which are probably similar to those in GW-694. Slope 1 might represent drainage of fractures which have not been solutionally enlarged, whereas slope 2 may represent drainage from microfractures or porous media portions of the aquifer.

The water level responses in GW-703 (Figure A-25, Table B-24) are not flashy, and this well is clearly the slowest responding well in this picket. Very rounded, subdued peaks are depicted for the storms (Figure A-25). Small rain events have no impact on the shape of the recession curves. As expected, based on the slow broad responses in this well, only one slope was distinguishable on the storm 1, 2 and 3 recession curves. Hence, this well monitors a portion of the aquifer which is poorly connected to the recharge area and not influenced by quick flow through conduits or fractures.

Although the peaks in the GW-704 water levels (Figure A-26, Table B-25) are somewhat rounded, the response of this well to storms is more similar to the other wells in this Picket than is the response in GW-703. The water level responses in this well are not particularly flashy. However, three similar valued slopes are apparent on the recession curve, particularly for storm 2. Slope 1 might represent drainage of fractures which have been partially solutionally enlarged, although are not large enough to be considered conduits. Slope 2 might represent drainage from intermediate sized fractures, whereas slope 3 may represent drainage from microfractures or porous media portions of the aquifer. Small peaks occur twice daily showing that this well responds to earth tides. The amplitude of the daily fluctuations varies from ≈0.041 to 0.133 ft suggesting partial confinement of the aquifer at GW-704.

Changes in specific conductance occurred during the storms, although they were somewhat irregular, and intermediate between the responses observed in GW-621 and GW-694. The largest increase occurred during storm 3 where specific conductance increased by 75 μmhos/cm (Table B-26). The fact that the largest change was observed during storm 3 is reasonable given that this is the largest storm represented in the data. The data suggest that there is direct flow of water between the recharge area and the water zone at depths between 246 and 256 ft, likely through a partially enlarged fracture as indicated by the water level data.

The water level responses in GW-706 (Figure A-27, Table B-27) appear somewhat flashy, and small secondary peaks are seen during the recessions which appear to be related to small, secondary precipitation events. However, the largest secondary storm which occurred during the recession of storm 1 resulted in minimal changes in the recession curve. Also, the peaks are rather rounded suggesting relatively slow flow. Only two slopes were distinguishable on the storm 3 recession curve, and the differences in the values between the slopes are relatively small (Table B-27). No specific conductance or temperature changes occured in this well during the storms. The recession slopes suggest there may be two types of storage being drained in GW-706. Slope 1 might represent drainage of fractures which have not been solutionally enlarged, whereas slope 2 may represent drainage from microfractures or porous media portions of the aquifer.

Picket C

Water levels were measured in eight wells at Picket C between October 18 and December 8, 1994. Several precipitation events occurred during this time period, but some of them were insufficient in duration, intensity or amount to produce any significant responses in the wells monitored. Hence, only four separate storms are discussed in relation to Picket C, and these storms occurred on 10/19/94, 11/9 through 11/10/94, 11/26 through 11/28/94, and 12/3 through 12/5/94, and these storms are identified as 1, 2, 3, and 4 on Figure A-28. The water level responses in all wells monitored in this Picket (except for GW-723) are similar and somewhat subdued showing relatively long delay times between precipitation and peak water levels. The slow, broad water level changes suggest no influence from conduit flow. It is possible that the storms monitored were not sufficiently large or intense to produce noticeable effects on the conduit portion of the groundwater system near Picket C.

No WL responses of any kind were observed in GW-723 (Figure A-28). Only a slow decreasing trend in water level was recorded. Apparently, there is no direct connection between this deep (depth = 444.5 ft) well and the shallower, more active flow system.

Only one slope was observed on the recession curves from each of the four storms in GW-724 (Figure A-29, Table B-28) and GW-725 (Figure A-30, Table B-29). Small ($\leq$0.03 ft), twice daily fluctuations occur during the storms in both wells indicating partial confinement at these wells. The time delay between peak precipitation and peak water levels varies between 41.5 and 106 hours, indicating that these are slow response wells with no influence from conduit flow. Both GW-724 and GW-725 exhibit the responses typical in areas which are not subject to a significant quickflow component through conduits or fractures.

The water level responses observed in GW-737 (Table B-31, Figure A-32) are nearly identical to those in GW-736 (Figure A-31, Table B-30), which is reasonable given that the two are both located in the valley floor only 48 ft apart. In addition, GW-736 is completed at a depth of 102 ft, whereas GW-737 is completed to 89 ft. Both GW-736 and GW-737 intersected fewer water-bearing fractures and cavities than expected considering the proximity of the wells to Bear Creek. Water levels in GW-736 responded to purging activities in GW-737, suggesting the two wells may be in direct communication via a fracture (Shevenell et al., 1992). Given the purging data and the hydrographs for these wells, it appears that groundwater flow in this area is through relatively low storage fractures. In addition, somewhat irregular, and small (≤0.01 ft) bumps occur during the storms indicating that these wells may also be partially confined. However, the small rises and falls are irregular and do not appear to occur every 12 hours. Two slopes occur during some storms in GW-736 and GW-737 which may suggest a slightly more rapidly draining portion of the aquifer through fractures, yet the 2 slopes are nearly equal. GW-736 and GW-737 exhibit the responses typical in areas which are not subject to a significant quickflow component through conduits or fractures.

The behavior of water levels in GW-738 (Figure A-33, Table 32) is somewhat surprising given that extensive cavity occurrence is known to occur in the completion interval of this well. During drilling of this well, numerous mud-filled cavities were encountered, and below depths of 55 ft, small blowouts of water and air occurred on the ground surface ≈10 ft south of the drill rig on the edge of Old Bear Creek Road (Shevenell et al., 1992). Hence, it was expected that this well would exhibit clear indications of conduit flow. Water level changes in GW-738 are similar to those in other wells in this picket (Table 32, Figure A-33). However, this well did exhibit two line segments on the recession curves during storms 2 through 4. Although the slopes are similar, the second slope is less than the first and suggests there may be slightly more rapid drainage from fractures during the early part of the storms. In addition, small (≤0.01 ft), twice daily fluctuations in water level occur during the storms, indicating that this well may be partially confined. No specific conductance or temperature changes were detected in this well during the storms. Because there were clear indications of conduits during drilling, and connections to the surface via fractures, it appears likely that the storms monitored were not sufficiently large or intense to produce noticeable effects on the conduit portion of the groundwater system near this well, and perhaps the rest of the Picket. Apparently, even the 2.41 inch storm was spread out over too long a time period (32 hours) for a large, sharp pulse to be seen in the conduit portion of the system.

The overall changes in water level and duration of peaks and recessions in GW-739 (Table B-33, Figure A-34) are similar to the other wells in this Picket. Small, cyclic variations occur in the water levels, with peaks occurring every 12 hours and have magnitudes of 0.03 to 0.08 ft. Given that the aquifers on the ORR are considered to be increasingly confined with depth (Solomon et al., 1992; Moore and Toran, 1992), the water level fluctuations in GW-739 suggest partial confinement. The water level data do not show any indication of conduit flow in this well. This is not surprising given that GW-739 was completed with a large open-hole interval (31 ft) in order to intercept sufficient quantities of water for sampling.

The water level responses in GW-740 (Table B-34, Figure A-35) are similar to those observed in GW-739, except no distinct response was seen during storm 1 which had the lowest intensity and total precipitation of the four storms monitored. GW-739 and GW-740 are located near one another, and GW-740 is a shallower well completed at a depth of 190 ft. In general, shallower wells are expected to respond more rapidly and to a greater extent to precipitation events. However, the fact that GW-740 did not respond to storm 1, whereas GW-739 did respond, shows that dramatic heterogeneity can be expected within the Cmn over relatively short distances. Similar to GW-739, GW-740 exhibits cyclic variations (magnitudes of 0.04 to 0.08 ft) which occur in the water levels, with peaks occurring approximately every 12 hours, showing this well is also responding to earth tides. The water level fluctuations in GW-740 are nearly identical to those in GW-739, also suggesting partial confinement of the aquifer where it is being monitored by GW-740. The water level data do not show any indication of conduit flow in this well. This is not surprising given that during purging of GW-740, the well was pumped dry after removal of ≈385 gal of water (approximately 1.8 well bore volumes), showing that this well does not monitor a particularly transmissive zone. As expected, no specific conductance or temperature changes occurred during the four storms.

Picket J

Water levels were measured in eight wells at Picket J between February 20 and March 3, 1994. Three main precipitation events occurred during this time period. The separate storms discussed in relation to Picket J occurred on the following dates: 2/20 through 2/21/94 (storm 1), 2/22 through 2/23/94 (storm 2), and 3/1 through 3/294 (storm 3). Storm 3 is divided into two segments, 3A and 3B, due to a hiatus in the rain and the fact that water levels began to recede in some wells following storm 3A. Storm 3A occurred on 3/1/94 between 4:00 and 17:00, whereas storm 3B occurred between 3/1/94 at 18:00 and 3/2/94 at 20:00. These storms are identified on Figure A-36.

Water level plots of GW-167 (Figure A-36, Table B-35) suggest that only storm 2 exhibits two distinct slopes, suggesting that poorly fractured portions (slope 1) may drain more rapidly than the intervening matrix blocks (slope 2). Other recessions may not have been sufficiently long to identify two slopes. This well exhibits the responses typical in shallow wells in which responses are relatively rapid, yet not necessarily associated with conduit flow. This well does not exhibit flashy WL responses to precipitation, as do wells such as GW-734 in which there is clearly active conduit flow.

Hydrograph plots in GW-220 (Figure A-37, Table B-36) suggest that only storms 1 and 2 exhibit three distinct slopes, suggesting conduits may be draining rapidly and that poorly fractured portions (slope 2) may drain more rapidly than the intervening matrix blocks (slope 3). Other recessions may not have been sufficiently long to identify two slopes. This well exhibits the responses typical in shallow wells in which responses are relatively rapid. The short delay times, and duration of peaks suggests this well is influenced by rapid conduit flow. However, no temperature or specific conductance responses were observed during the storms.

Hydrograph plots of GW-603 (Figure A-38, Table B-37) are very similar to those of GW-604 (Figure A-39, Table B-38), which have been discussed previously. Water level responses in GW-733 (Figure A-40, Table B-39) to the storms are somewhat slower than in the shallower wells GW-603 and GW-604, which is reasonable given that GW-733 is considerably deeper (TD = 256.5 ft). Plots show that only storm 2 may exhibit two distinct slopes, suggesting that poorly fractured portions (slope 1) may drain more rapidly than the intervening matrix blocks (slope 2). However, the two slopes are nearly the same value and may not be distinct. The other storms did not have complete recessions. Rapid conduit flow is not indicated by the hydrograph data given the relative long delay times observed. This is reasonable because a relatively small amount of water was produced from the completion interval during drilling. The relatively large water level rises in this well probably represent the effects of low storage coefficients in a relatively low permeability formation.

Precipitation and water level data for GW-734 for two 1992 storms which produced clear water level changes, and three 1994 storms are illustrated in Figures A-41 and A-42, and selected data are tabulated in Tables B-40 and B-41. Responses to the storms are more rapid than in other wells in the picket which is reasonable given that GW-734 is completed at relatively shallow depths (≈60 ft) in a large cavity. Storms 1 and 3 of 1994 had recessions which were not complete prior to the initiation of the next storm event. Table B-40 lists slopes for the recession curves.

More distinct slopes are observed in the 1992 storms which did not overlap with one another to the extent that the 1994 storms did. Nevertheless, three slopes are clearly identified from each of the storms with complete recessions. The responses in this well clearly show the effects of successive drainage of the conduit, fracture, and matrix portions of the aquifer. The cavity intersected by GW-734 is exhibiting typical karst responses. Peak water levels have been observed to occur in fracture and matrix flow dominated wells in Melton Valley 4 days after peak precipitation (Moore, 1992), whereas peak water levels occur only 1 to 5 hr after the end of precipitation in GW-734. The short response time of the well to precipitation indicates the well taps a relatively small system or basin (White, 1988).

A small increase in water level is observed on the recession limb of storm 2 which is not associated with any additional recharge from precipitation. This small increase may suggest that two separate conduit passages feed into the conduit intersected by GW-734. However, the response is very small and may not be significant. Also of note in storm 2 is that water levels continued to rise between 3:30 AM and noon, even though there was no recorded precipitation for the hours of 8:00, 9:00, and 10:00. This indicates that the conduit system tapped by GW-734 is partly recharged by relatively slow percolation through the unconsolidated zone and fractures through bedrock, rather than dominantly through direct inputs via karst features such as sinkholes.

There are possible changes in specific conductance and temperature during the 1994 storms (Figure A-43 in GW-734). However, a data logger or Hydrolab malfunction resulted in lost data during critical times. Hence, no quantitative evaluation of these parameters can be made from the available data. The existing data do suggest, however, that water flow to this well, and not simply a pressure pulse, can occur quite rapidly following a precipitation event.

Water level plots of GW-735 (Figure A-44, Table B-42) suggest that only storm 2 may exhibit three distinct slopes. The other storms did not have complete recessions. Rapid conduit flow is not indicated by the hydrograph data given the relative long delay times observed. The relatively large water level rises in this well probably represent the effects of low storage coefficients in a relatively low permeability formation.

GW-748 is a shallow (TD = 27.2 ft) well completed in the Maryville Limestone. This well is included for comparison with wells completed in karst portions of the Cmn. Precipitation and water level data are illustrated in Figure A-45 and selected data are tabulated in Table B-53. Water level changes during the storms ranged from 0.59 to 3.13 ft. Delays to the start of water level rises from the initiation of precipitation varied from 8.5 to 9 hours. Storm 1 and 2 responses overlap and specific conclusions pertaining to water level rises and delay times are not possible. This well is clearly showing slow responses to precipitation and is not influenced by karst flow. The duration of the peaks during the storms are longer (2 to 5 hrs) than in the Cmn karst wells. None of the storms show more than one distinct slope on the recession curve, in part because of incomplete recessions, but more important, because this well is not affected by conduit flow.

In GW-750 (Figure A-46, Table B-44), each storm had recessions which were not complete prior to the initiation of the next storm event. Plots suggest that none of the storms exhibit three distinct slopes. Rapid conduit flow is not indicated by the hydrograph data given the relative long delay times observed in this well.

DISCUSSION

Hydrograph data from numerous wells indicated that some wells are dominated by conduit flow, whereas others are not. Sixteen wells have recession curves with three line segments. Other wells show no evidence of quickflow. Water level responses are not well correlated to total depth of well, screen length or the height of the water column above the monitoring interval. However, all deeper wells (>300 ft deep) with large water columns in the wells show diffuse flow behavior, and all wells exhibiting flashy, conduit flow are at depths of <200 ft (although not all wells at depths <200 ft exhibit quickflow characteristics). Observed responses of all monitored wells to precipitation events are summarized below.

The hydrographs discussed in this report provided significant insight into the behavior of flow in different portions of the karstic Cmn. The data presented herein allows several interpretations and conclusions. For instance, the presence of two secondary conduits feeding into one main conduit is indicated at GW-715 as is seen from the double peak in water level during one continuous storm. In addition, karst features are locally more well developed in some areas at shallow depths. Both quickflow and slow flow through matrix intervals are found at the shallow depths, but at depths >200 ft, flow is through fractured and matrix intervals. In addition, GW-739 (deeper well) responds to storm 1 but the shallower nearby well, GW-740, does not respond to this storm showing the highly heterogeneous nature of this karst flow system.

Table 4 summarizes some of the data collected from the pickets. The wells in this table are grouped by their relative responses to the precipitation events, and the extent to which karst development controls the observed responses. The first group includes GW-220, GW-715, and GW-734 in which water levels showed the typical flashy responses expected in active conduit systems, and the recession curve was comprised of three distinct slopes indicative of successive drainage from conduits, fractures, and matrix portions of the aquifer. The second group includes wells in which water levels showed less flashy responses, yet the recession curve was also comprised of three slopes, but with slope values being more similar to one another than in the first group. These recessions indicate successive drainage from conduits, fractures, and matrix portions of the aquifer, yet the conduits in this group are less important (and probably smaller) in the overall flow than in Group 1. Group 3 wells did not show three distinct slopes, but had only one or two slopes. In some cases, it is believed that recession time was insufficient for the second slope to become apparent. In other cases in this table, '1 or 2' is indicated if there was a slight break in slope, yet the slopes 1 and 2 were not appreciably different from one another. Group 3 wells show no evidence of contributions from conduit flow, but suggest there may be two forms of storage, fracture and matrix.

The delay time between precipitation and initiation of water level rise can be rapid for all three groups of wells, and this time is a function of the degree to which the conduits, fractures and matrix are hydraulically connected with one another and with the surface recharge zone. If a monitored conduit is connected to the near surface via another conduit or fracture, rapid water level rises will be seen following precipitation if a sufficiently large precipitation event occurs. However, if recharge toward the conduit is through the diffuse flow zones, water level rises will be delayed in comparison to those with a more direct connection to the surface. In contrast, a relatively small amount of recharged water entering a low permeability fracture may cause water levels to rise rather rapidly due to the relatively low storage in these features. Even shallow wells not completed in fractures or cavities may have a rapid initiation of water level rise as a result of their proximity to the recharging waters in the vadose zone. Hence, delay times can be useful to qualitatively identify different types of flow regimes (Table 4), yet additional information is required from the recession curves. For instance, even rapidly responding wells in fractures or matrix will not have a period of very rapid drainage as is seen in the slope 1 of recession curves of Group 1 wells.

Table 4 shows that delay times from the start of precipitation to the start of water level rise are longer in Groups 2 and 3 than in Group 1. The slightly shorter minimum delay time in Group 3 in comparison to Group 2 reflects the effects of a variety of different types of wells represented in Group 3. GW-167 has a short delay time because it is a shallow (30 ft) well which would be expected to respond relatively rapidly to precipitation, yet would not necessarily show evidence of conduit flow and rapid drainage. The delay times for GW-711, GW-713 and GW-714 are likely to be relatively short as a result of water recharging through relatively low permeability, low storage zones in these portions of the aquifer for which the pressure pulse is transmitted rapidly. Relatively small increases in water being added to areas with low storage should result in a fairly rapid pressure pulse being transmitted if the area does not have high transmissivity. Maximum delay times to start of water level rises are progressively longer for Groups 1 through 3.

Other summary parameters in Table 4 also show consistent trends. The value of the delay time between maximum precipitation and the peak water level is another indication of how rapidly wells respond to the precipitation event. Conduit influenced areas also show very short peak durations and water levels fall very soon after the end of the precipitation event. This flashy water level response is characteristic of rapidly draining conduits. Group 3, in contrast, show relatively long durations of the peaks because rapid drainage of conduits does contribute to flow in these areas, and this trend reflects the slower responses expected from the lower K fractures and matrix intervals. Durations of the recessions vary somewhat, in part because many recessions were not complete. However, the average time of the recession curves is 196, 164 and 217 hours for all three groups. The similarity in recession times between conduit dominated and baseflow (matrix) dominated portions of the aquifer is reasonable, because the recession duration is controlled by the time required to drain the matrix intervals. In addition, similar ranges in WL rises are observed showing that the magnitude of WL rise can not be an indicator of conduit influence. The largest WL rise did occur in a conduit (GW-734), yet the second largest occurred in a well dominated by slow flow (GW-167). The magnitude of WL rises is a function of the precipitation amount and intensity, and the storage coefficient in the aquifer.

Table 5 lists the average slopes and continuum T calculated using all storms for all wells showing three distinct line segments on their recession curves for at least one storm event. The data and results from some of the storms appear anomalous (e.g., GW-715 storm 4, GW-604 storm 3, and GW-735 storm 3). In each of these cases, the slope of the second line segment in the recession is greater than or equal to that of the first segment. The recession for the fourth storm in GW-715 is not complete, and the brief, sharp decrease observed at the end of the record (Figure A-6) may have resulted from data logger or transducer malfunction. Hence the results from storm 4 are not considered reliable. The recessions from the third storm in GW-604 and GW-735 were also not complete prior to termination of data collection. Because the first and second slopes are nearly equal to each other, the break in slope selected may not be accurate, and perhaps only the first slope is represented by the data. Hence the calculated continuum T from these two wells for the third storm and from GW-715, storm 4, may not be reliable, and the values are not included in the calculated averages.

Table 5 shows that, on average, the S_{y_1} values for Group 1 are smaller than those of Group 2, and continuum T are higher which is reasonable given that these wells monitor more karstified portions of the aquifer. Average values of slopes 1, 2 and 3 decrease with group between Groups 1 and 3, showing that conduits in Group 1 drain most rapidly and fractures and matrix intervals drain most slowly. Generally, higher continuum T values were calculated for the first group of wells which show a greater influence from conduit flow (Table 5). These results can be useful in conducting groundwater flow modeling because the data can be used to assign different T values in different portions of the aquifer system. Hence, the results from the slopes, as well as the S_y and T calculations, are realistic given the varying hydrogeologic parameters in this aquifer.

As expected, the T/S values for the conduit portion of the recession curve are greater than those of the fracture and matrix portions of the curve at all wells for all storm events, because conduit T is high and storage is low. These T/S values vary by storm, yet the highest intensity storms are not necessarily associated with the larger T/S values. For instance, storm 1 in GW-220 had an intensity of 0.096 in/hr (total precipitation of 1.44 in), storm 2 had an intensity of 0.137 in/hr (total precipitation of 2.33 in), and storm 3 had an intensity of 0.085 in/hr (total precipitation of 1.1 in), yet storm 1 had the highest T/S values for all three segments in GW-220 (Picket J).

The S_y for each portion of the recession curve is also noted in Table 5. Based on numerous studies on the Oak Ridge Reservation, the S_y value of $\approx 3.0 \times 10^{-3}$ for the third (continuum) segment is probably a reasonable estimate, and lower calculated values for the first two segments (conduit and fracture dominated) are likely to be realistic averages for the Y-12 area. Based on these calculations, the S_y for the conduit dominated portions of the aquifer are expected to be on the order of 1 to 8×10^{-4}, and the fractured portions on the order of 1×10^{-3}, with these values varying somewhat with position within the aquifer.

Additional data on recession curves are available from cross borehole tests in which water was injected into one well in a picket, and water level responses were monitored in surrounding wells (Shevenell et al., 1995). Table 6 lists results of calculations made with the recession curves from these types of tests as well as results obtained from hydrographs. Dramatically different T/S and S_y values are obtained with the cross borehole testing data, because the cross borehole tests involved injecting water into a source well under pressure, thus creating artificial conditions. Also, the aquifer parameters represented in the cross borehole testing are only those between the injection and monitor well, and not the aquifer as a whole. The lower S_{y1} in the cross borehole test results for GW-735 may indicate that low storage conduit flow is important between wells GW-734 and GW-735. Nevertheless, calculations using both types of data indicate that continuum T near the GW-735 well bore is between about 20 and 30 m^2/d. Data from the wells in other pickets show high continuum T might occur near GW-694 and GW-725, with lower, more typical values of about 5 m^2/d being associated the the GW-683, GW-695, GW-704, GW-738 and GW-739 locations. With the exception of GW-694 results, there is good agreement between the T calculated using cross borehole recessions and hydrograph recessions. The disagreement between the two T values for GW-694 may result because three slopes were available for analysis from the cross borehole tests, whereas only two were available from the hydrograph.

With few exceptions (GW-750), the largest WL rise in a well occurred during the storm with the largest precipitation amount and intensity. Conversely, the smallest WL rise was generally associated with the smallest precipitation event. The lag time between initiation of precipitation and the time that the WL began to rise in an individual well is not well correlated by storm.

For instance, the highest precipitation event at a well does not necessarily correlate with the shortest lag time seen for the well. This effect is reasonable because not all storms rain in exactly the same location or over as large an area, and delay times can vary between storms depending on where the recharge area is. Also, storm intensity does not remain constant throughout its duration. For instance, a storm may start with low intensity and have greater intensity later during the storm (and vice versa). Hence, delay times and peak durations are a function of the type of storm, whether a cavity or fracture is present, and perhaps to a lesser degree, the storage conditions in the aquifer at the time of the storm. The importance of the type of storm is also notable in the Picket C wells. No specific conductance or temperature changes were detected in GW-738 during the storms. Because there were clear indications of conduits during drilling, and connections to the surface via fractures, it appears likely that the storms monitored at Picket C were not sufficiently large or intense to fill the cavities or produce noticeable pressure effects on the conduit portion of the groundwater system near this well, and other wells in the picket. Hence, the character of the storm is very important in determining the speed with which water levels begin to rise in a particular well after initiation of precipitation. Delay times can be useful in distinguishing conduit from non-conduit flow behavior, but only in wells which have been monitored during the same storms. Hence, delay times would not be expected to be comparable from picket to picket or storm to storm. Because of these variabilities between storm events, rain gauges should be placed at each monitoring location in the future in order that it will be known what the exact intensity of the storm is at the site. The precipitation data for the work here were not obtained at the sites. Hence, poor responses could simply mean that much lower rainfall occurred at the monitored site or in its recharge area than occurred at the weather station in the city of Oak Ridge.

Hydrographs were obtained from several wells over a wide range of depths. Figure 4 illustrates the range of depths monitored for each of the Cmn zones, where the zones noted occur in the completion intervals of the wells. This plot illustrates that the vast majority of hydrograph data are from wells at depths <300 ft, with data available from only 3 wells at depths >300 ft. Nine, 10 and 11 wells were monitored in zones 2, 6 and 4, respectively, whereas only four wells were completed in zone 5 and one deep well in zone 3. Hence, generalized interpretations regarding zone 3 can not be made because (1) there is only one well in this study for which data are available, and (2) this is a deep well not influenced by conduit flow. Nevertheless, other generalizations regarding the specific zones can be made with the available data, when the distribution of data in Figure 5 is considered.

Figures 4 and 5 show the distribution of calculated continuum T by Cmn zone and the depth or group into which the wells fall. These plots show that the shallower wells generally have the higher T values, and the deeper wells often have lower T values, which is reasonable because fractures and cavities likely are smaller at depths due to increasing pressures and there is less solutional enlargement of secondary porosity features with depth. However, data from some wells do not strictly follow this general trend because (1) T are for the continuum and are not necessarily dominated by the higher T conduit and fracture features, where present, and (2) this aquifer is highly heterogeneous. For instance, even at shallow depths, a relatively large range in T values was found (e.g., 0.8 m^2/d in a 40 ft well (GW-621), and 26.7 m^2/d in a 37 ft well (GW-054)). Figure 6 shows that Group 1 wells with clear conduit influences generally have higher continuum T than Group 3 wells which have no contribution from conduit flow. This generalization also does not hold universally because shallow wells which do not intersect conduits often have higher continuum T by virtue of their location in the shallow, active flow system, because T tends to decrease with increasing depth. Hence, shallow non-conduit areas may have similar continuum T to areas where conduits are more important. These two plots (Figures 5 and 6) show that depth is a very important controlling factor of conduit development and continuum T. These data also indicate that zone 2 has calculated T over a wider range than the other zones, suggesting heterogeneity within this zone may be somewhat greater than within the other zones.

Similar trends can be identified when viewing S_y as a function of depth and Group (Figures 7 and 8), although in a less consistent fashion. Zone 2 shows generally lower S_y for the first slope (which is the S_y of cavities, or fractures if cavities are not present) in the shallower wells. Because conduit development is more extensive at shallower depths, they likely contribute to the total porosity to a greater extent than do smaller conduits at deeper levels, and thus, the S_y of the continuum is less. Group 1 wells generally have lower S_y (Figure 8) for the same reasons. This trend of increasing S_y from Groups 1 to 3 is much more consistent than is the depth relationships noted on Figure 7, because, as Figure 8 shows, S_y is a strong function of the presence of cavities. Note that these data also indicate that zone 2 is more heterogeneous in its S_y values than the other Cmn zones.

When considering wells from all zones, it is clear that there can be a wide variation in S_y over all depths in the Group 1 wells which are all influenced by conduit flow (Figure 9). However, the calculated S_y values of the Group 3 wells are more nearly equal to one another because these are in areas of fracture and matrix flow. This suggests that in these portions of the aquifer, the S_y of the fractured portion of the aquifer, which is not subject to enhanced permeability through dissolution, does not change appreciably with depth in any of the Cmn zones. The non-conduit portions of the aquifer are expected to be less heterogeneous than the conduit dominated portions of the aquifer. Similar trends in T are also observed where the majority of the T values for Group 3 are near 5 m^2/d. Only one well in Group 3 shows elevated T, and this is the a shallow (depth = 30 ft) well GW-167 located in the active flow system in the valley floor (Figure 10). The T values of the Group 1 wells, on the other hand, show considerable scatter over a wide depth range, though deeper wells generally have lower T than shallower wells, as noted above. Hence the variability in T and S_y in the Group 1 wells can be attributed to variations in the extent of conduit development in different portions of the aquifer, and to their depths.

These depth dependencies were also investigated by compiling all known water zones encountered during drilling (Jones et al., 1992) and whether the well was completed in a particular water zone. Many times during drilling, particularly in the newer wells, fractures, cavities, or increased water production is noted on drilling logs as the drill bit penetrates these zones before arriving at the completion interval. Many of the wells at Y-12 were drilled to very shallow depths (<50 ft), and realistic generalizations on depth dependencies can not be made. Therefore, a subset of the data was selected such that all data from wells drilled to ≥100 ft (Figure 11) or 200 ft (Figure 12) were included, and all water zones at depths of <100 ft from wells drilled to all depths were included (Figure 13). All of these plots show that cavities which allow quickflow are much more important and common at the shallower depths than slow flow water zones through areas not subject to significant secondary porosity development. As depths increase, the frequency of cavities decreases substantially, and they are eventually absent, whereas the other types of slow flow water zones increase significantly and dominate flow at depth below ≈150 ft. This is true even in the plot which only considers data collected to a depth of 100 ft. Hence, secondary porosity development in the form of conduits is strongly depth dependent, with decreasing development with increasing depth. The data used to construct Figures 11, 12, and 13 generally do not include information on which Cmn zone the water producing feature was encountered. Hence, these comparisons by Cmn lithology can not be made.

Limitations

The method of estimating S_y and continuum T using three slope recession curves from wells responding to flow through conduits, fractures and matrix blocks will provide useful information on aquifer characteristics, but has several limitations to its use.

(1) Sharp storm pulses produce the best and most useful data. Long storms forming broad peaks tend to mask some of the quickflow characteristics expected in wells monitoring conduit areas.

(2) Recession curves should be complete, because incomplete recessions may not contain the third slope in karst aquifers, and the method to calculate continuum T and the S_y values may not result in realistic estimates of continuum T because only the higher T portions of the aquifer (conduit and fracture) may be represented.

(3) In the calculations, the logarithm of WL is used. Hence, the absolute WL elevation (e.g., feet above sea level) can not be used because identical responses in different wells at different elevations will yield dramatically different calculated T values. A consistent method of identifying WL is to use the WL above transducer, which in the studies here, was ≈5 ft.

(4) Following equation (6), it is assumed that the drainage area corresponding to volume changes represented by the three line segments are the same, and that the $AS_{y_t} / Q_1 = X_t$ expressions could be solved for Q_1 and equated. This limitation imposes the assumption that the recharge area associated with the conduit, fracture and matrix responses are equal, yet this would not be true if a dominant source of the recharge to the conduit portion of the aquifer were though a sinkhole. The sinkhole area would be much smaller than the area comprising recharge to the matrix portions of the aquifer.

(5) The methods described for estimating continuum T and S_y values needs to be applied in karst areas, on wells exhibiting three distinct slopes on a semi-logarithmic plot. Incomplete recessions showing only two slopes will not always produce reasonable results.

CONCLUSIONS

This report describes the development of a method to quantitatively analyze well hydrographs in order to obtain estimates of non-conduit T, and S_y associated with karst dominated portions of an aquifer. Several wells intersect conduits which respond rapidly (30 minutes to 5 hours) to precipitation events. The hydrographs from these wells show three discrete line segments on recession curves obtained during a number of storms. These segments are believed to represent drainage from the conduit, fracture, and matrix dominated portions of the aquifer in the vicinity of the well bores.

Hydrographs from several wells in the karst Maynardville Limestone near Oak Ridge, Tennessee were used to estimate the S_y associated with the conduit, fracture and matrix portions of the aquifer. Continuum T were also estimated for different positions within the aquifer. Data from short injection tests at one well indicate continuum T at this well bore is ≈ 5 m^2/d, and tests at numerous other wells in the aquifer yield results between 1 and 7 m^2/d. The T estimated with well hydrographs from two storms indicates a T of 9.8 m^2/d, suggesting that the use of hydrographs provides reasonable estimates of continuum T. In the study area near Oak Ridge, well developed conduit systems in which water levels in wells show a flashy response typically have shown S_y's of about 1×10^{-4}, 1×10^{-3}, and 3×10^{-3} for conduit, fractured, and matrix portions of the aquifer. Less well developed conduit areas show more nearly equal S_y's (8.6×10^{-4}, 1.3 $\times 10^{-3}$, 3×10^{-3}). Areas with no evidence for the presence of conduits have only one, or in some cases two, slopes on the recession curve. In these cases, water level responses are slow. Recession curves with a single slope represent drainage from only the lower T matrix. Those with two slopes have an additional, more rapid response segment on the recession curve which represents drainage from the higher T, lower S_y, fractures in the system. Using easily obtainable and relatively inexpensive hydrograph data with the method described here provides reliable estimates of continuum T, and S_y of conduit, fracture, and matrix intervals in many portions of the aquifer. Such information will be useful identifying heterogeneity in the aquifer and in constructing numerical groundwater flow models.

ACKNOWLEDGMENTS

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FIGURES

Figure 1. Generalized geologic map of the Oak Ridge Reservation, modified from Lemiszki (1992). Locations of wells discussed in this report are identified by the transect (Picket) locations W, A, B, C, and J.

Figure 2. The natural logarithm of water level versus time for GW-734, 1992 data.

Figure 3. Hydrographs from three wells representative of three distinct groupings of well responses. (A) shows a well completed in a cavity (GW-715), B() shows a well (GW-604) completed in less responsive fractures than in GW-715, and (C) shows a deep well (GW-710) with no influence from conduit flow. See text for detailed discussion.

Figure 4. depth of wells in this study by Cmn zone.

Figure 5. Transmissivity (m^2/d) by Cmn zone and depth for wells in this study.

Figure 6. Transmissivity (m^2/d) by Cmn zone for the three groups of wells in this study.

Figure 7. Specific yield by Cmn zone and depth for wells in this study.

Figure 8. Specific yield by Cmn zone for the three groups of wells in this study.

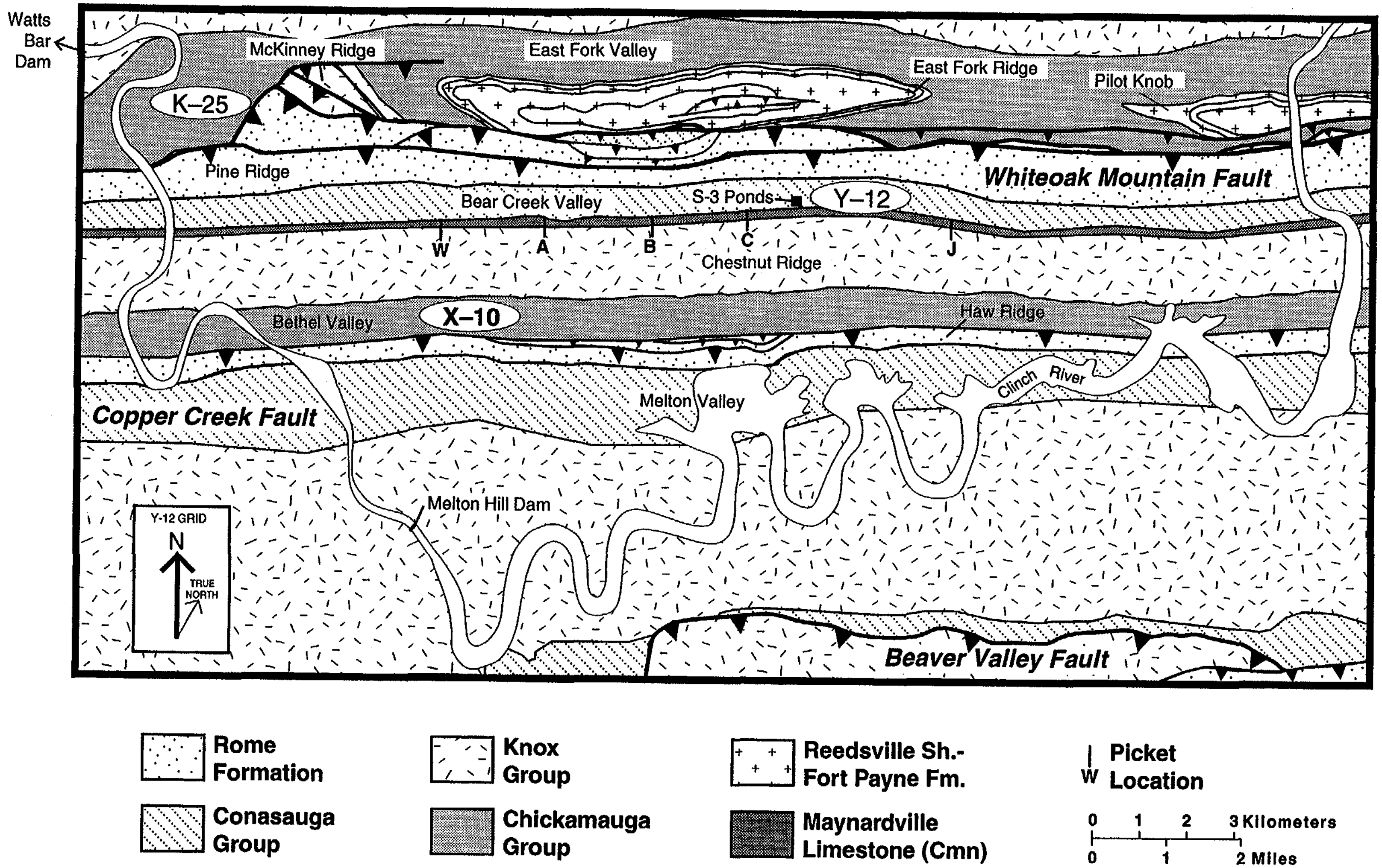
Figure 9. Specific yield versus total depth for the three groups of wells in this study.

Figure 10. Transmissivity versus total depth for the three groups of wells in this study.

Figure 11. Frequency of water zones and cavities in all wells drilled to depths >100 ft at the Y-12 Plant.

Figure 12. Frequency of water zones and cavities in all wells drilled to depths >200 ft at the Y-12 Plant.

Figure 13. Frequency of water zones and cavities in all wells drilled to depths <100 ft at the Y-12 Plant.



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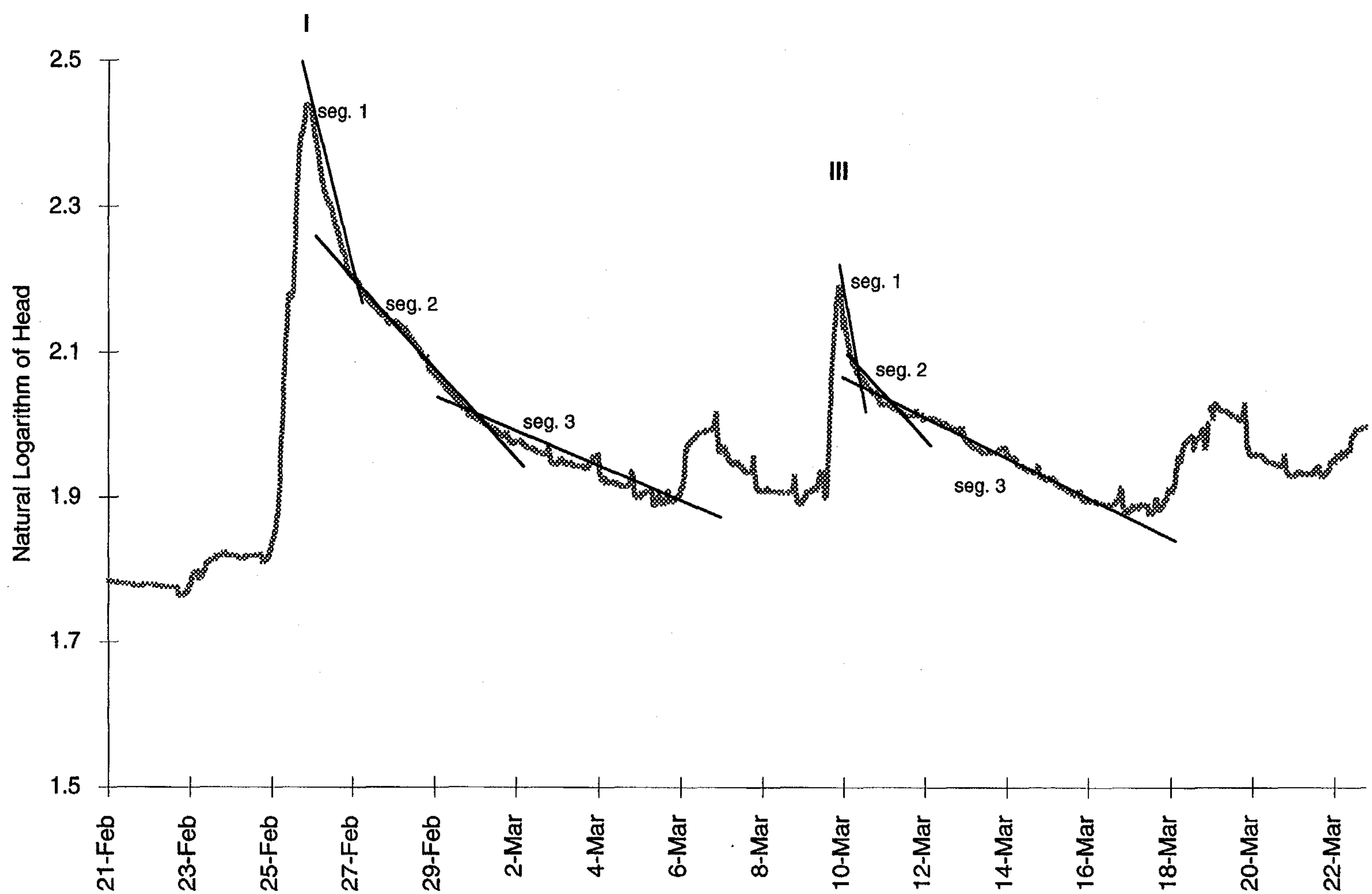

Figure 2. The natural logarithm of water level versus time for GW-734, 1992 data.

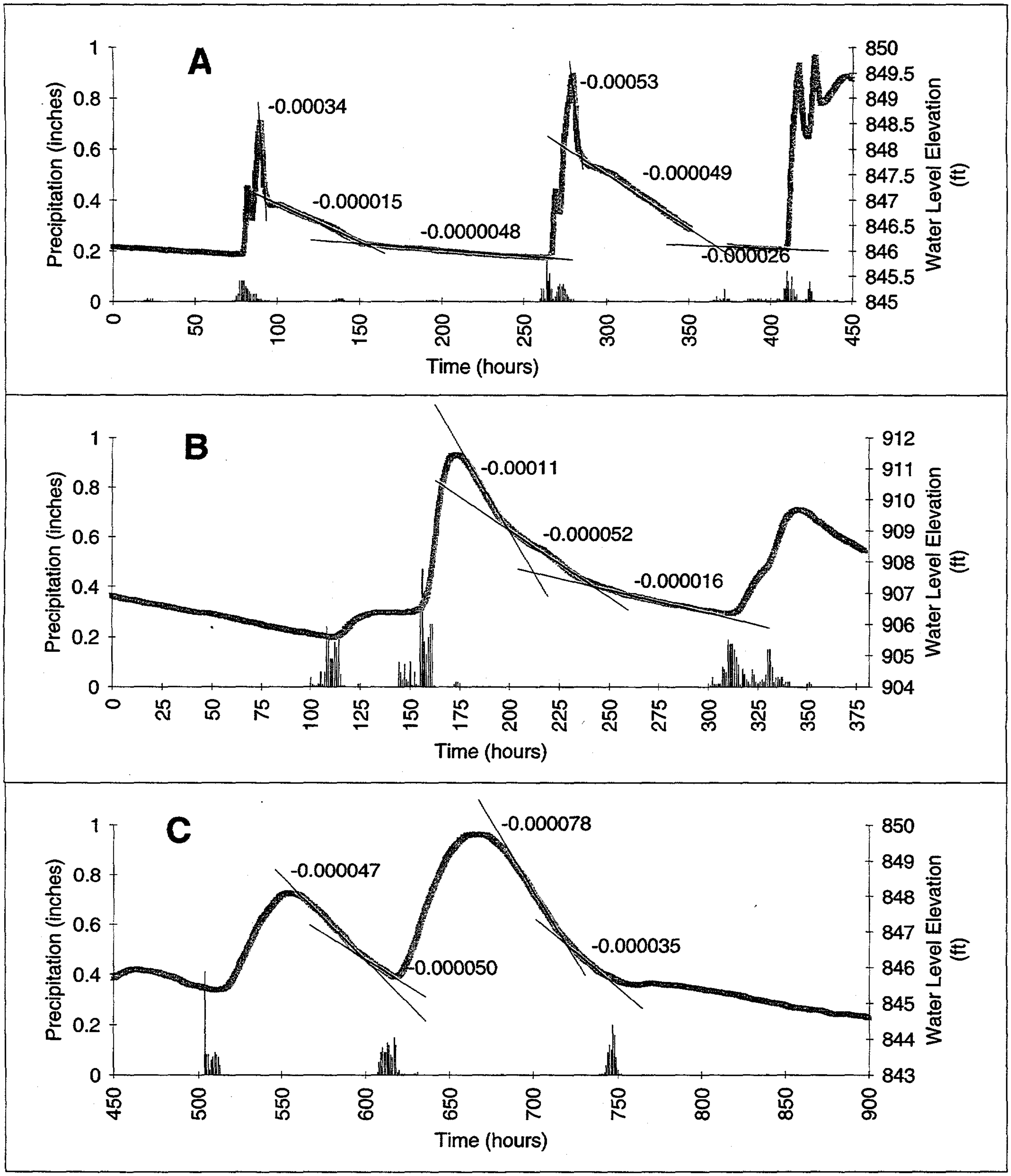

Figure 3. Hydrographs from three wells representative of three distinct groupings of well responses. (A) shows a well completed in a cavity (GW-715), (B) shows a well (GW-604) completed in less responsive fractures than in GW-715, and (C) shows a deep well (GW-710) with no influence from conduit flow. See text for a detailed discussion.

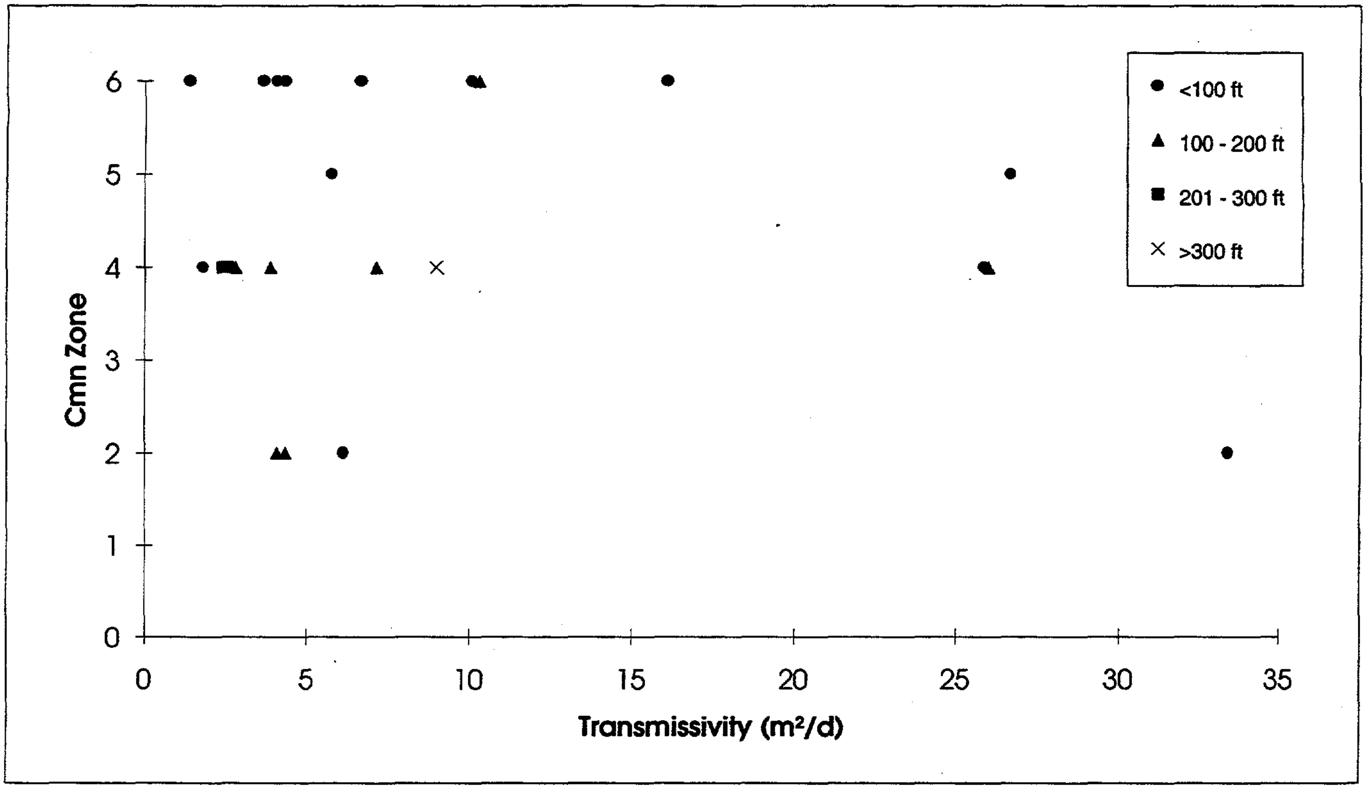

Figure 4. Total depth of wells in this study by Cmn zone.

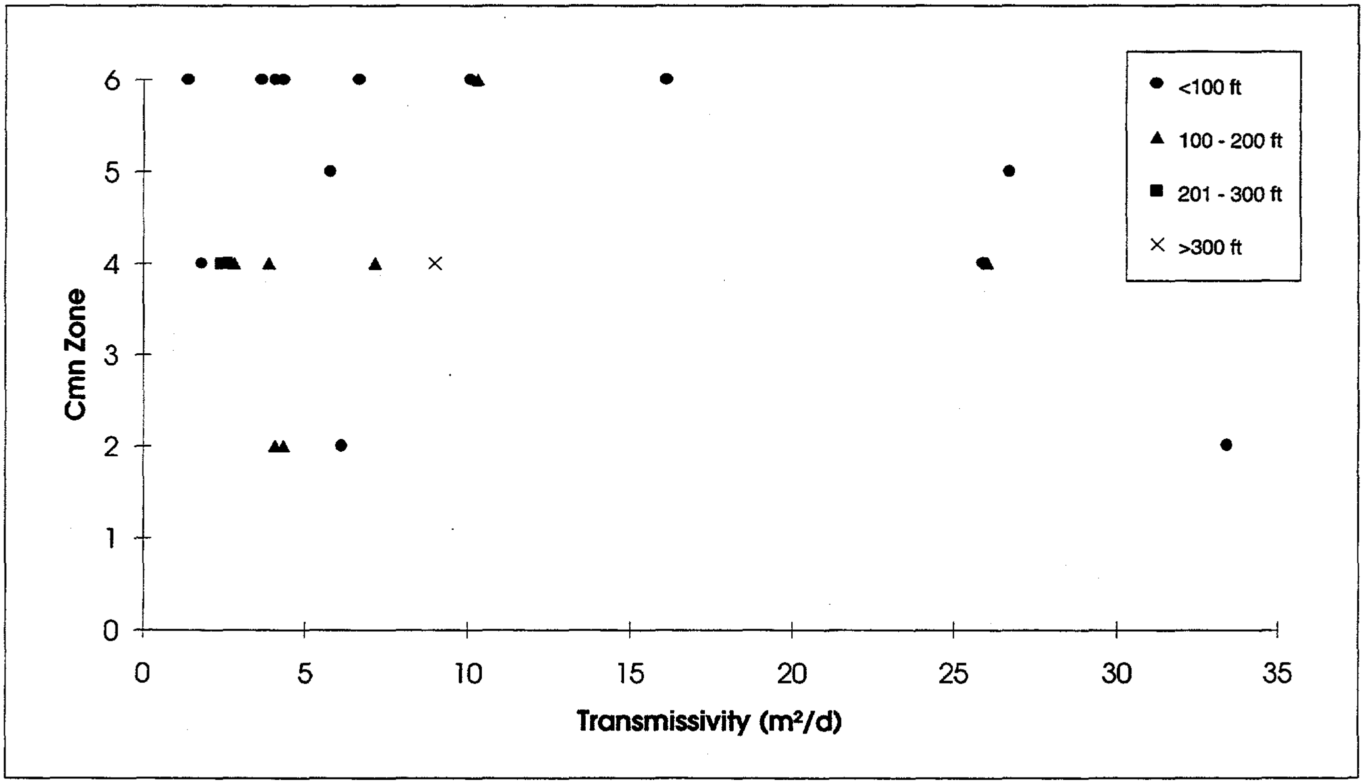

Figure 5. Transmissivity (m^2/d) by Cmn zone and depth for wells in this study.

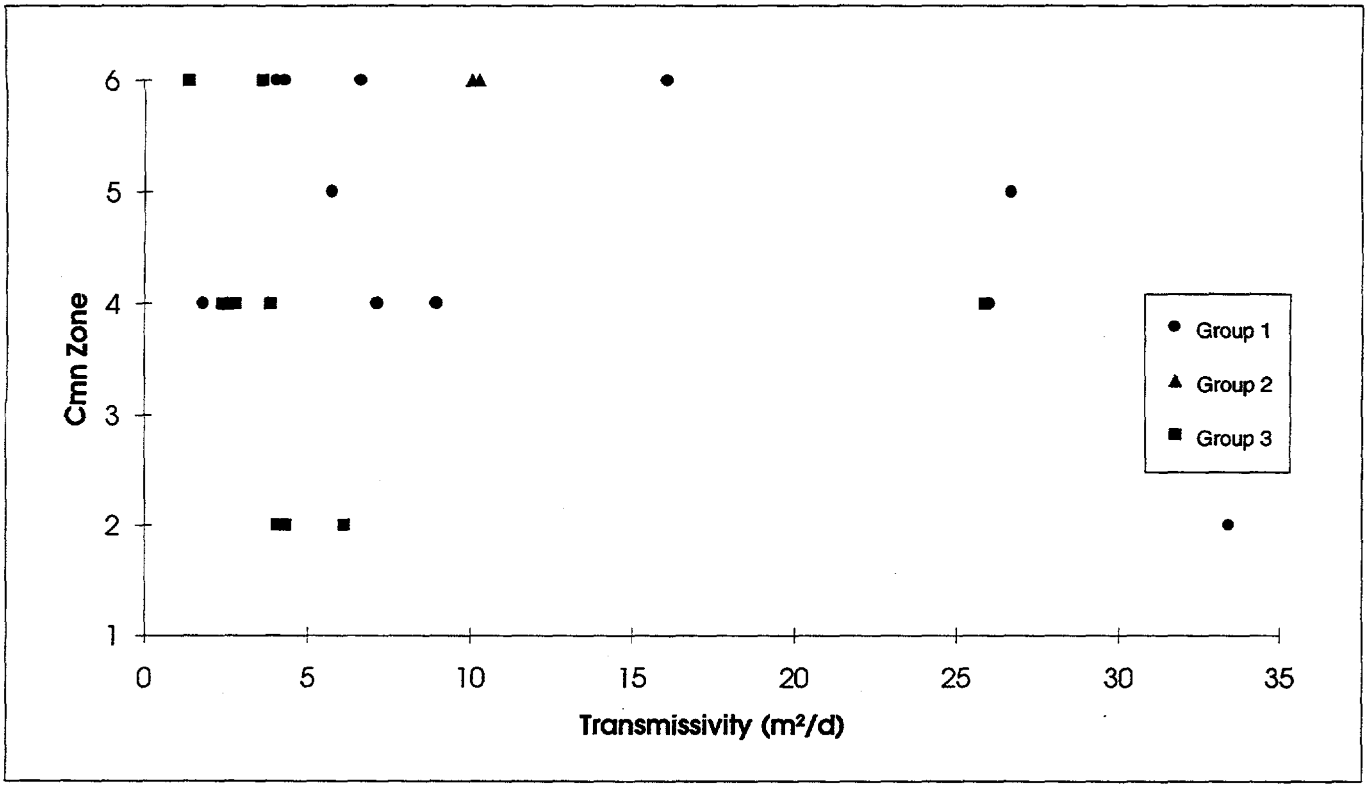

Figure 6. Transmissivity (m²/d) by Cmn zone for the three groups of wells in this study.

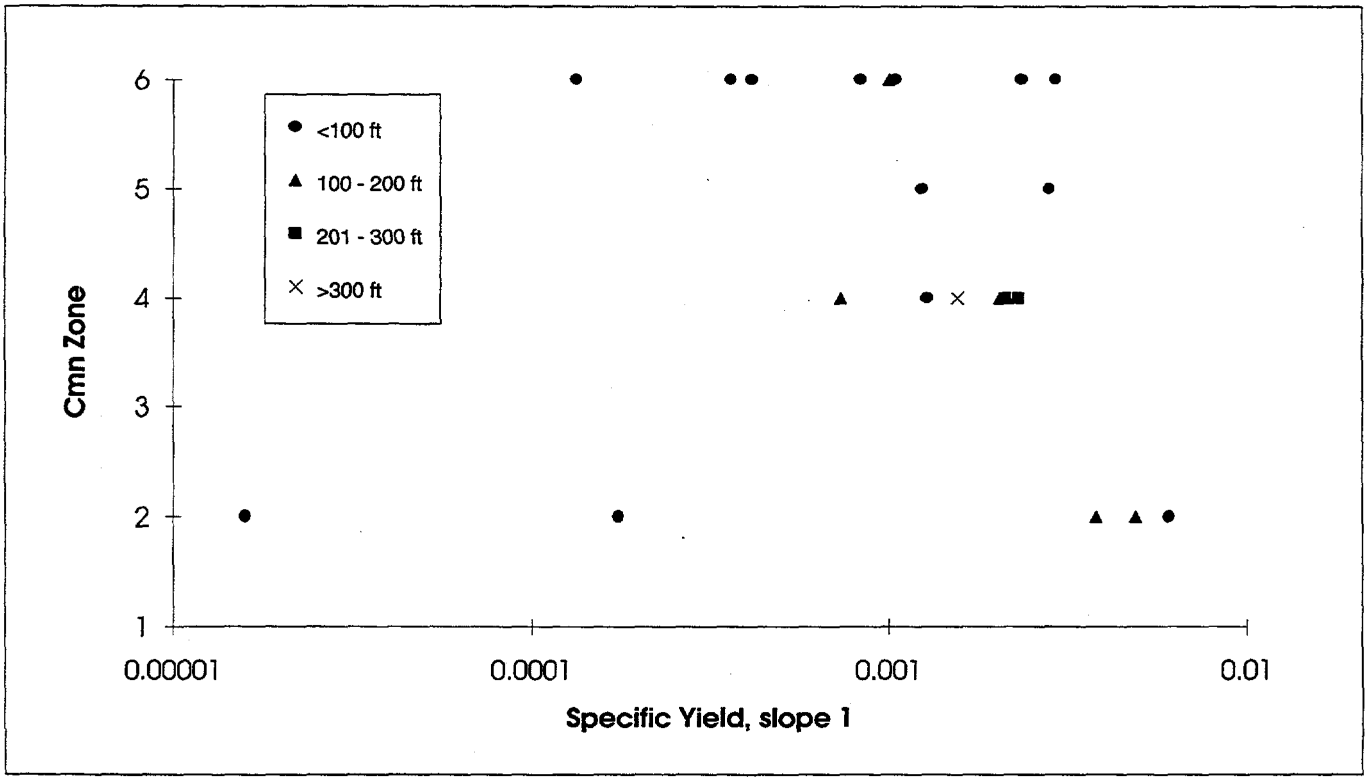

Figure 7. Specific yield by Cmn zone and depth for wells in this study.

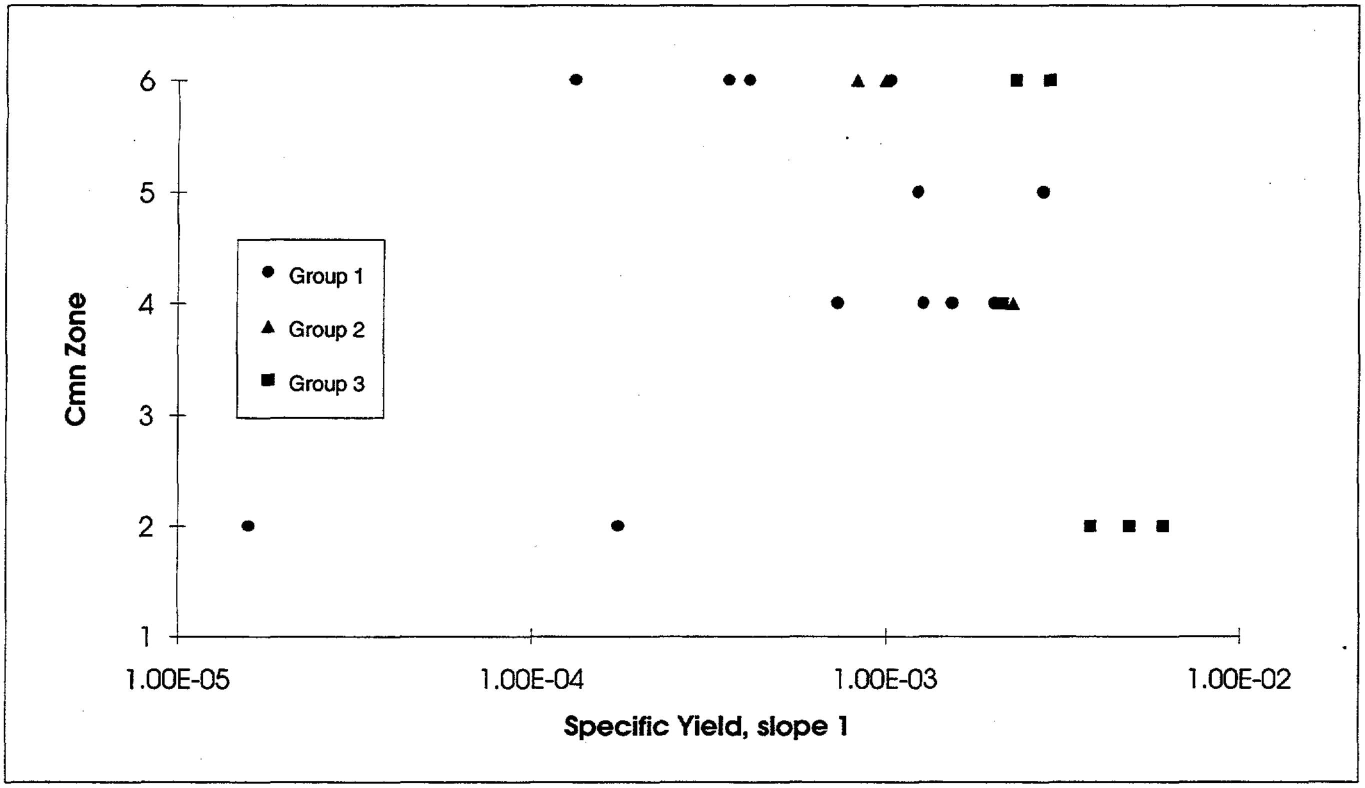

Figure 8. Specific yield by Cmn zone for the three groups of wells in this study.

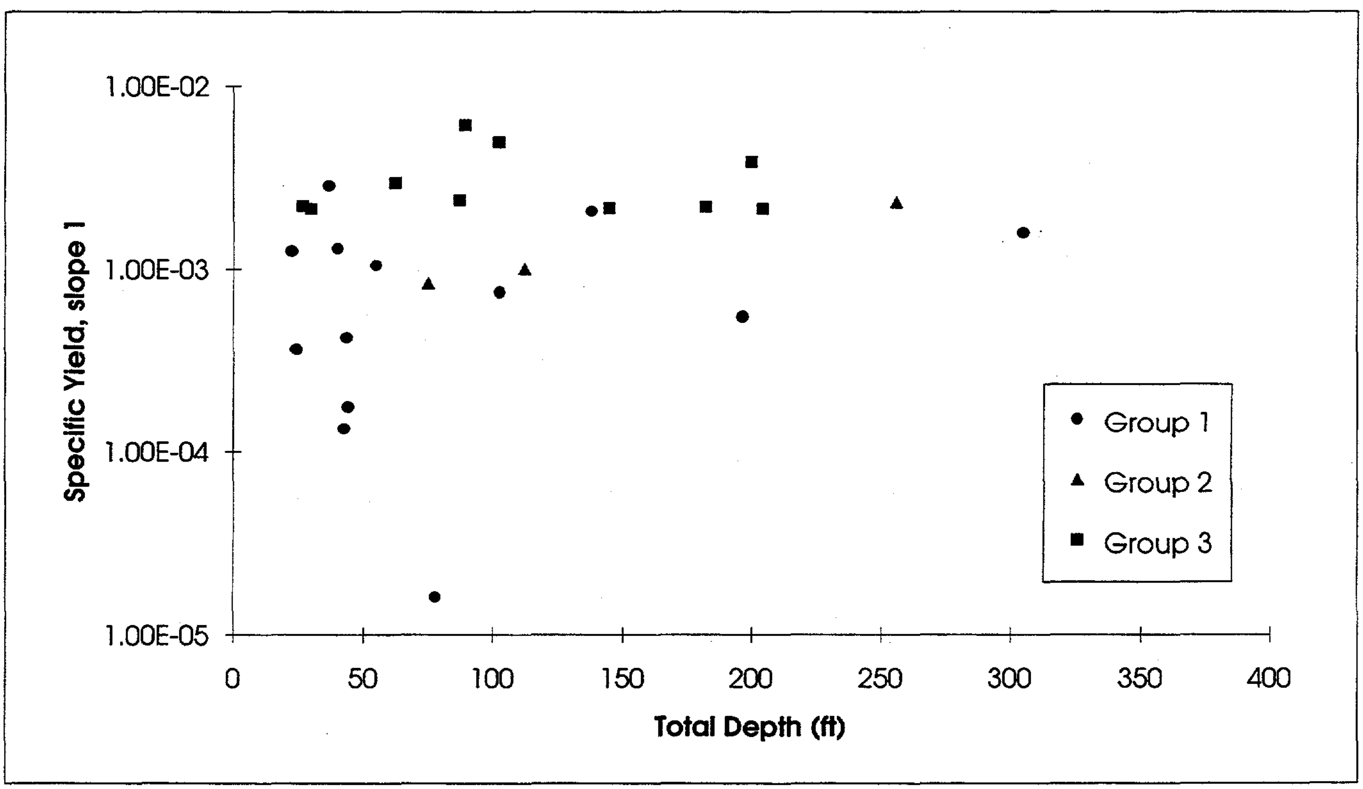

Figure 9. Specific yield versus total depth for the three groups of wells in this study.

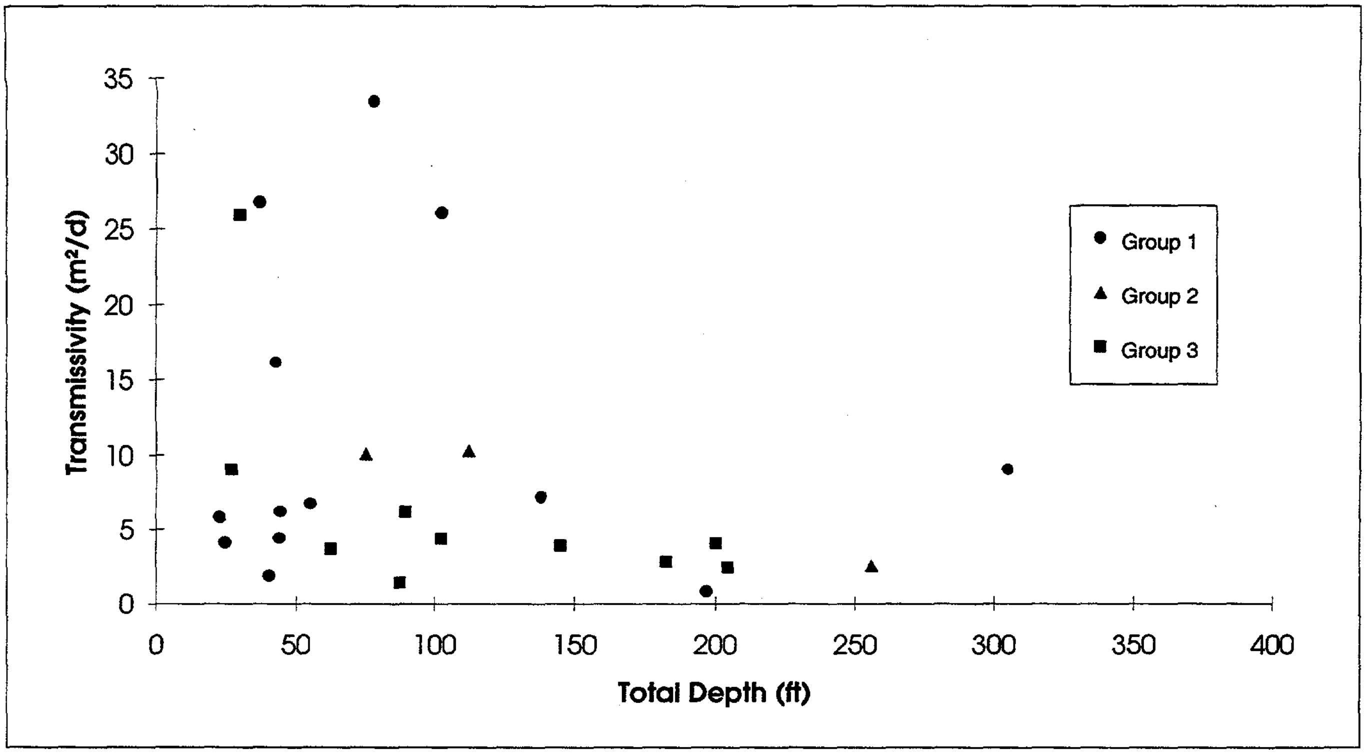

Figure 10. Transmissivity (m^2/d) versus total depth for the three groups of wells in this study.

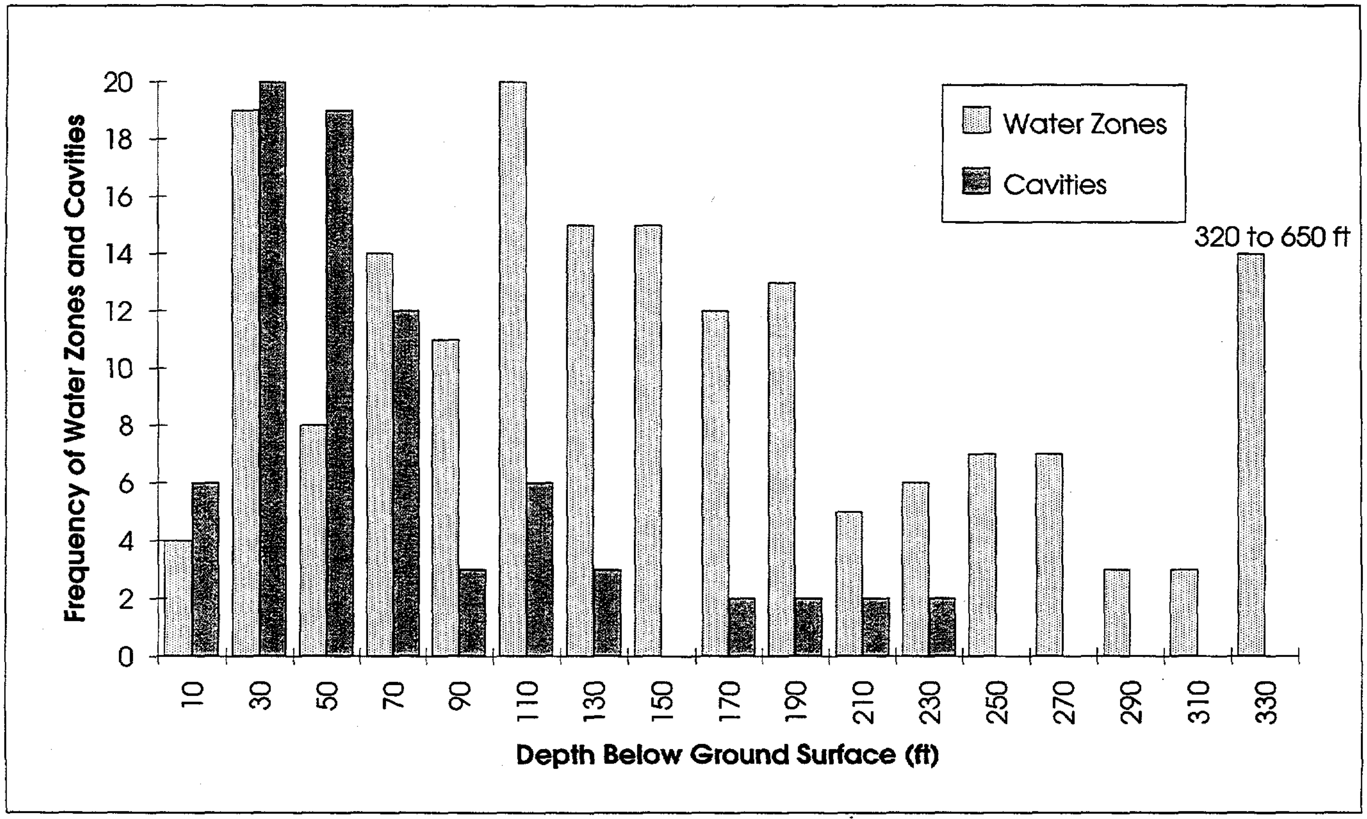

Figure 11. Frequency of water zones and cavities in all wells drilled to depths >100 ft at the Y-12 Plant.

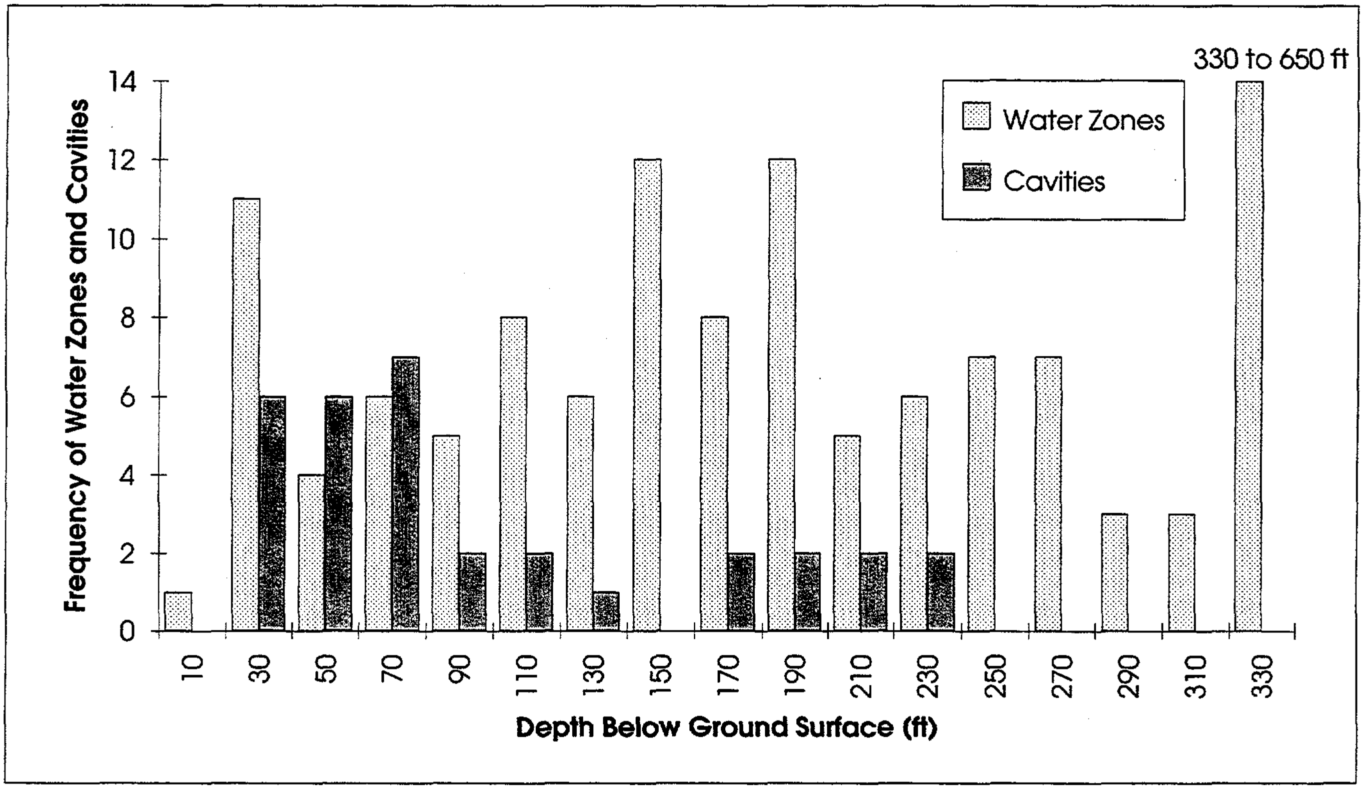

Figure 12. Frequency of water zones and cavities in all wells drilled to depths >200 ft at the Y-12 Plant.

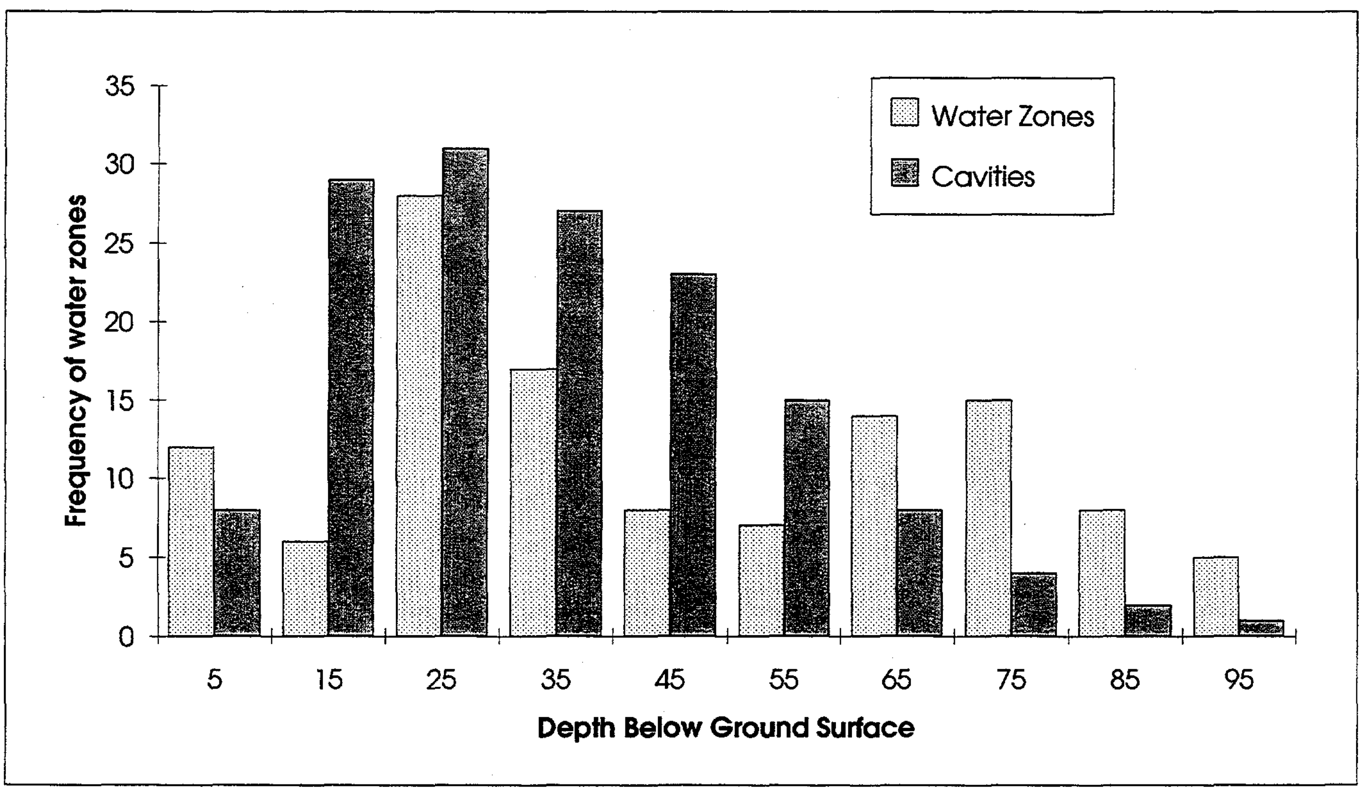

Figure 13. Frequency of water zones and cavities in all wells drilled to depths <100 ft at the Y-12 Plant.

TABLES

Table 1. Hydrologic parameters calculated from the 1992 GW-734 hydrograph data and equations (1) through (7).

Table 2. Continuum transmissivity and specific yields estimated for the conduit, fracture, and matrix portions of the aquifer at GW-734 from three hydrograph recession curves.

Table 3. Completion and location information for wells discussed in this study.

Table 4. Comparison of responses to precipitation events in three types of wells.

Table 5. Slopes, transmissivities, and specific yields in the three types of wells monitored.

Table 6. Calculated transmissivity based on the three slope recession method using cross borehole test recessions.

Table 1. Hydrologic parameters calculated from the 1992 GW-734 hydrograph data and equations (1) through (7).

	Storm I							Storm III						
	Max.	Seg. 1	Inflection Point 1	Seg. 2	Inflection Point 2	Seg. 3	Min.	Max.	Seg. 1	Inflection Point 1	Seg. 2	Inflection Point 2	Seg. 3	Min.
t (hrs)	0		21		95		203	0		8.5		25.5		155
Y (ft-Elevation)	906.3		904.12		902.31		901.44	903.77		902.87		902.42		901.45
Y (ft-Above transducer)	9.86		7.68		5.87		5.00	7.32		6.42		5.97		5.00
Y (m - Above transducer)	3.01		2.34		1.79		1.52	2.23		1.96		1.82		1.52
lambda (hr-1)*		1.19E-02		3.63E-03		1.49E-03			1.54E-02		4.27E-03		1.37E-03	
Qn/Qn+1 @		1.28		1.31		1.17			1.14		1.08		1.19	
'=exp(lam1(t2-t1)) #														
(Vn-Vn+1) = (Q1-Q2)/lam1		18.6Q1		64.9Q2		99.8Q3			7.97Q1		16.4Q2		118.7Q3	
=(Q1-(Q1/1.28)/lam1#				83.07Q1		167.34Q1					18.7Q1		146.14Q1	
ASyn/Qn	8.50		35.90		114.70				8.90		36.40		122.30	
ASyn/Q1	8.5		27.9		68.2			8.9		32		99.8		
'=ASy2/Q2*(Q2/Q1) #														
T/S (m2/hr)	1143		3401		1391			14455		4004		1282		
Using Sy 3 X 10-3														
T (m2/d)	20.8		6.1		2.6			27		7.5		2.4		
Using Sy ratios														
Sy	4.12E-04		1.35E-03		3.00E-03			2.93E-04		1.06E-03		3.00E-03		
T (m2/d)	10.2		10.2		10.2			9.4		9.4		9.4		
Sy1/Sy2	0.305							0.277						
Sy2/Sy3	0.409							0.320						
Sy1/Sy3	0.125							0.089						

* Calculated using the minimum and maximum times and water levels (Y in feet) for each of the three line segments (Eq. (1)).

@ Where n can be taken as the segment number.

Where the example equation is for the first entry listed.

Table 2. Continuum transmissivity and specific yields estimated for the conduit, fracture, and matrix portions of the aquifer at GW-734 from three hydrograph recession curves.

	$\frac{T_1}{Sy_1}$	$\frac{T_2}{Sy_2}$	$\frac{T_3}{Sy_3}$	Sy_1	Sy_2	Sy_3 (Assumed)	T_1 (m^2/d)	Saturated Thickness (m)	K (m/d)
1992	11143	3401	1391	4.12E-04	1.35E-03	0.003	10.2	99.1	1.03E-01
1992	14455	4004	1282	2.93E-04	1.06E-03	0.003	9.4	99.1	9.49E-02
1994	15410	10222	5082*	1.09E-03	1.64E-03	0.003	23.3*	99.1	2.35E-1*
Average	13669	5876	1337	5.98E-04	1.35E-03		9.8		9.89E-02
Stdev	14933	7113	1282	4.30E-04	2.90E-04		0.6		5.71E-03

Note: Transmissivities of the Knox aquifer based on previous tests are 1.0 to 7.3 m^2/d (Moore and Toran, 1992).

Transmissivities based on injection tests into GW-734 from the 2 short injection tests are 5.0 m^2/d.

* questionable results

Table 3. Completion and location information for the wells discussed in this study.

Well	Northing	Easting	Land Surf. Elevation (ft amsl)	Top of Weathered	Top of Fresh	Casing OD (in)	Well Diamter	Top Screen	Bottom Screen	Top Open	Bottom Open	Length Completion Interval (ft)	Formation*	Water Zones in Completion Interval Depths in ft +
				Depth Below Ground Surface (ft)										
GW-054	28823	41295	889.81		7.40	2.37	4.00	35.2	37.2			2.0	Cmn	Not Noted
GW-056	28698	41384	886.65		6.40	2.37	4.00	53.2	55.2			2.0	Cmn	Not Noted
GW-057	28688	41380	886.83		3.40	2.37	4.00	20.8	22.8			2.0	Cmn	Not Noted
GW-058	28715	43211	909.67		20.80	2.37	4.00	42.2	44.2			2.0	Cmn	Not Noted
GW-059	28702	43215	909.82		16.00	2.37	4.75	22.8	24.8			2.0	Cmn	Not Noted
GW-167	28661	65146	929.67			2.37	6.62	26.0	30.1			4.1	Cmn	Not Noted
GW-220	28949	64225	912.74		11.00	4.50	11.00	34.7	44.7			10.0	Cmn	Not Noted
GW-225	29155	47461	940.21		30.00	4.50	10.00			150.0	200.0	50.0	Cmn	Not Noted
GW-226	29156	47473	940.56		28.00	4.50	10.00			45.0	55.0	10.0	Cmn	Water 1-2 gpm @ 30-55
GW-603	28430	64803	959.41	24.00	60.00	4.50	9.50	64.9	75.2			10.3	Cmn	Water @ 67
GW-604	28437	64837	959.53	31.00	55.00	4.50	9.50	102.5	112.4			9.9	Cmn	Water @ 104.5
GW-621	29023	45033	923.07	22.00		4.50	7.88	24.8	40.5			15.7	Cmn	Numerous cavities 27-43
GW-683	28282	41552	969.45	22.00	26.00	4.50	10.63	146.0	196.8			50.8	KNOX	Cav @ 149-158
GW-684	28525	41354	895.53	0.00	9.00	4.50	10.50	113.8	128.4			14.6	Ccr/Cmn 47	Cav @ 122-124, Water @ 110-115
GW-685	28667	41448	889.28	5.00	15.50	7.00	10.63			88.5	138.3	49.8	Cmn	Water @ 110-120
GW-694	28845	44893	938.58	11.00	21.00	7.00	10.60			154.0	204.5	50.5	Cmn	Water @194.5, 202.0
GW-695	28845	44868	937.22	6.00	18.00	4.50	9.88	52.4	62.4			10.0	Ccr	Not Noted
GW-703	28806	44931	951.80	7.00	10.00	7.00	10.63			135.0	182.0	47.0	Ccr/Cmn 35	Not Noted
GW-704	28845	44935	941.99	16.00	23.00	7.00	10.63			246.0	256.0	10.0	Cmn	Water @ 255-256
GW-706	28946	44944	925.78	17.00	27.00	7.00	10.60			157.0	182.5	25.5	Cmn	Water @ 171.5, 175.5
GW-710	27645	36471	908.03		3.50	7.00	10.60			539.7	744.5	204.8	Ccr	?
GW-711	27873	36535	901.96	15.00	20.50	7.00	10.60			616.0	666.2	50.2	Ccr/Cmn	Water @ 650-666
GW-712	28233	36507	873.61	12.00	66.00	7.00	10.60			441.5	457.5	16.0	Ccr	Water @ 447.5
GW-713	28236	36434	877.83	26.80	63.80	7.00	10.60			305.0	315.2	10.2	Ccr/Cmn 100	Frac @ 308
GW-714	28422	36435	872.30	27.00	35.00	7.00	10.60			115.1	145.0	29.9	Cmn	water @133-145 (diffuse - mw)
GW-715	28425	36453	872.17	34.00		4.25	10.60	33.1	43.1			10.0	Cmn	Cav @ 37.6-38.6 (m), 43.6-44.6 (m)
GW-723	29006	49089	1019.31	26.70	29.70	7.00	10.60			340.6	444.5	103.9	Ccr/Cmn 139	Water @ 431.5-432
GW-724	29198	48995	976.62	33.50	40.00	7.00	10.60			289.6	301.6	12.0		Frac @ 299.0 (200-300 gpm water)
GW-725	29405	48989	958.26	14.00	17.50	7.00	10.60			132.5	142.5	10.0		Water @ 136.1-136.9 / Frac @ 142.5 (mw)
GW-728	28774	43010	907.00		30.00	4.50	6.25			296.0	305.3	9.3		Not Noted
GW-733	28447	65057	955.69	11.10	42.50	7.00	10.60			240.1	256.5	16.4	Ccr/Cmn 73	Water @ 249.5-251.5 (w).
GW-734	28682	64943	937.42	35.40	39.40	7.00	10.60			59.4	?		Cmn	Cav @ 59.4 >103.4 (mW)
GW-735	28867	64872	921.34	19.00	77.50	4.50	10.60	67.9	78.1			10.2	Cmn/Cn 75.5	Water @ 75.5-77.5 (mw)
GW-736	29381	48936	957.55	7.50	12.00	4.50	10.60	92.4	102.5			10.1	Cmn	Frac @ 94.0 (mW)
GW-737	29365	48890	957.50		14.00	4.50	10.60	79.4	89.5			10.1	Cmn	Frac/cav @ 83-85 (mW)
GW-738	29150	49026	980.36	12.00	15.10	4.50	10.60	67.3	87.5			20.2	Cmn	Cav @ 75.1-77.1 (mW)
GW-739	29010	49126	1020.66	34.00	42.00	7.00	10.60			289.2	320.0	30.8	Ccr/Cmn 125	Water @ 313-320.
GW-740	29027	49055	1016.95	38.10	45.10	7.00	10.60			165.6	190.0	24.4	Ccr/Cmn 110	Frac @ 187.5 (mW)
GW-748	29741	64579	918.89	8.00	11.80	4.50	9.87	17.0	27.0			10.0	Cm	water @ 17-27 (diffuse)
GW-750	28975	64835	915.96	18.50	24.80	4.50	10.60	62.4	72.4			10.0	Cn/Cm 45	water @ 64.0, 64.8-70.8 (diffuse),

* Numbers following contact designations are the depths in feet below ground surface of the contacts.

\+ mw = slightly muddy water (<5 gpm), m = very muddy water, mW = slightly muddy water (>5 gpm)

Table 4. Comparison of responses to precipitation events in three types of wells.

	Picket	Well Depth (m)	Number of Slopes	Delay to start Min (hrs)	Delay to start Max (hrs)	Delay to Peak Min (hrs)	Delay to Peak Max (hrs)	Duration Peak Min (hrs)	Duration Peak Max (hrs)	Duration Recession (hrs)	Recession Complete	WL Rise Min (ft)	WL Rise Max (ft)
Group 1													
GW-054	A	11.3	3	4	4	4	19	0	1	214.5	Y	0.39	3.61
GW-056	A	16.8	3	0.5	2	3	18	0	1.5	180	N	0.19	2.2
GW-057	A	6.9	3	0	2	3	19.5	0	3	159.5	Y	0.55	2.63
GW-058	B	13.5	3	0.5	4	4.5	35	0	1.5	261	Y	0.94	6.3
GW-059	B	7.6	3	0.5	3.5	4	25.5	0.5	1.5	259.5	Y	0.9	4.48
GW-220	J	13.8	3	0	8	1.5	6	0	0	135.5	Y?	0.85	1.83
GW-621	B	12.3	3	1	3	8	35.5	0	2.5	258	Y	1.51	7.17
GW-683	A	60.0	3	0.5	2.5	2.5	18.5	0	5.5	194.5	Y?	0.07	2.55
GW-685	A	42.2	3	0.5	5	1	20	0.5	3.5	205.5	Y	0.16	2.24
GW-715	W	13.6	3	4	23.5	5	7	0	0	174	Y	1.29	4.98
GW-728	A	93.1*	3	0.5	5.5	3.5	13.5	0	1.5	213	Y	0.07	6.88
GW-734	J-1992	18.3	3	0	2	7	17	0	0	203	?	2.24	5.3
GW-734	J-1994	18.3	3	0	9.5	5	14.5	0	1	144.5	Y?	3.89	10.5
GW-735	J	25.3	3	3	10	8	8	0.5	1	145	Y	3.13	7.01
Average				1.1	6.0	4.3	18.4	0.1	1.7	196.3		2.28	5.92
Std. Dev.				1.5	5.7	2.2	9.0	0.2	1.5	42.8		1.26	3.17
Group 2													
GW-603	J	22.9	3	7.5	12	14.5	22.5	0.5	3.5	111	Y	0.57	5.57
GW-604	J	34.3	3	7.5	12	15	25	0	1.5	134	Y	0.78	5.09
GW-704	B	78.0	3?	0	4	39	61	1	2	247	?	1.29	8.1
Average				5.0	9.3	22.8	36.2	0.5	2.3	164.0		0.68	5.33
Std. Dev.				4.3	4.6	14.0	21.5	0.5	1.0	72.8		0.15	0.34
Group 3													
GW-167	J	9.2	1 or 2	0.0	9.5	11.0	18.0	1.0	1.5	139.5	Y?	5.06	9.15
GW-225	B	61.0	2	0.5	4.5	38.5	73.5	1.5	12	228	?	1.48	9.07
GW-226	B	16.8	2	1.5	5.5	28.5	66	0.5	5.5	237	Y	2.36	9.71
GW-694	B	62.3	2	1	4.5	36	47.5	0	2	224.5	?	1.18	6.44
GW-695	B	19.0	2	3.5	5.5	34	46	3	3.5	229.5	Y	1.48	7.03

	Picket	Well Depth (m)	Number of Slopes	Delay to start Min (hrs)	Delay to start Max (hrs)	Delay to Peak Min (hrs)	Delay to Peak Max (hrs)	Duration Peak Min (hrs)	Duration Peak Max (hrs)	Duration Recession (hrs)	Recession Complete	WL Rise Min (ft)	WL Rise Max (ft)
GW-703	B	55.5	1	18.5	26.5	40	123.5	5.5	11	245.5	Y	1.09	4.54
GW-706	B	55.6	2?	0.5	4	7.5	47.5	0	1	229	?	1.18	6.32
GW-710	W	226.9	1 or 2	8	24.5	22	51	1.5	9.5	250.5	Y?	0.3	3.29
GW-711	W	203.1	1 or 2	0	9	37.5	53.5	0.5	0.5	272	Y	0.58	3.53
GW-712	W	139.4	1 or 2	2.5	27	19	47.5	1.5	3	155.5	Y?	0.3	3.99
GW-713	W	96.1	1 or 2	2	27.5	36	41.5	1.5	12	129	N	0.59	2.91
GW-714	W	44.2	1 or 2	3	8	24	35	0.5	4	158	Y?	1.14	4.94
GW-724	C	92.0	1	0	24	51	106	2.5	4.5	258	Y	0.45	2.73
GW-725	C	43.4	1	0	20	41.5	86	1	2.5	272	Y	0.47	2.58
GW-733	J	78.2	1 or 2	6	13	20	37.5	1.5	4	130	Y?	0.1	4.35
GW-736	C	31.1	1 or 2	0	20.5	39.5	97.5	2.5	17	267.5	Y	0.46	2.56
GW-737	C	27.1	1	0.5	20.5	39.5	60.5	4.5	13.5	264.5	Y	0.44	2.55
GW-738	C	26.7	1 or 2	1	13.5	23	44.5	2.5	4	291.5	Y	0.43	2.75
GW-739	C	97.6	1	0	9	33.5	69.5	0	2.5	248	Y	0.33	2.7
GW-740	C	57.9	1	1	1.5	40	61	1	22	270.5	Y	0.52	2.73
GW-748	J	8.3	1 or 2	8.5	8.5	15.5	22.5	2	5	135	?	0.59	3.13
GW-750	J	22.2	1 or 2	4.5	8.5	13.5	24	0.5	1.5	128	N	2.45	3.13
Average				2.8	13.4	29.6	57.3	1.6	6.5	216.5		1.04	4.55
Std. Dev.				4.2	8.2	11.9	26.9	1.3	5.5	63.7		1.01	2.39
Without Picket C data													
Average				3.8	15.1	22.1	36.7	1.2	4.6	166.4		1.23	4.27
Std. Dev.				3.0	7.8	9.9	14.6	0.5	5.6	58.5		1.62	2.16
Unreliable Data													
GW-684	A	39.1	2	0	7.5	0	14	0.5	11	262	Y	0.06	0.31

* Open over a large depth interval.

Table 5. Slopes, transmissivities, and specific yields in the three types of wells monitored.

Well	Picket	Average Slope 1	Slope 1 Std Dev	Average Slope 2	Slope 2 Std Dev	Average Slope 3	Slope 3 Std Dev	T (m2/d)	± T	Sy1	± Sy1	Sy2	± Sy2
Group 1													
GW-054	A	-5.91E-05	2.75E-05	-3.01E-05	2.02E-05	-1.69E-05	1.393-5	26.71	25.4	2.81E-03	4.77E-03	5.42E-03	1.00E-02
GW-056	A	-3.21E-05	2.04E-05	-1.67E-05	9.93E-06	-7.27E-06	3.18E-06	6.69	7.12	1.04E-03	2.54E-04	2.09E-03	7.26E-04
GW-057	A	-3.02E-05	1.59E-05	-2.01E-05	1.06E-05	-9.05E-06	5.69E-06	5.8	3.64	1.24E-03	1.15E-03	1.37E-03	4.04E-04
GW-058	B	-6.75E-05	6.35E-06	-2.09E-05	3.48E-06	-5.82E-06	7.73E-07	4.34	0.52	4.14E-04	1.42E-05	1.03E-03	2.99E-04
GW-059	B	-6.87E-05	1.03E-05	-1.89E-05	5.90E-07	-5.46E-06	1.04E-06	4.08	0.7	3.61E-04	1.38E-05	1.03E-03	2.39E-04
GW-220	J	-1.34E-04	7.44E-05	-2.92E-05	2.28E-05	-9.10E-06	5.74E-06	6.15	4.25	1.75E-04	1.69E-05	8.42E-04	1.09E-04
GW-621	B	-3.78E-05	1.44E-05	-2.01E-05	1.19E-05	-1.27E-05	3.50E-06	1.81	0.83	1.28E-03	3.65E-04	1.91E-03	3.83E-05
GW-683	A	-1.68E-05	1.30E-05	-2.94E-04	1.46E-06	-9.63E-07		0.81	0.6	5.43E-04	3.62E-04	2.45E-03	9.49E-04
GW-685	A	-1.85E-05	9.14E-06	-1.55E-05	1.57E-05	-6.44E-06	5.12E-06	7.17	9.33	2.04E-03	2.55E-03	2.18E-03	7.67E-04
GW-715	W	-3.10E-04	1.82E-04	-1.97E-04	2.83E-04	-1.52E-05	1.27E-05	16.11	13.19	1.33E-04	8.19E-05	1.49E-03	6.27E-05
GW-728	A	-3.22E-05	2.10E-05	-1.68E-05	1.61E-05	-7.59E-06	4.58E-06	8.99	10.17	1.55E-03	8.14E-04	2.60E-03	7.04E-04
GW-734	J	-1.66E-04	6.24E-05	-6.71E-05	4.57E-05	-1.88E-05	1.76E-05	26.02	15.05	7.33E-04	3.58E-04	1.35E-03	2.06E-04
GW-735	J	-8.24E-05	4.44E-05	-4.79E-05	2.98E-05	-3.74E-05		33.43	9.43	1.59E-05	3.71E-04	2.34E-03	
Ave		-8.12E-05		-6.11E-05		-1.17E-05		11.39		9.49E-04		2.01E-03	
Std Dev		8.19E-05		8.55E-05		9.21E-06		10.68		8.26E-04		1.18E-03	
Group 2													
GW-603	J	-8.68E-05	3.09E-05	-5.46E-05	7.62E-06	-1.61E-05		10.09	0.01	8.32E-04	8.43E-05	1.02E-03	
GW-604	J	-7.62E-05	3.98E-05	-4.95E-05	9.00E-06	-1.72E-05		10.31	0.05	1.00E-03	2.69E-04	1.19E-03	
GW-704	B	-3.55E-05	7.70E-06	-2.42E-05	3.60E-06	-1.57E-05	3.33E-06	2.57	0.41	2.30E-03	2.42E-04	2.35E-04	3.50E-05
Ave		-6.62E-05		-4.28E-05		-1.63E-05		7.66		1.38E-03		8.15E-04	
Std Dev		2.71E-05		1.63E-05		7.77E-07		4.41		8.03E-04		5.09E-04	
Group 3													
GW-167	J	-1.15E-04		-4.48E-05	NA			25.9		2.11E-03		3.00E-03	
GW-225	C	-4.02E-05	1.09E-05	-3.01E-05	4.06E-06			4.08	1.22	3.81E-03	1.45E-03	3.00E-03	NA
GW-226	C	-5.07E-05	2.58E-05	-2.18E-05	2.37E-06			6.49	2.93	4.08E-03	7.33E-05	3.00E-03	NA
GW-694	B	-2.56E-05	2.61E-06	-1.27E-05	6.36E-06			2.42	1.22	2.11E-03	9.55E-04	3.00E-03	NA
GW-695	B	-2.67E-05	6.87E-06	1.81E-05	2.36E-06			3.66	0.52	2.93E-03	4.25E-04	3.00E-03	NA
GW-703	B	-1.54E-05	8.02E-06										
GW-706	B	-2.61E-05		-1.26E-06				2.82	NA	2.15E-03	NA	3.00E-03	NA

Table 48, continued.

Well	Picket	Slope 1	Std Dev	Slope 2	Std Dev	Slope 3	Std Dev	(m2/d)	± T	Sy1	± Sy1	Sy2	± Sy2
GW-710	W	-2.44E-05	2.72E-05	-2.20E-05	1.91E-05			No suitable responses					
GW-711	W	-3.39E-05	2.25E-05	-7.76E-06				No suitable responses					
GW-712	W	-2.41E-05	1.91E-05	-7.58E-06				No suitable responses					
GW-713	W	-2.15E-05	2.99E-05					No suitable responses					
GW-714	W	-1.43E-04	3.35E-04	-8.18E-06				3.89		2.13E-03		3.00E-03	
GW-724	C	-7.22E-06	5.46E-06					Only one slope					
GW-725	C	-8.96E-06	7.69E-06					Only one slope					
GW-733	J	-4.40E-05	1.05E-05	-2.37E-05				No suitable responses					
GW-736	C	-7.66E-06	6.85E-06	-6.96E-06	7.22E-06			4.35	3.4	4.90E-03	3.68E-03	3.00E-03	NA
GW-737	C	-1.06E-05	4.91E-06	-1.56E-05	4.90E-06			6.16	1.96	6.10E-03	4.19E-03	3.00E-03	NA
GW-738	C	-8.47E-06	7.77E-06	-6.27E-06	6.38E-06			1.41	1	2.35E-03	4.20E-04	3.00E-03	NA
GW-739	C	-6.30E-06	6.04E-06					Only one slope					
GW-740	C	-8.76E-06	6.65E-06					Only one slope					
GW-748	J	-1.33E-05	3.32E-06	-8.86E-06	1.60E-06			9	1.34	2.19E-03	1.77E-05	3.00E-03	
GW-750	J	-1.33E-05	6.79E-06					No suitable responses					
Ave		-3.07E-05		-1.33E-05				6.38		3.17E-03		3.00E-03	
Std Dev		3.45E-05		1.43E-05				6.81		1.37E-03		6.38E-11	
No Response													
GW-055	A	No Response											
GW-723	C	No Response						No response					
Unreliable Data													
GW-684	A	-8.82E-06	1.07E-05	-4.85E-06	6.97E-06			2.82	4.04	1.27E-03	6.92E-04	3.00E-03	

Table 6. Calculated transmissivity based on the three slope recession method using cross borehole test recessions. Rows in bold show average values from hydrographs for comparison.

	T_1/Sy_1	T_2/Sy_2	T_3/Sy_3	Sy_1	Sy_2	Sy_3 (assumed)	T (m^2/d)	Saturated Thickness (m)	K (m/d)
Picket W									
No suitable slopes observed for use with this method									
Picket A									
GW-683	63.7	8	4.2	2.00E-04	1.60E-03	3.00E-03	1.7	31.52	0.05
GW-683	**1492**	**331**	**270**	**5.43E-04**	**2.45E-03**	**3.00E-03**	**0.81**	**31.52**	**0.03**
SS-5-1	1.3	1.1	0.5	1.10E-03	1.30E-03	3.00E-03	0.18	31.52	0.01
SS-5-2	1.8	1.1	0.3	4.75E-04	8.03E-04	3.00E-03	0.12	31.52	0.00
Picket B									
GW-694	1142	313	101	2.65E-04	9.65E-04	3.00E-03	40.5	64.9	0.62
GW-694	**1147**	**807**		**2.11E-03**	**3.00E-03**		**2.42**	**64.9**	**0.04**
GW-695	157	58	10	1.95E-04	5.27E-04	3.00E-03	4.1	64.9	0.06
GW-695	**1249**	**1220**		**2.93E-03**	**3.00E-03**		**3.66**	**64.9**	**0.06**
GW-704	725	141	14.5	5.98E-05	3.09E-04	3.00E-03	5.8	64.9	0.09
GW-704	**1117**	**1094**	**857**	**2.30E-03**	**2.35E-03**	**3.00E-03**	**2.57**	**64.9**	**0.04**
Picket C									
GW-725	1484	119	90	1.82E-04	2.27E-03	3.00E-03	36.2	83.8	0.43
GW-725	**Only one slope**								
GW-738	108	9.8	3.8	1.04E-03	1.15E-03	3.00E-03	1.5	83.8	0.02
GW-738	**600**	**470**		**2.35E-03**	**3.00E-03**		**1.41**	**83.8**	**0.02**
GW-739	39	14.5		1.11E-03	3.00E-03		5.8	83.8	0.07
GW-739	**Only one slope**								
Picket J									
GW-735-1	2709	87	54	6.00E-05	1.88E-03	3.00E-03	21.8	99.1	0.22
GW-735-2	2449	24	29	3.60E-05	3.66E-03	3.00E-03	11.8	99.1	0.12
GW-735	**21025**	**14286**	**11143**	**1.59E-03**	**2.34E-03**	**3.00E-03**	**33.43**	**99.1**	**0.34**

APPENDIX A

Appendix A: Figures A-1 through A-46 showing well hydrographs with hourly rainfall in Pickets W, A, B, C, and J. Selected plots of specific conductance and temperature versus time are included in this appendix.

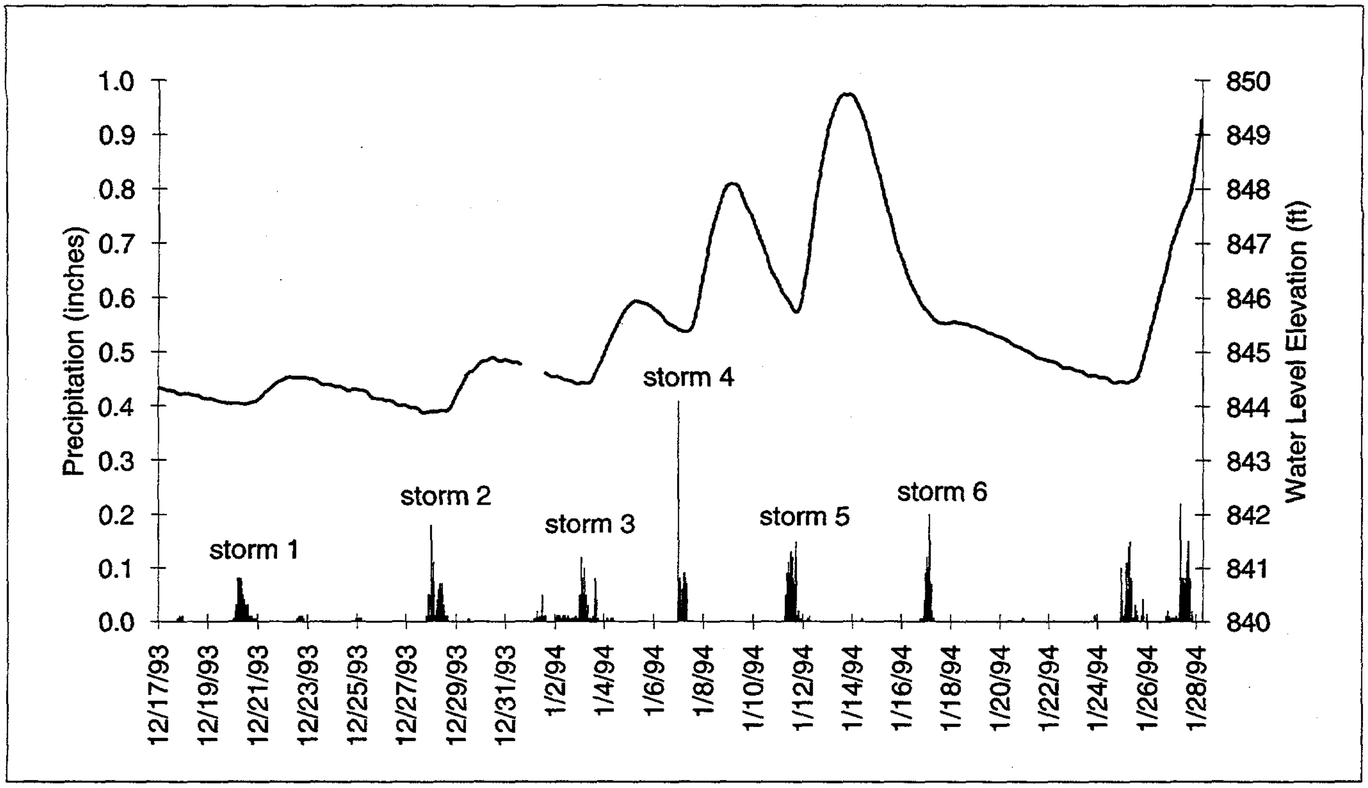

Figure A-1. Well hydrograph from GW-710

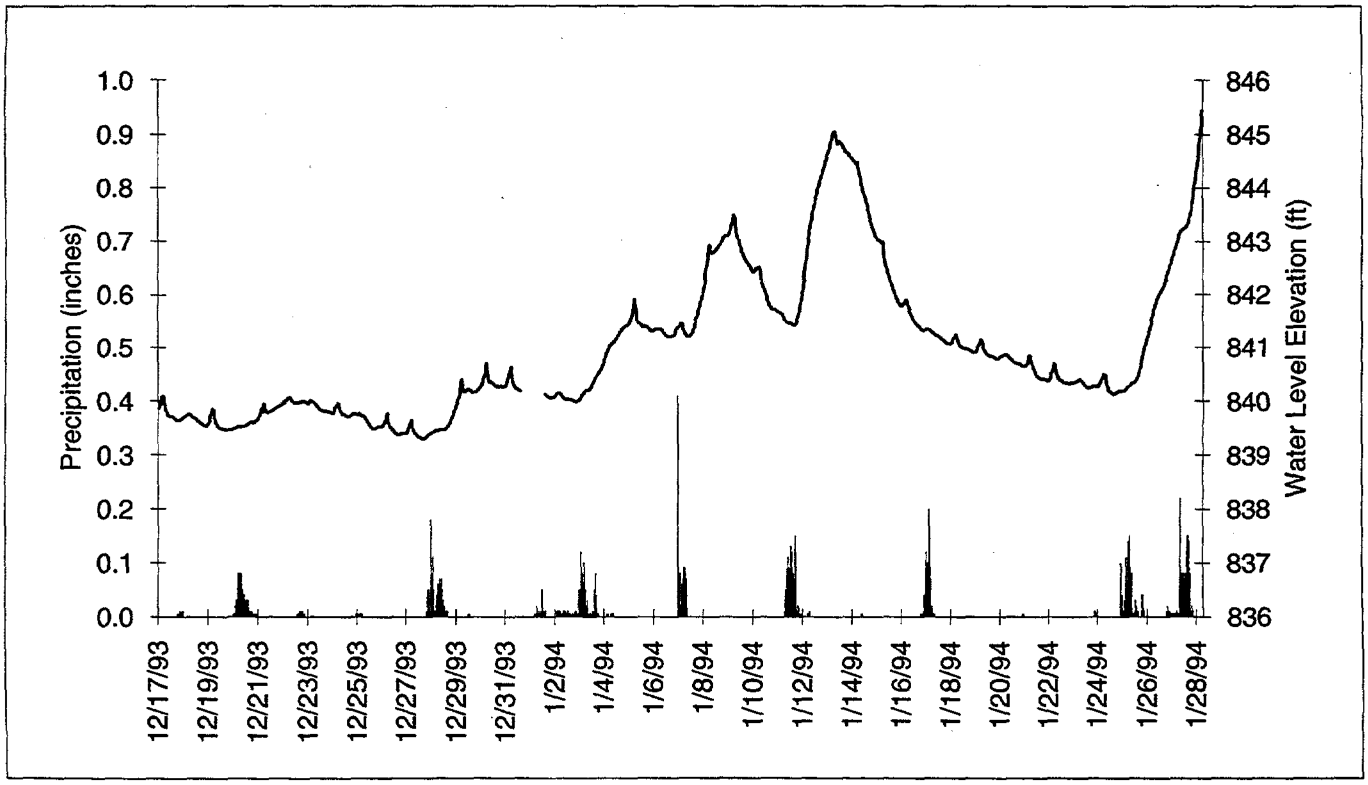

Figure A-2. Well hydrograph from GW-711.

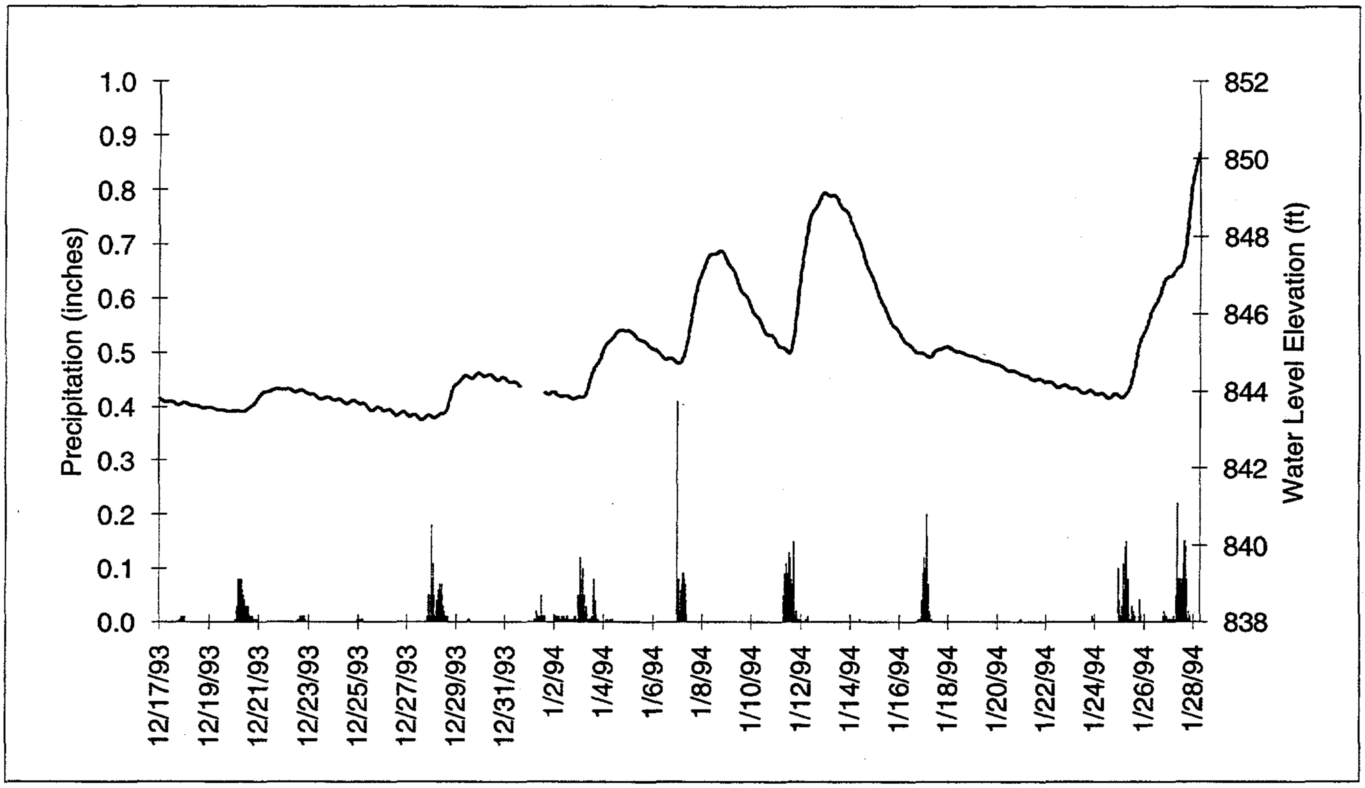

Figure A-3. Well hydrograph from GW-712.

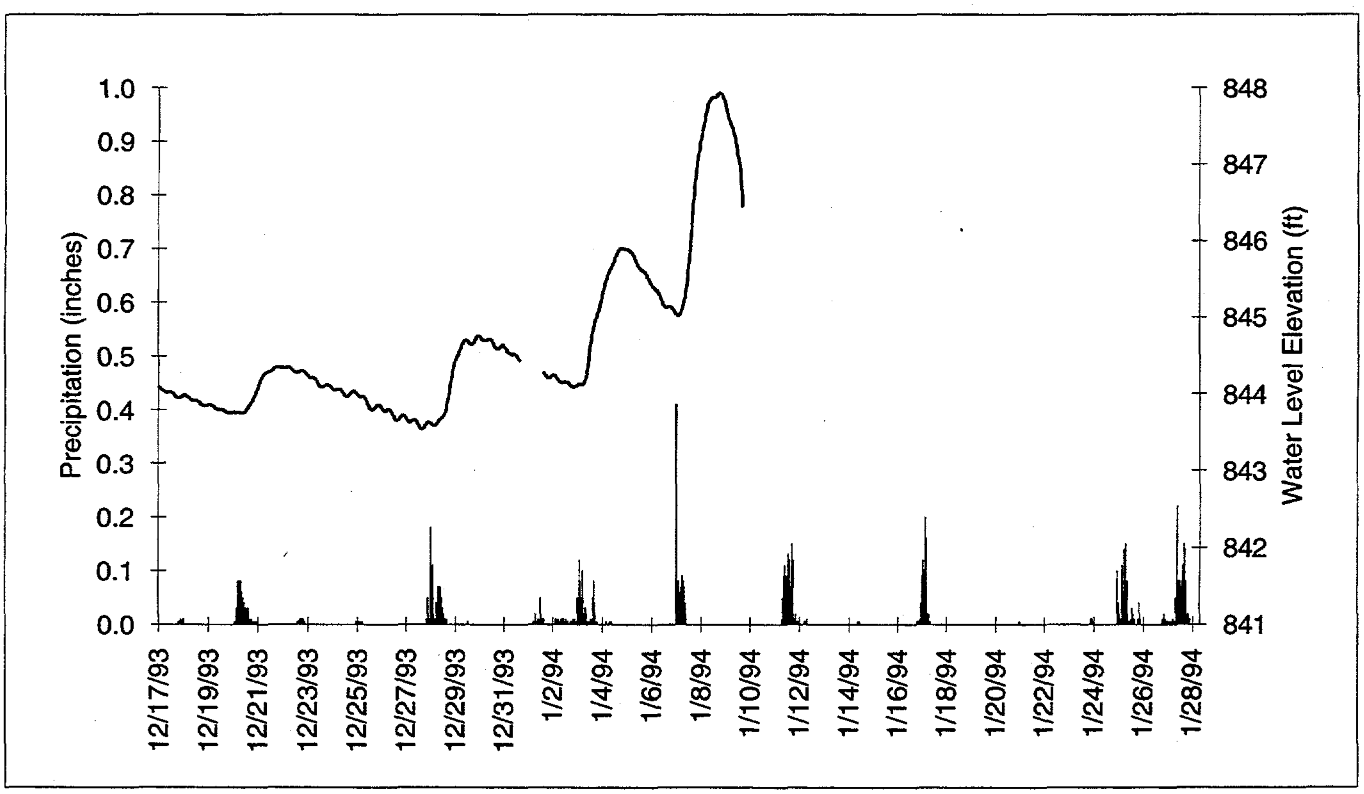

Figure A-4. Well hydrograph from GW-713.

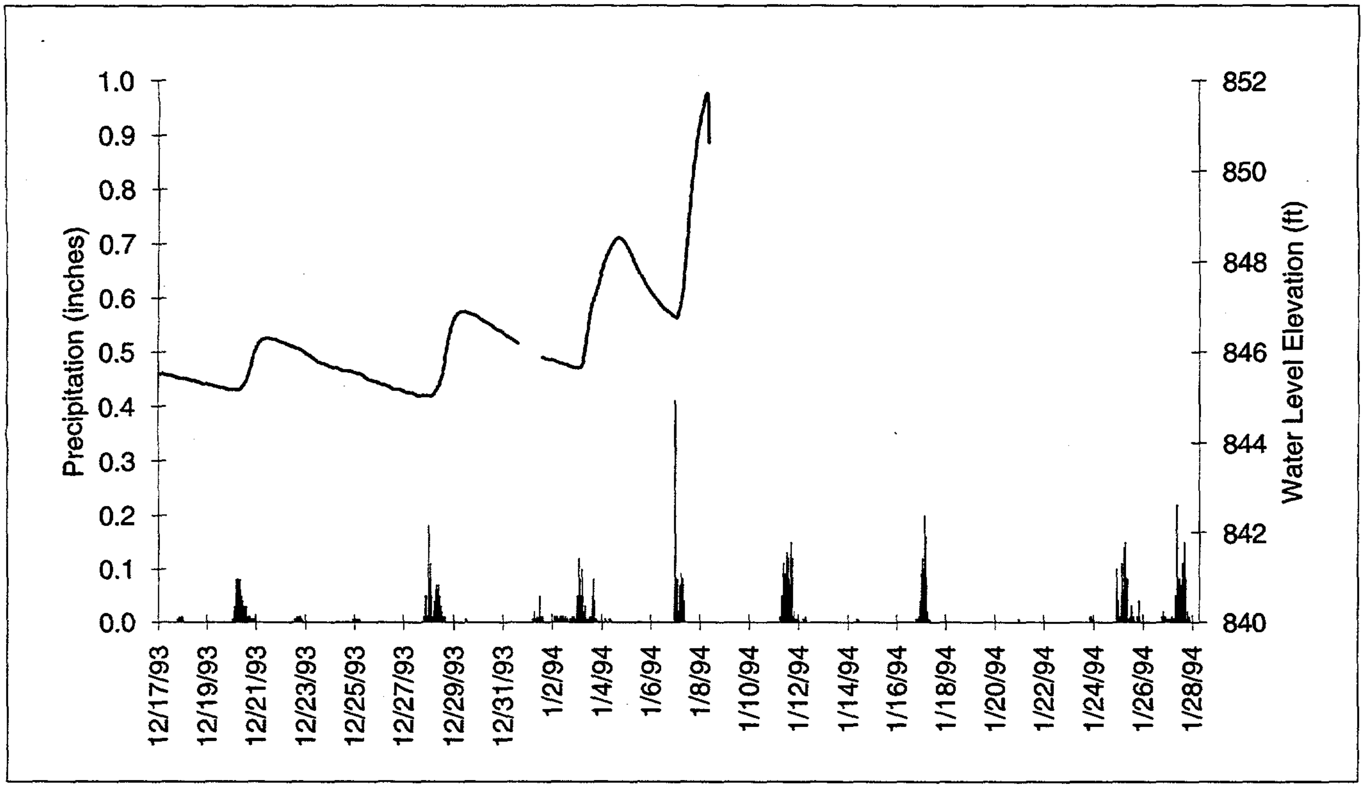

Figure A-5. Well hydrograph from GW-714.

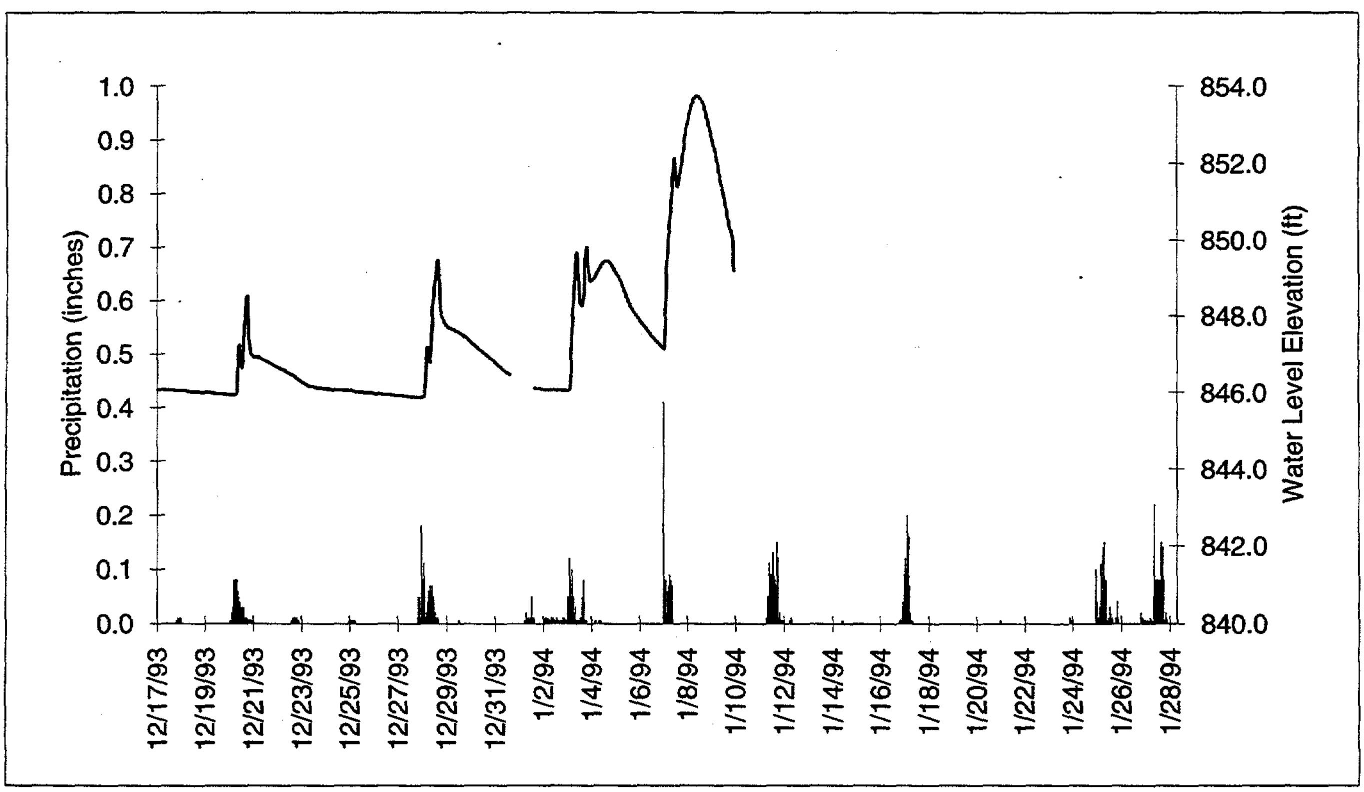

Figure A-6. Well hydrograph from GW-715.

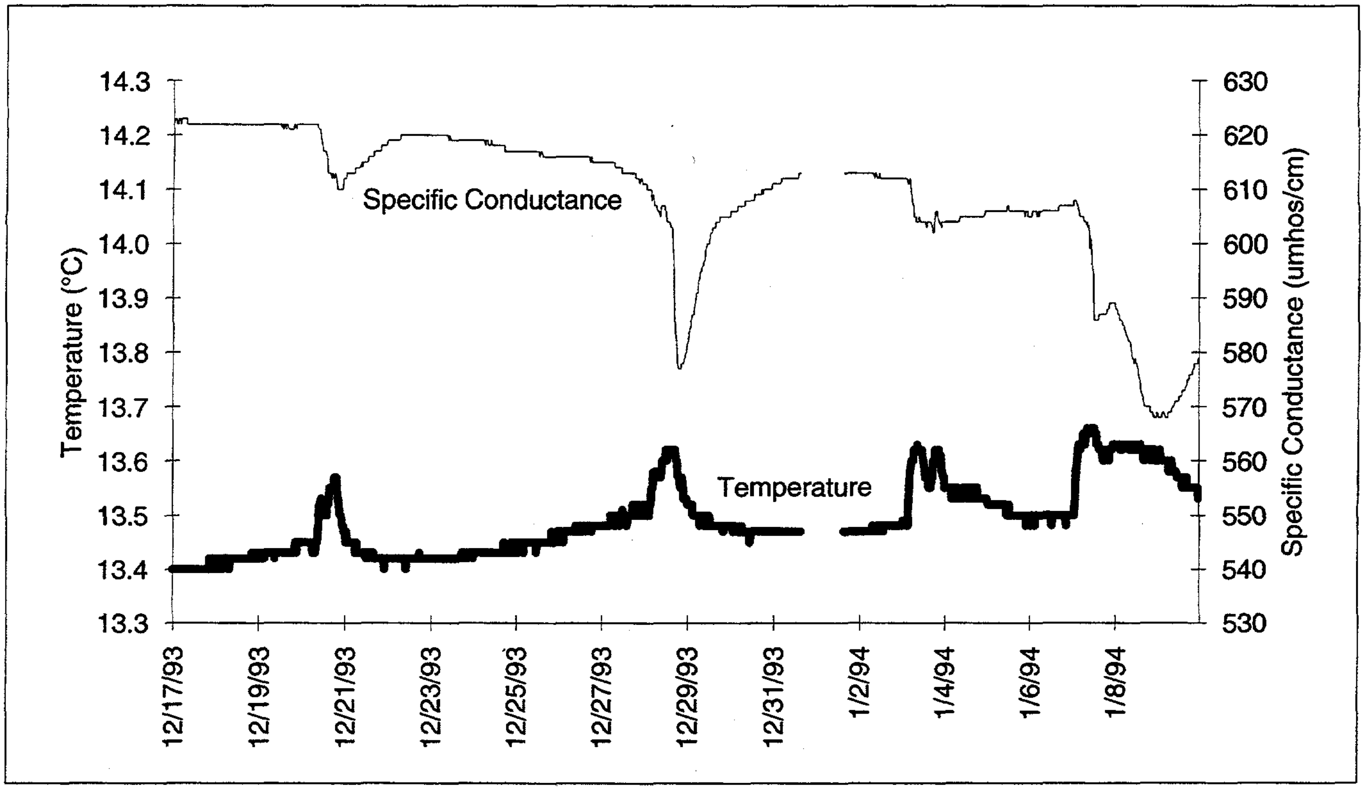

Figure A-7. Specific conductance and temperature from GW-715.

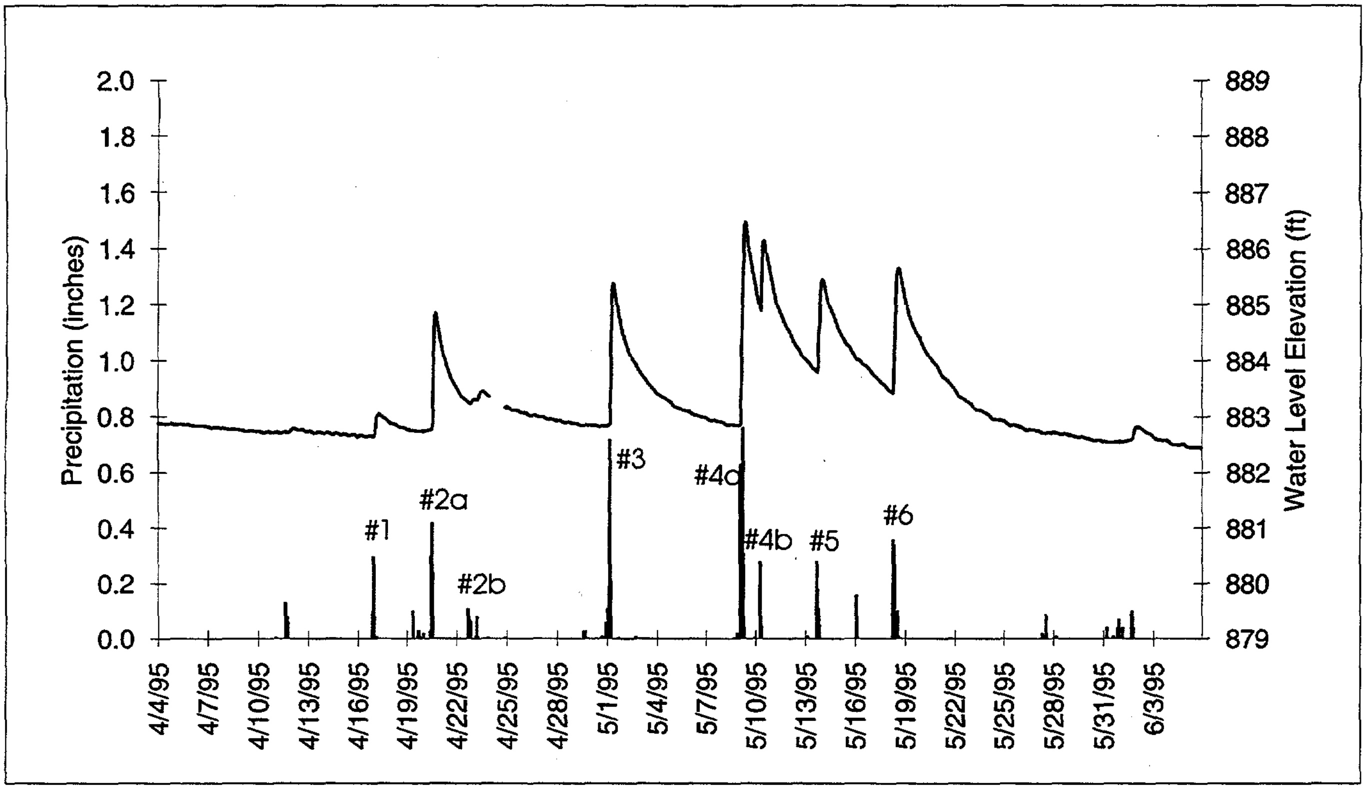

Figure A-8. Well hydrograph from GW-054.

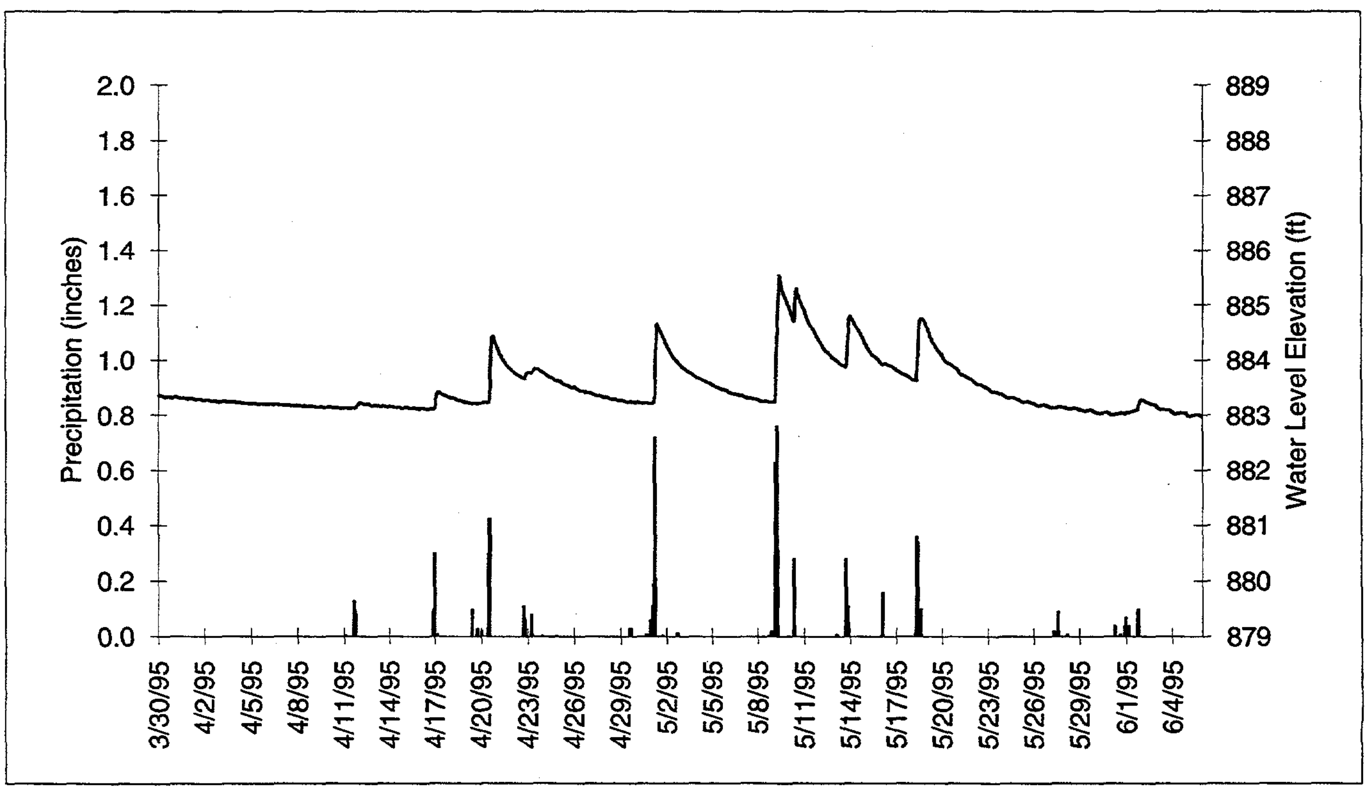

Figure A-9. Well hydrograph from GW-056.

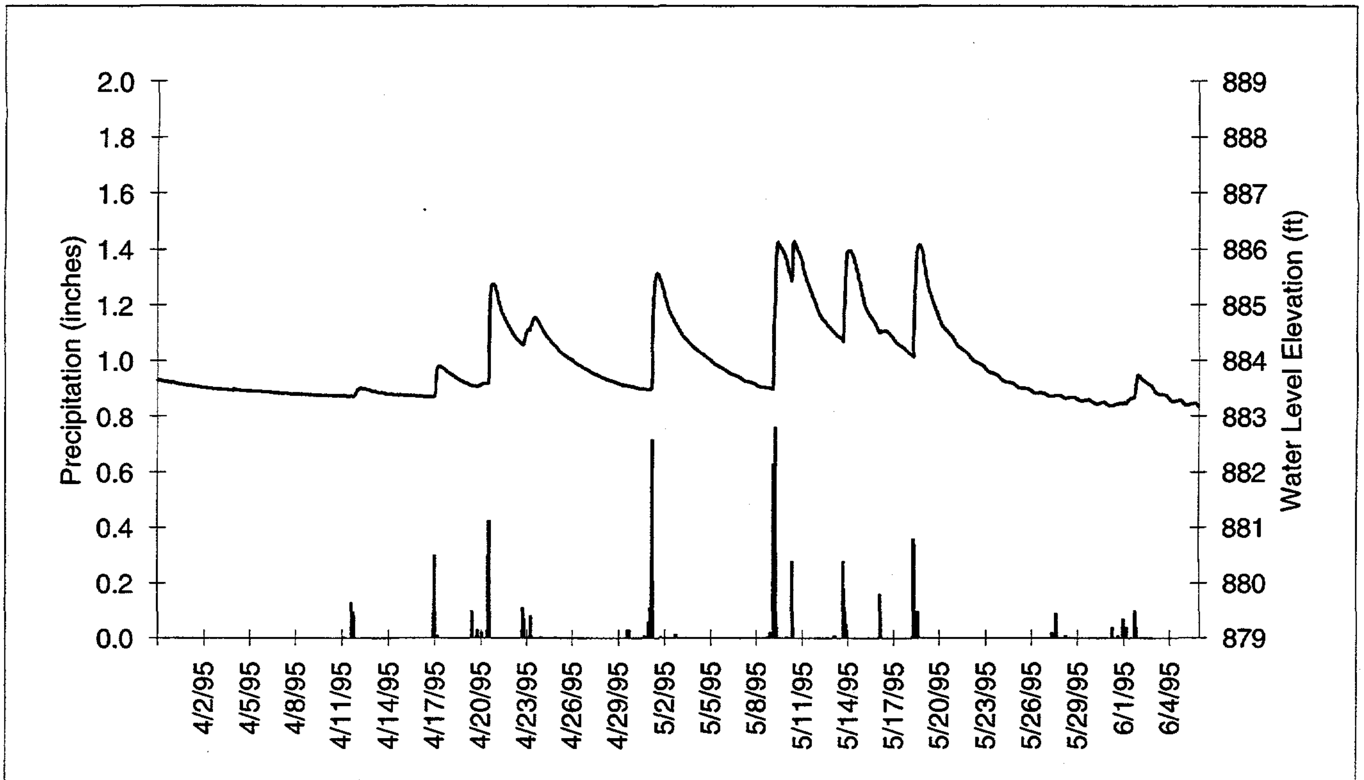

Figure A-10. Well hydrograph from GW-057.

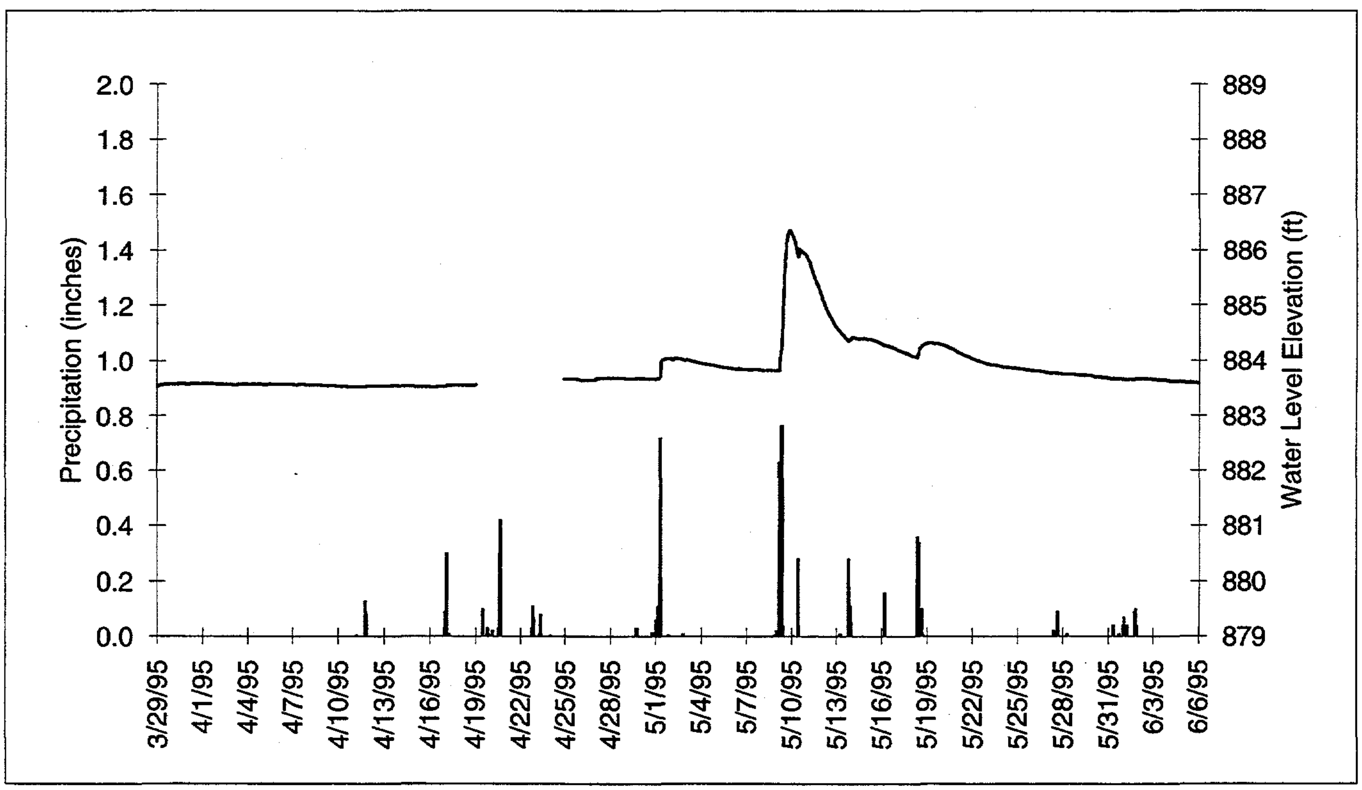

Figure A-11. Well hydrograph from GW-683.

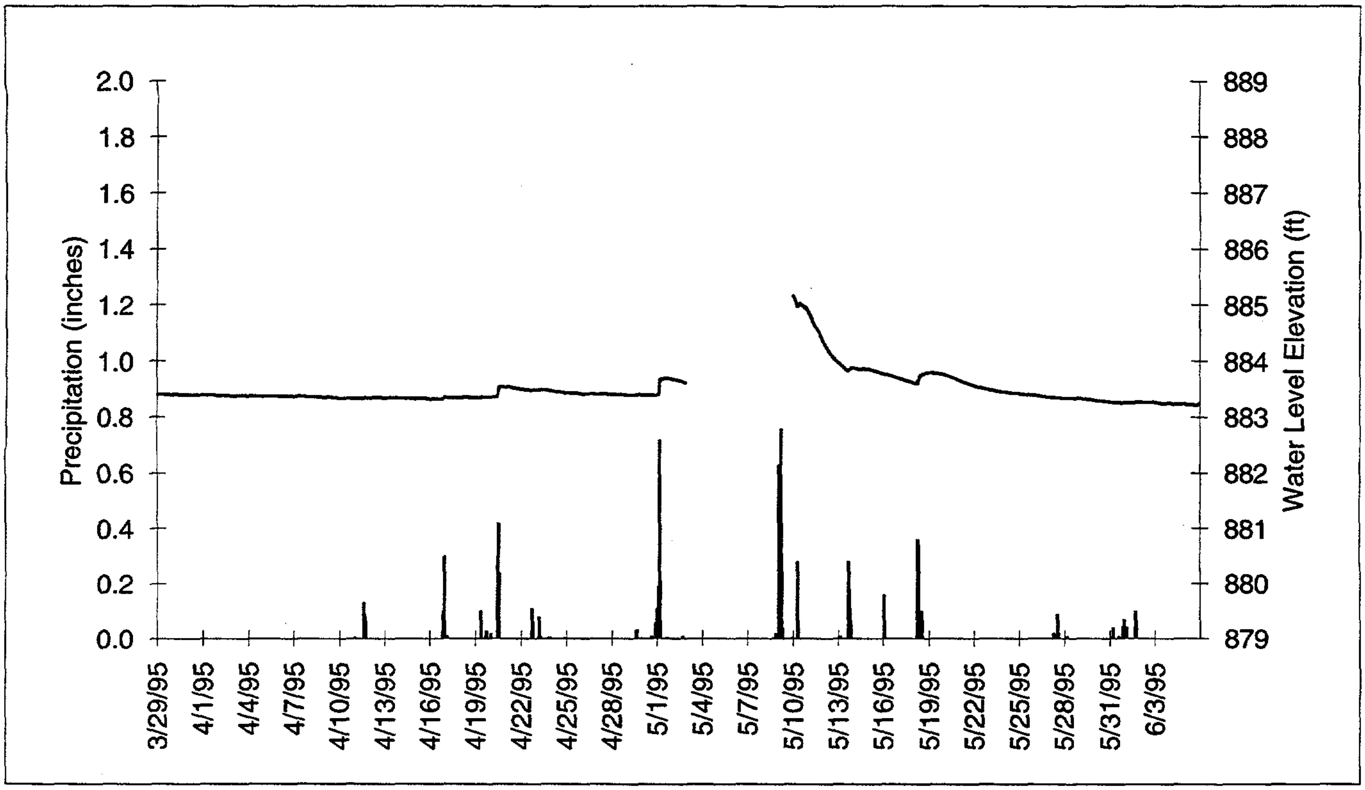

Figure A-12. Well hydrograph from GW-684.

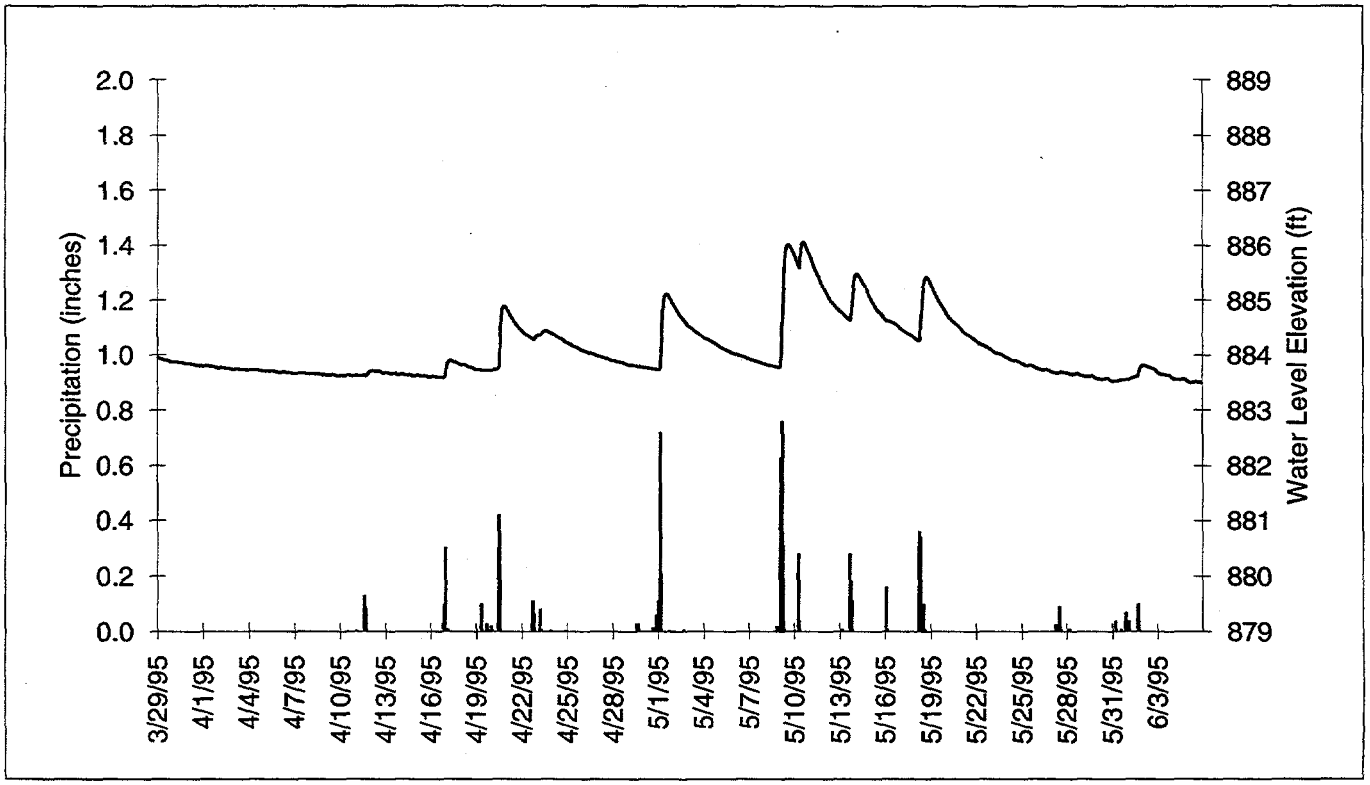

Figure A-13. Well hydrograph from GW-685.

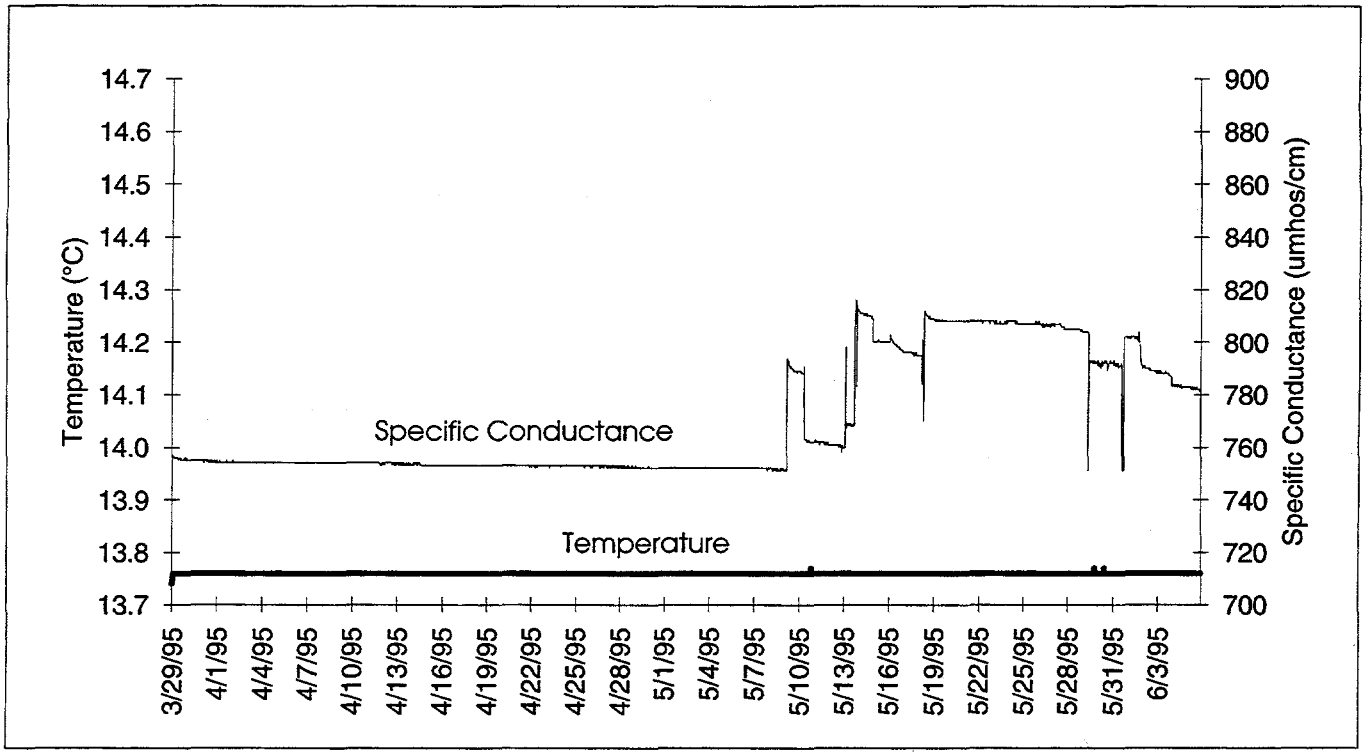

Figure A-14. Specific conductance and temperature from GW-685.

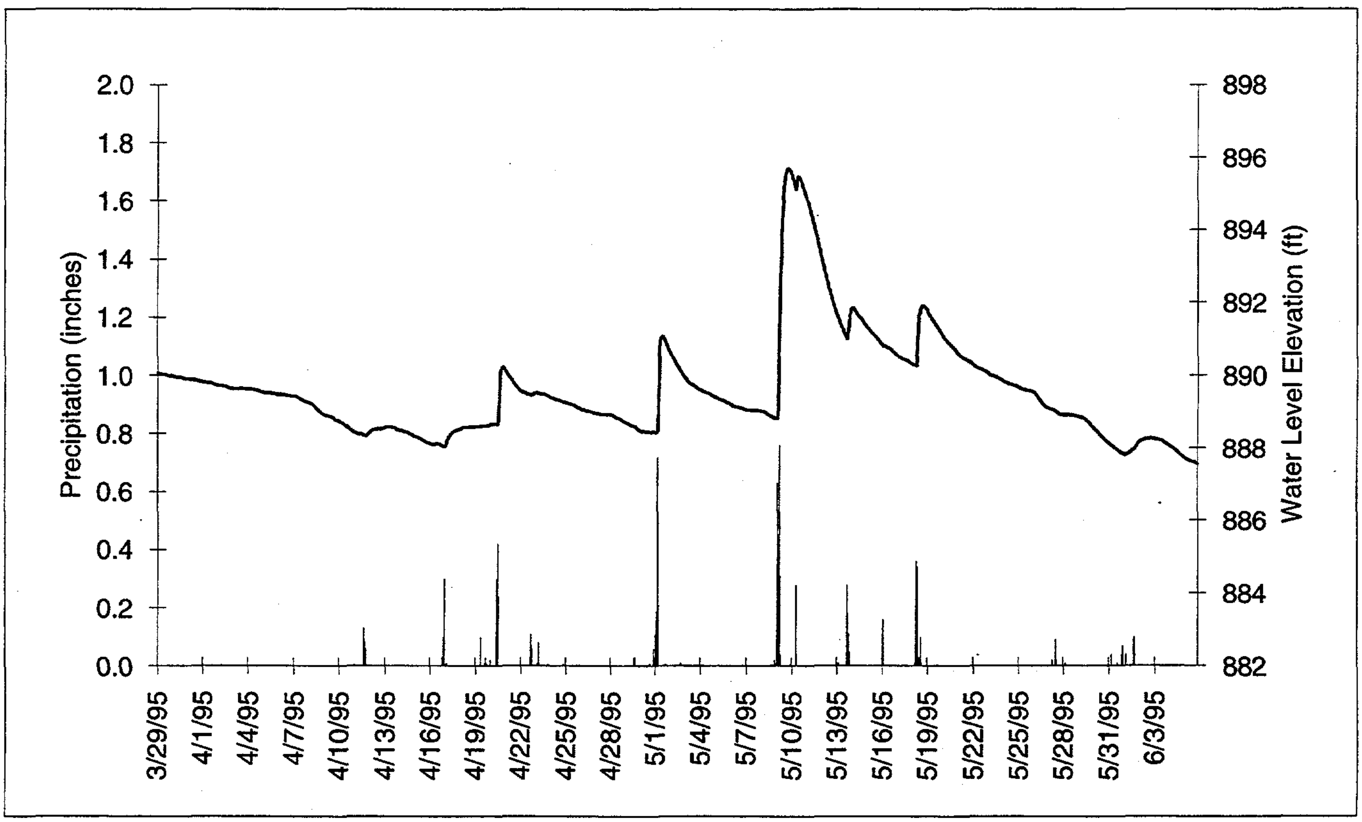

Figure A-15 Well hydrograph from GW-728.

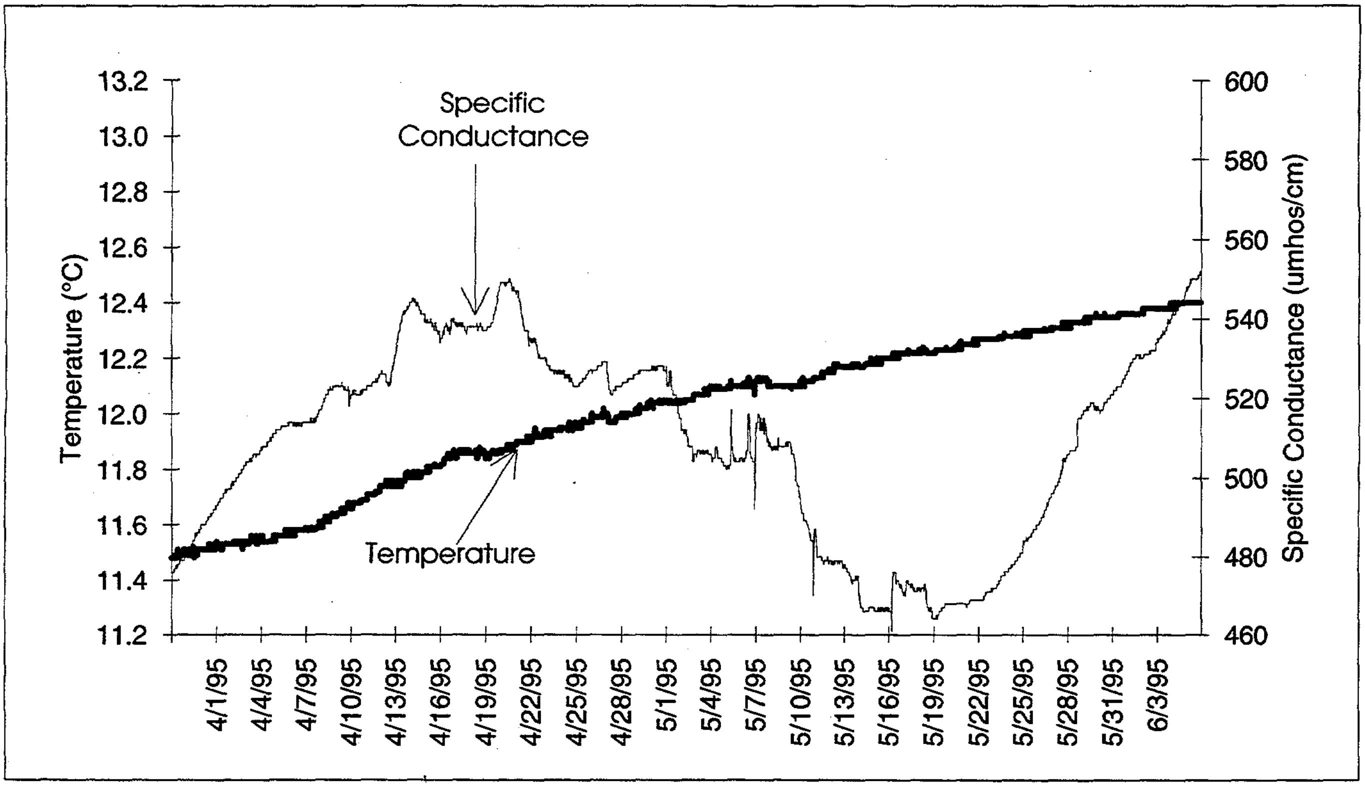

Figure A-16. Specific conductance and temperature from GW-728.

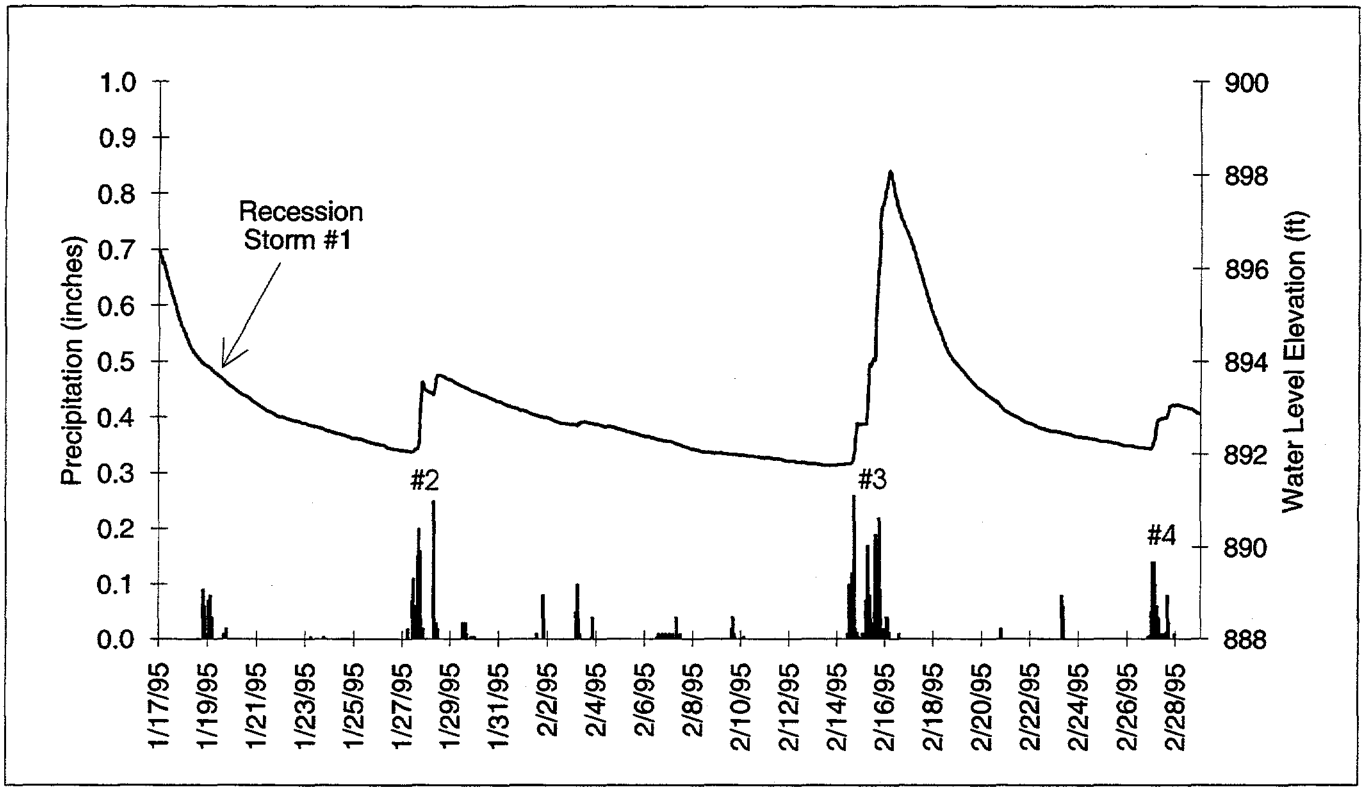

Figure A-17. Well hydrograph from GW-058.

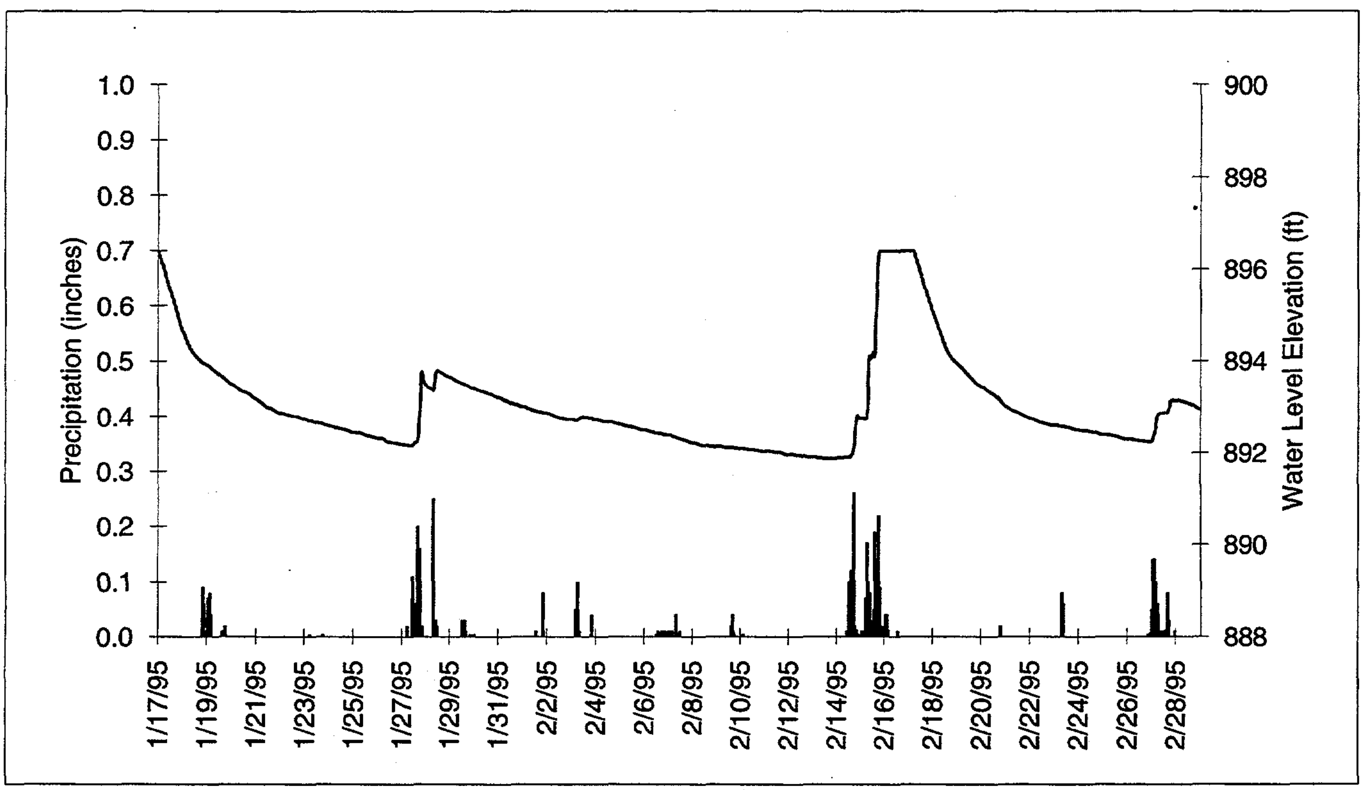

Figure A-18. Well hydrograph from GW-059.

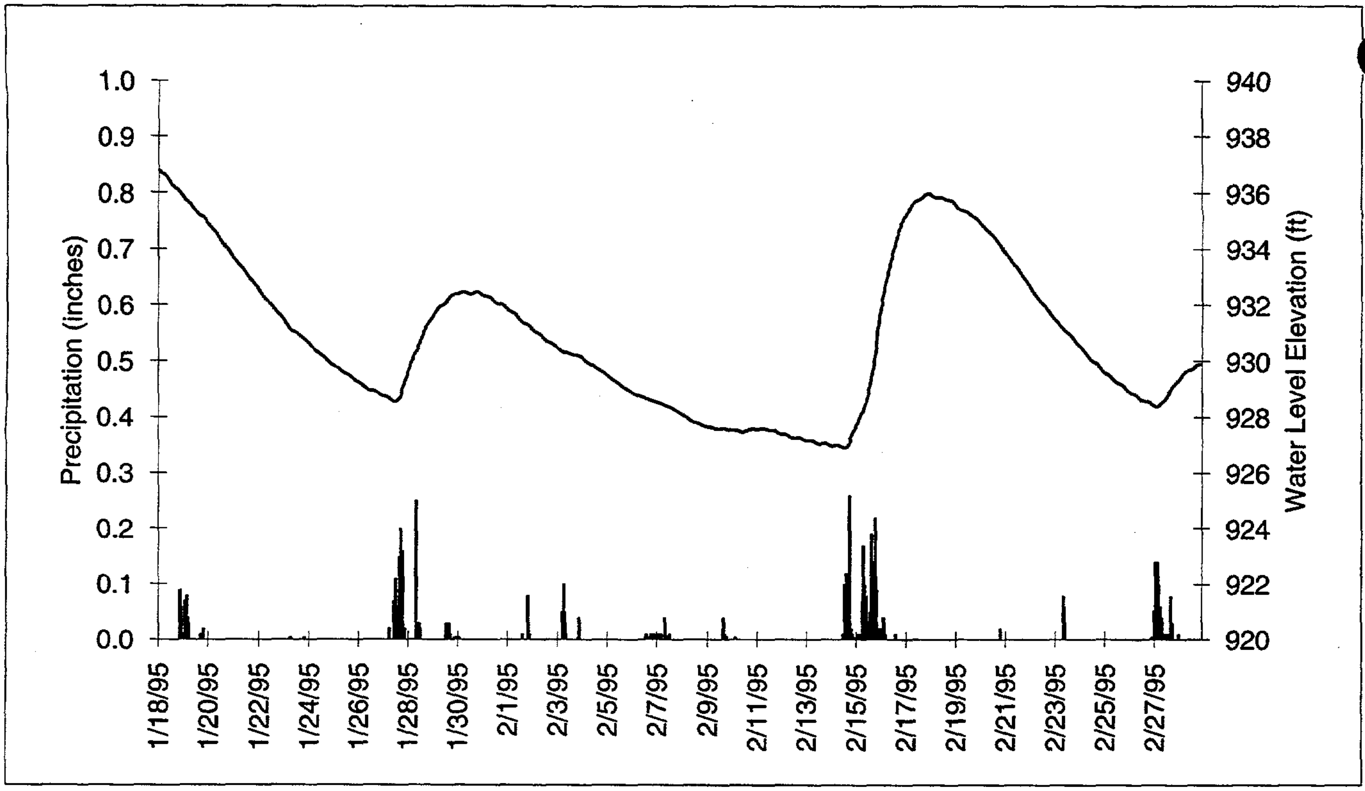

Figure A-19. Well hydrograph from GW-225.

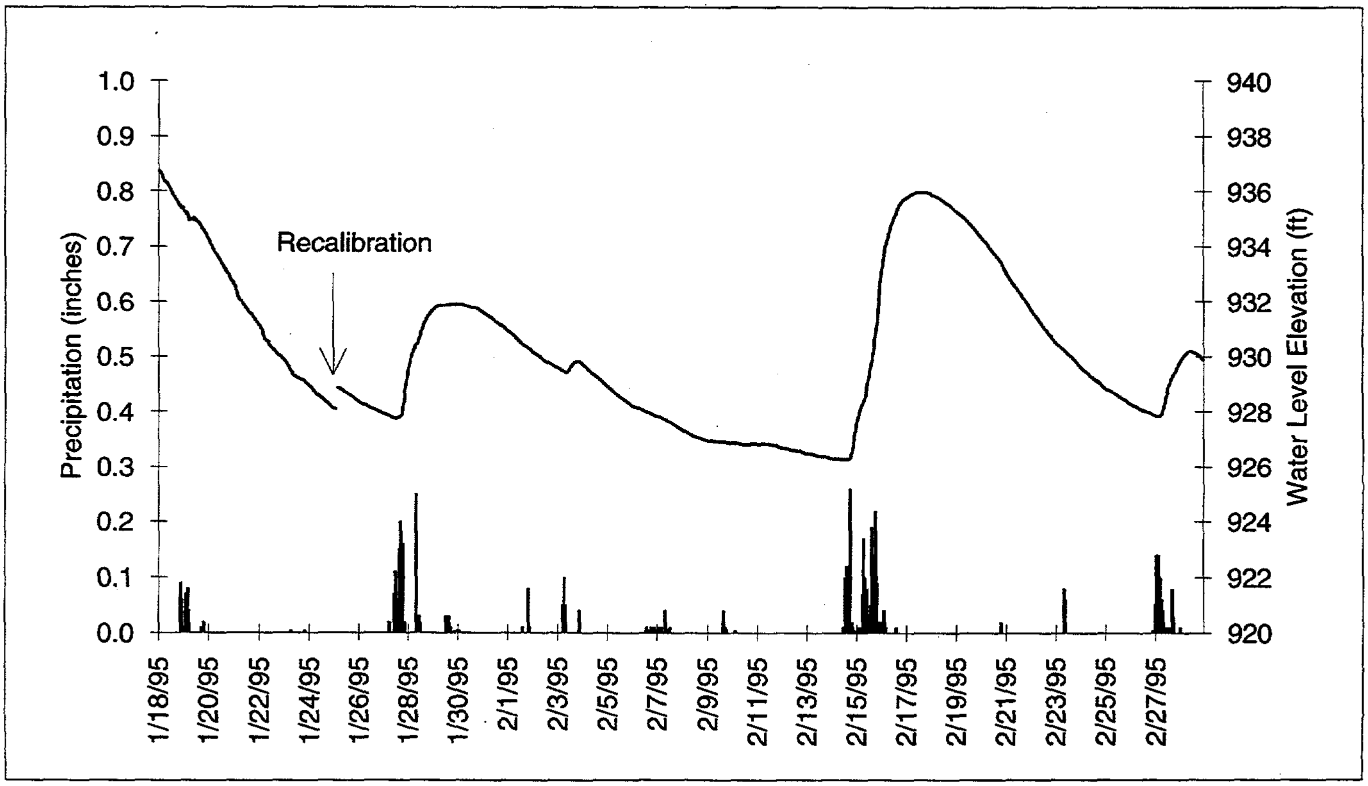

Figure A-20. Well hydrograph from GW-226.

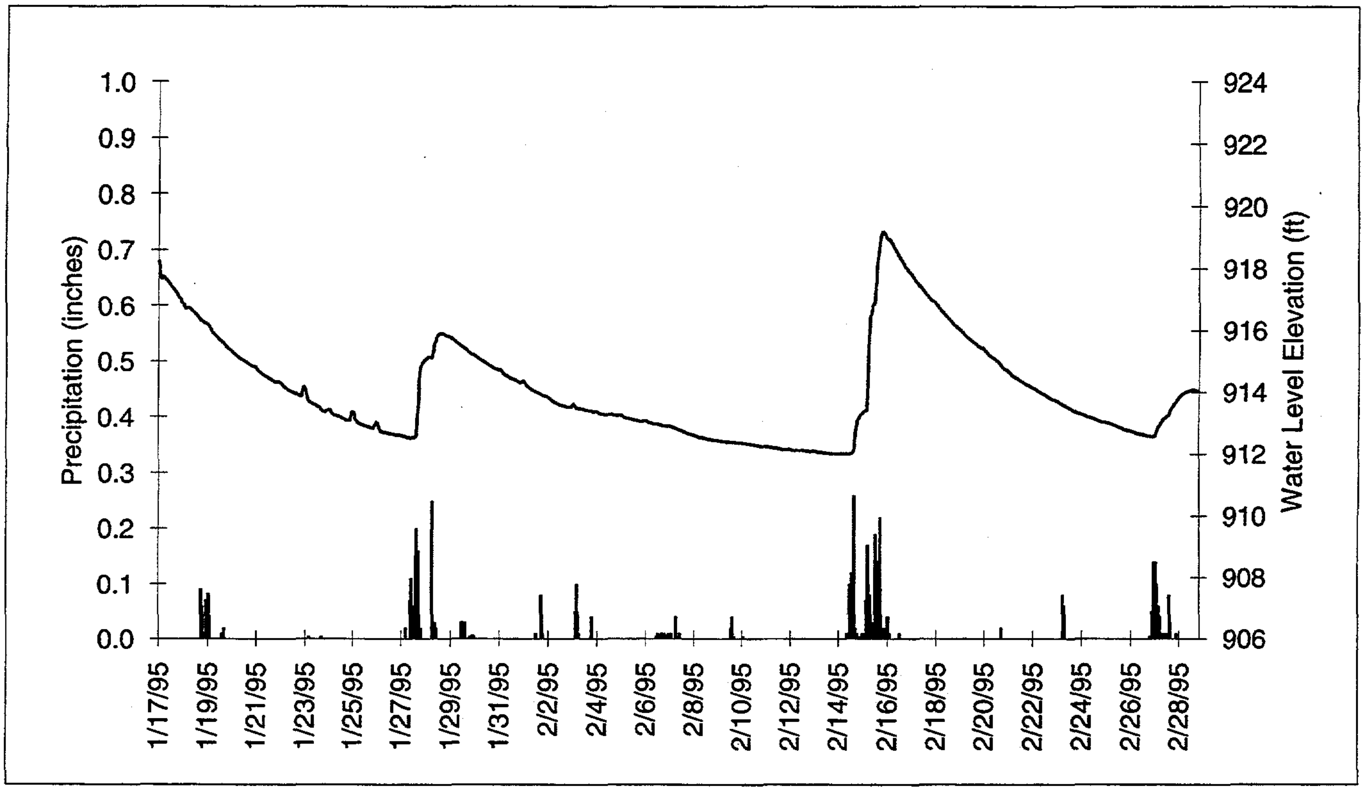

Figure A-21. Well hydrograph from GW-621.

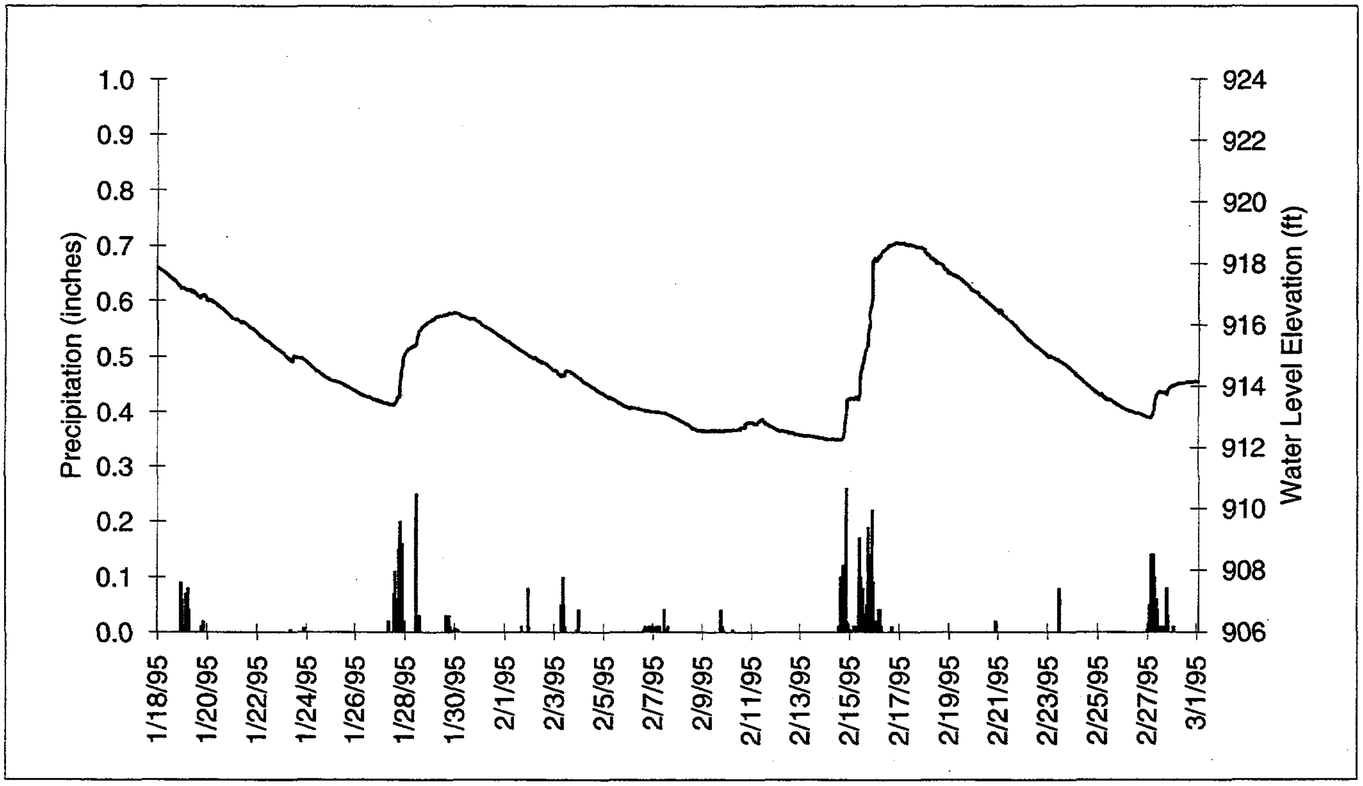

Figure A-22. Well hydrograph from GW-694.

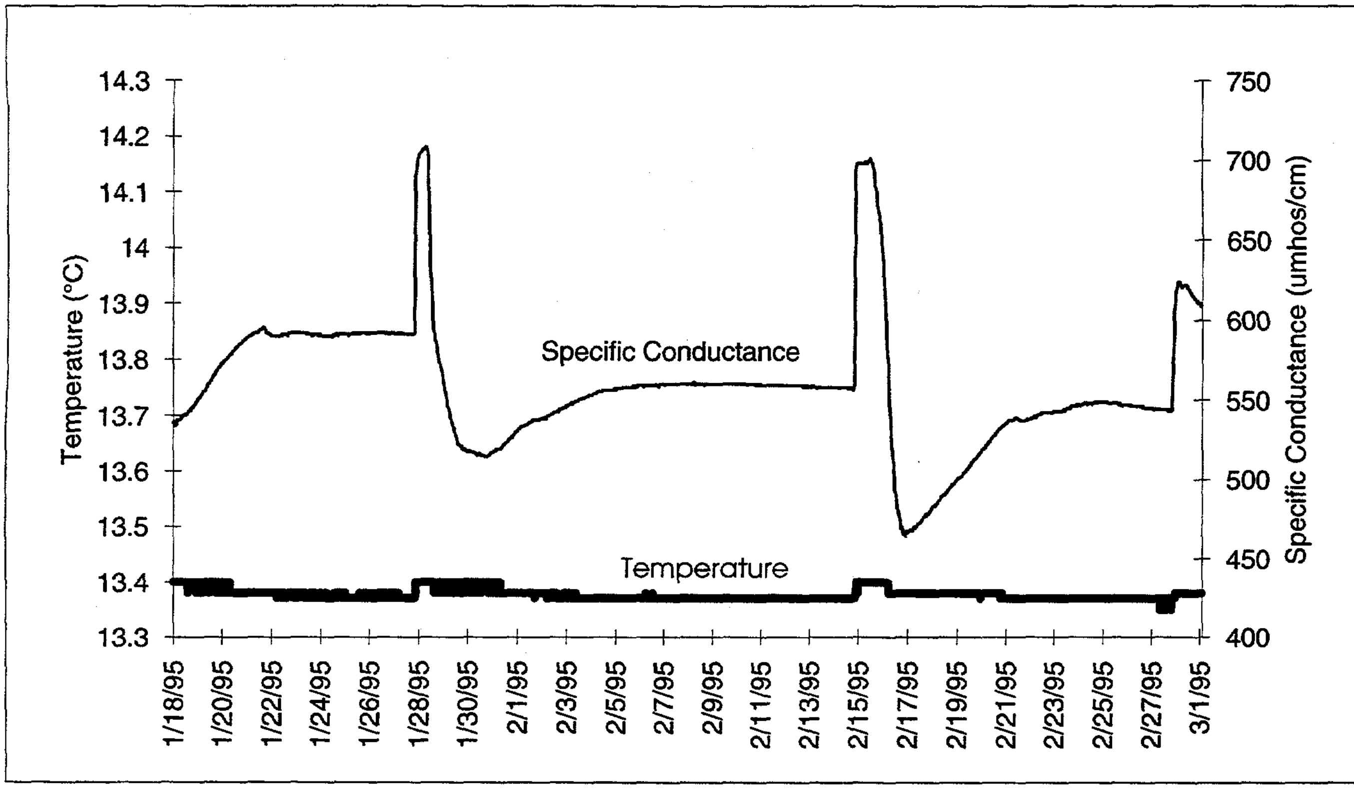

Figure A-23. Specific conductance and temperature from GW-694.

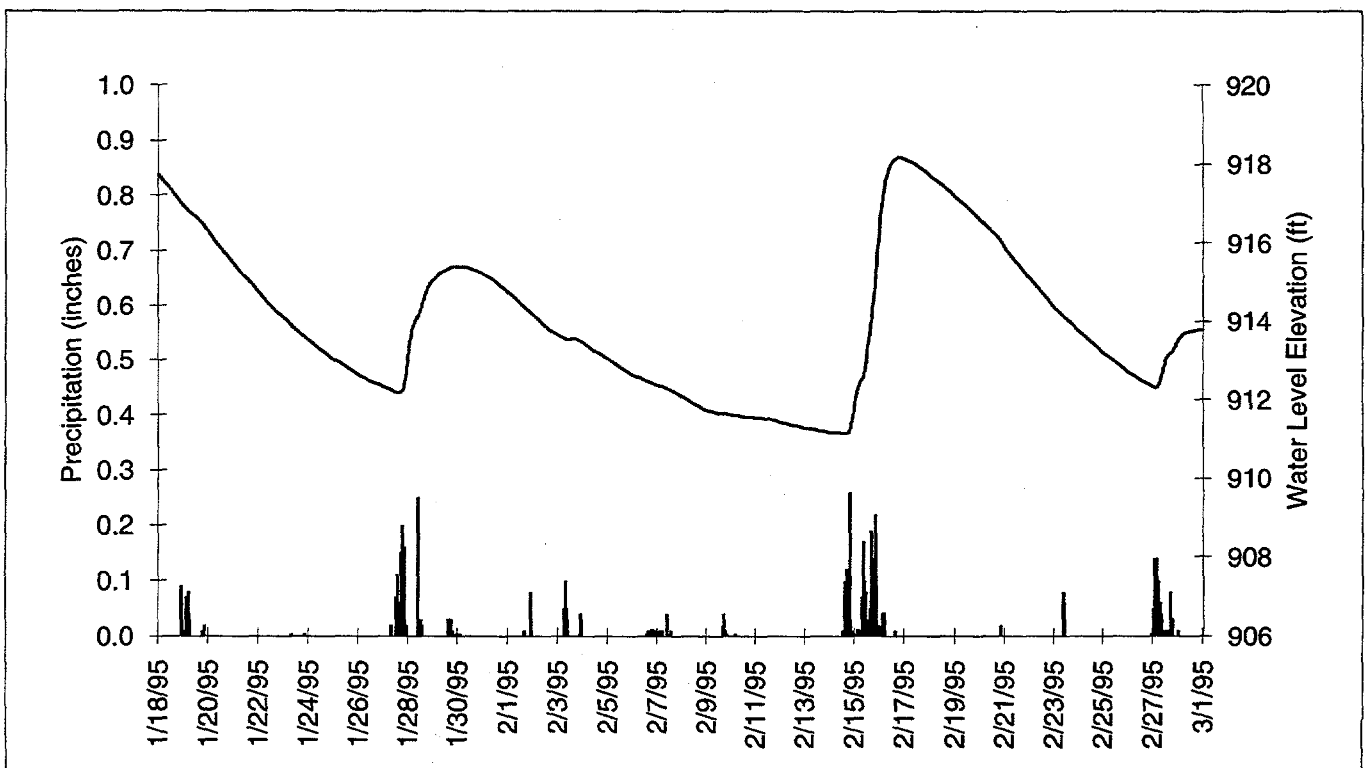

Figure A-24. Well hydrograph from GW-695.

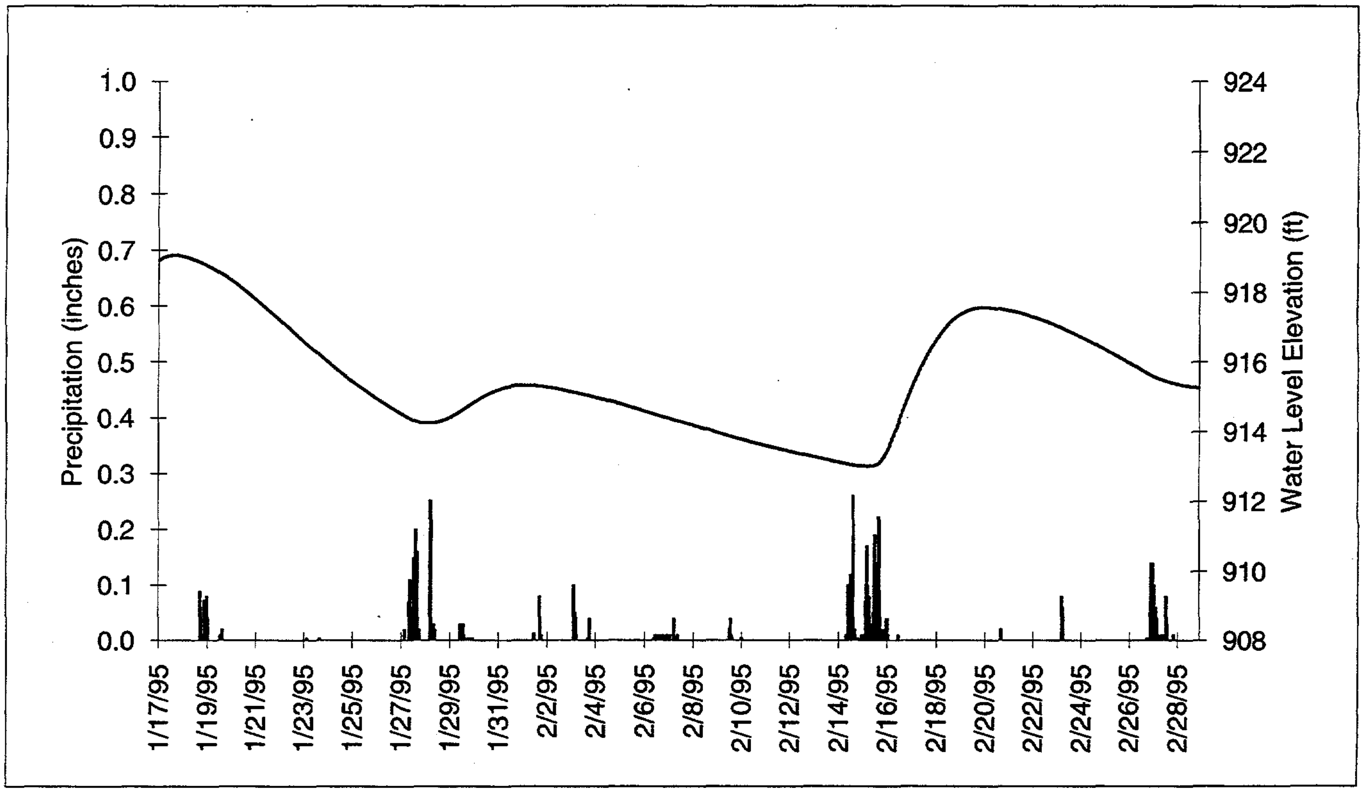

Figure A-25. Well hydrograph from GW-703.

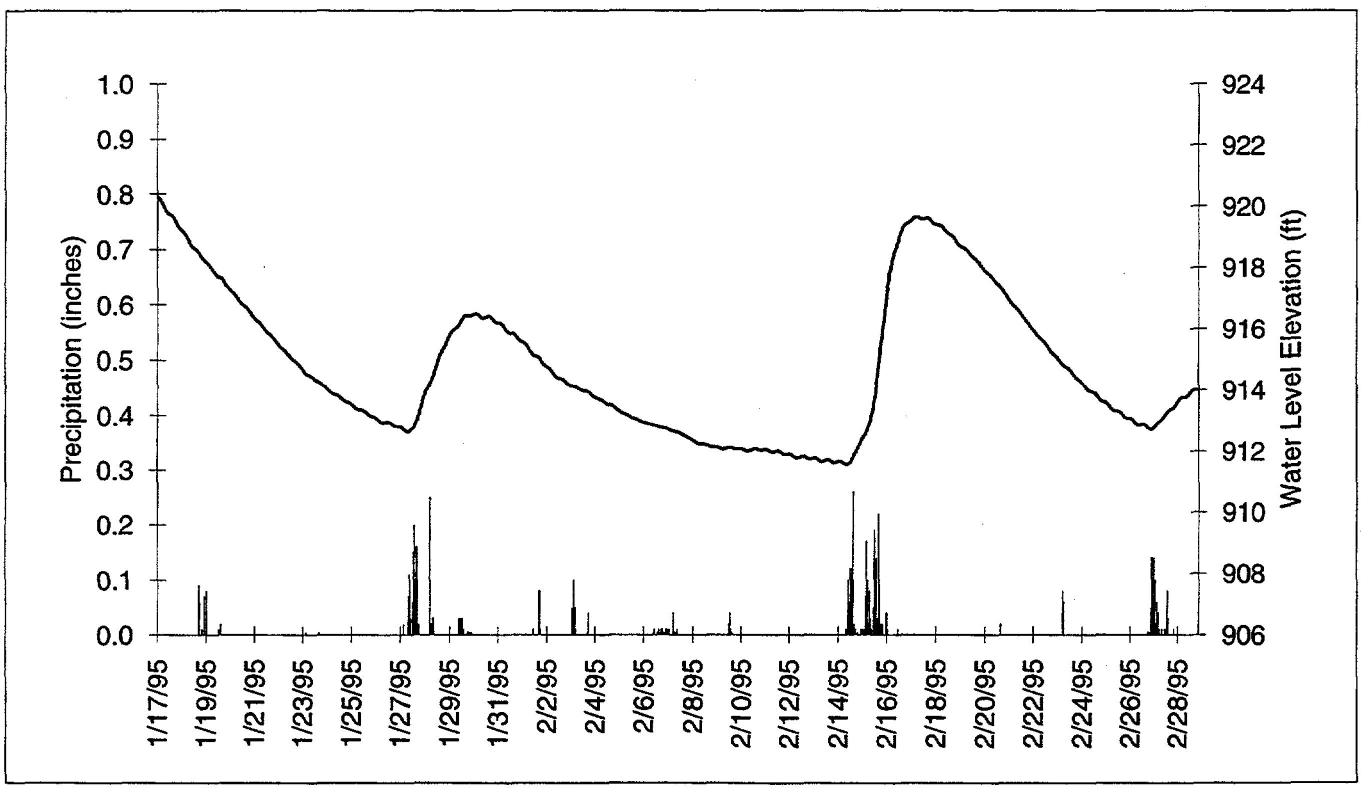

Figure A-26. Well hydrograph from GW-704.

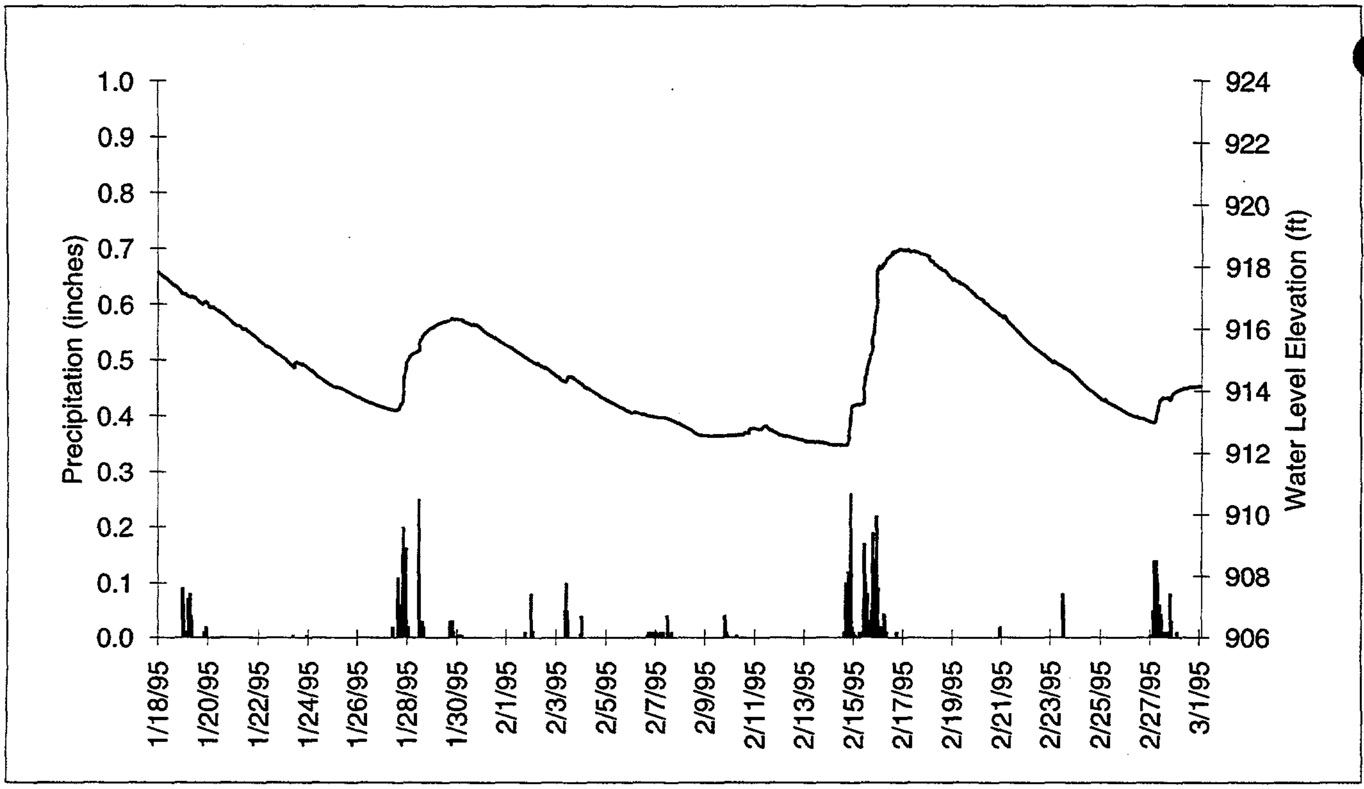

Figure A-27. Well hydrograph from GW-706.

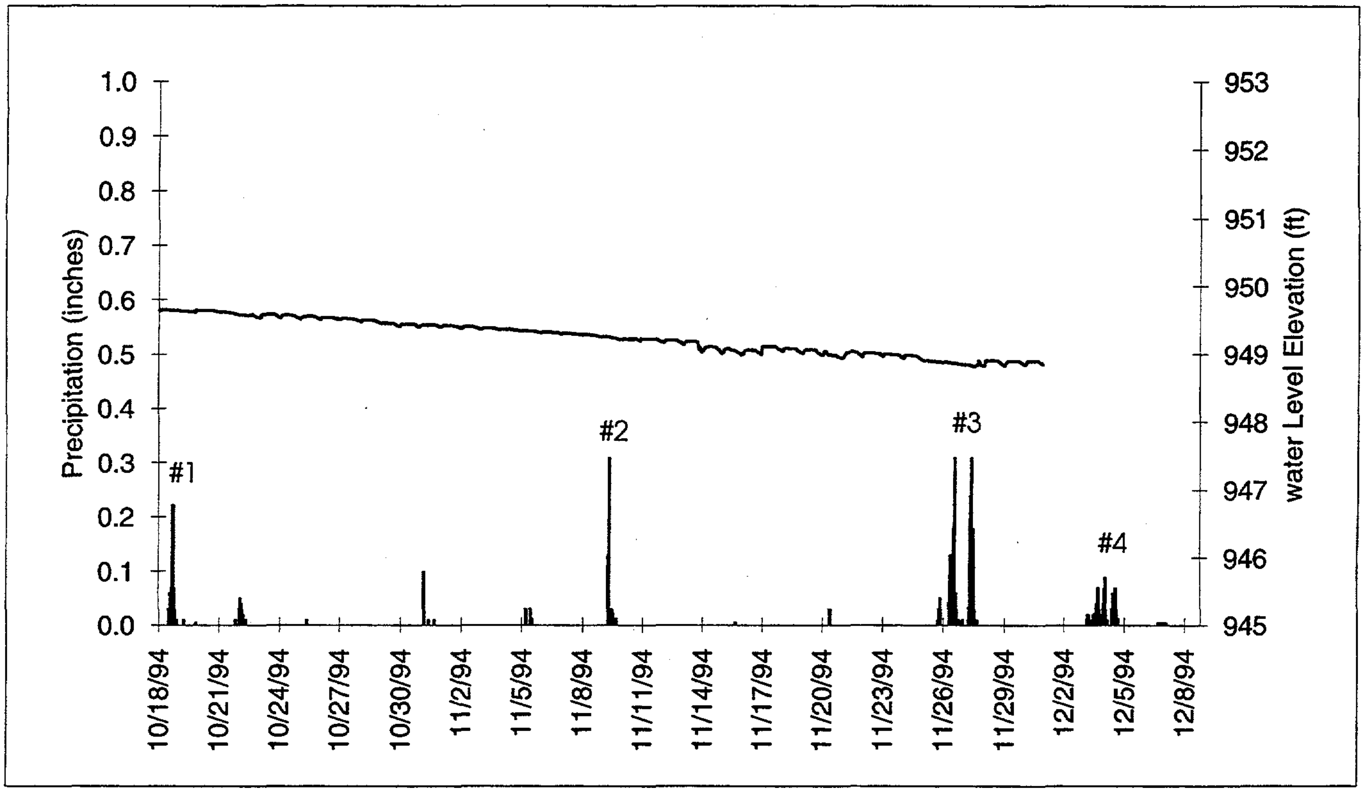

Figure A-28. Well hydrograph from GW-723.

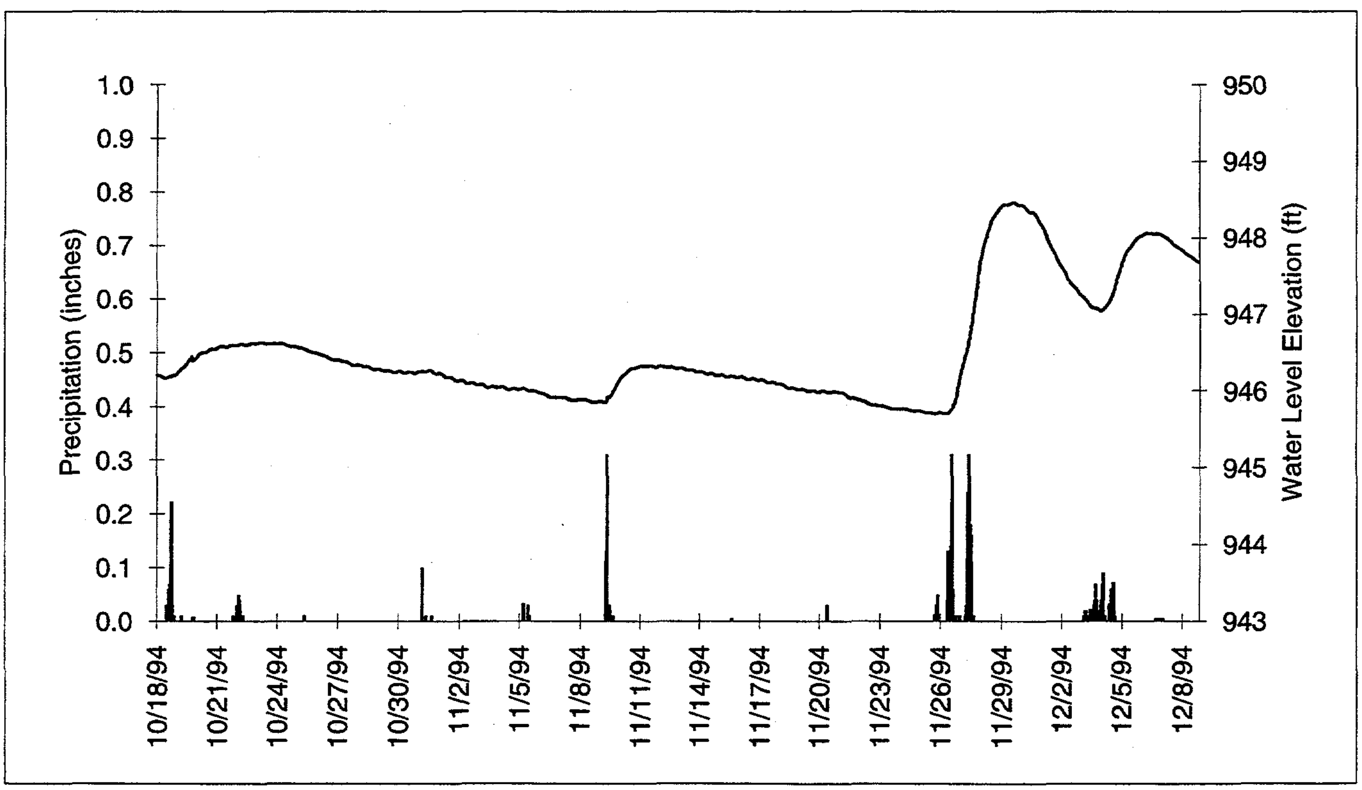

Figure A-29. Well hydrograph from GW-724.

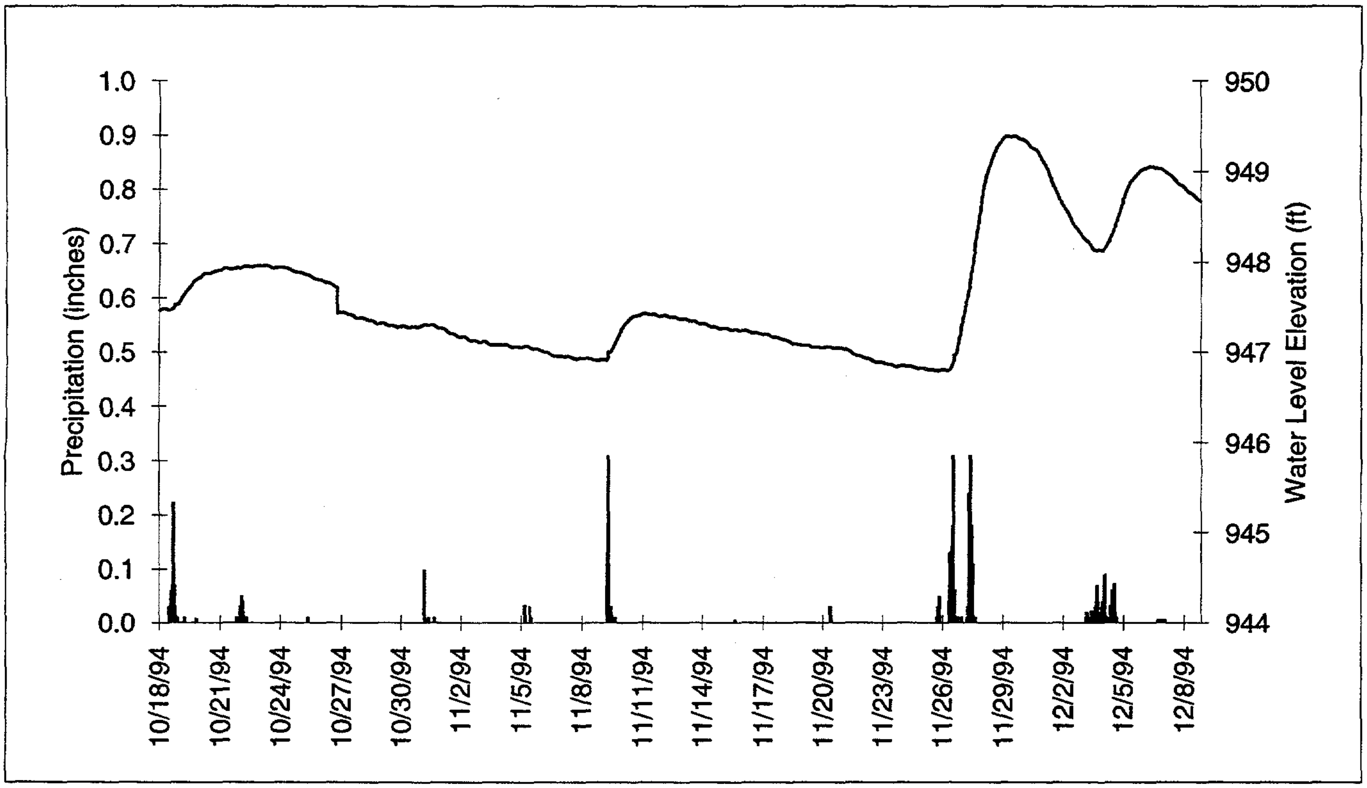

Figure A-30. Well hydrograph from GW-725.

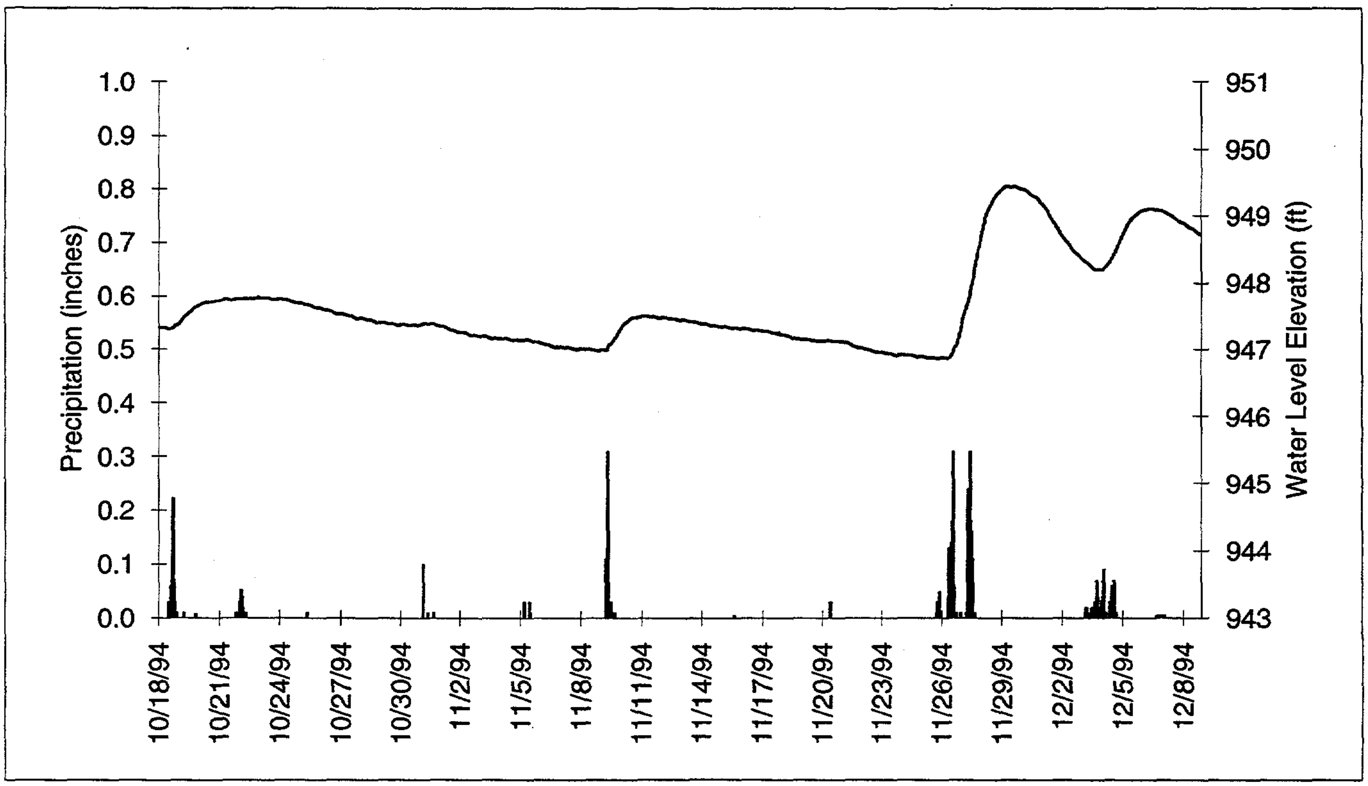

Figure A-31. Well hydrograph from GW-736.

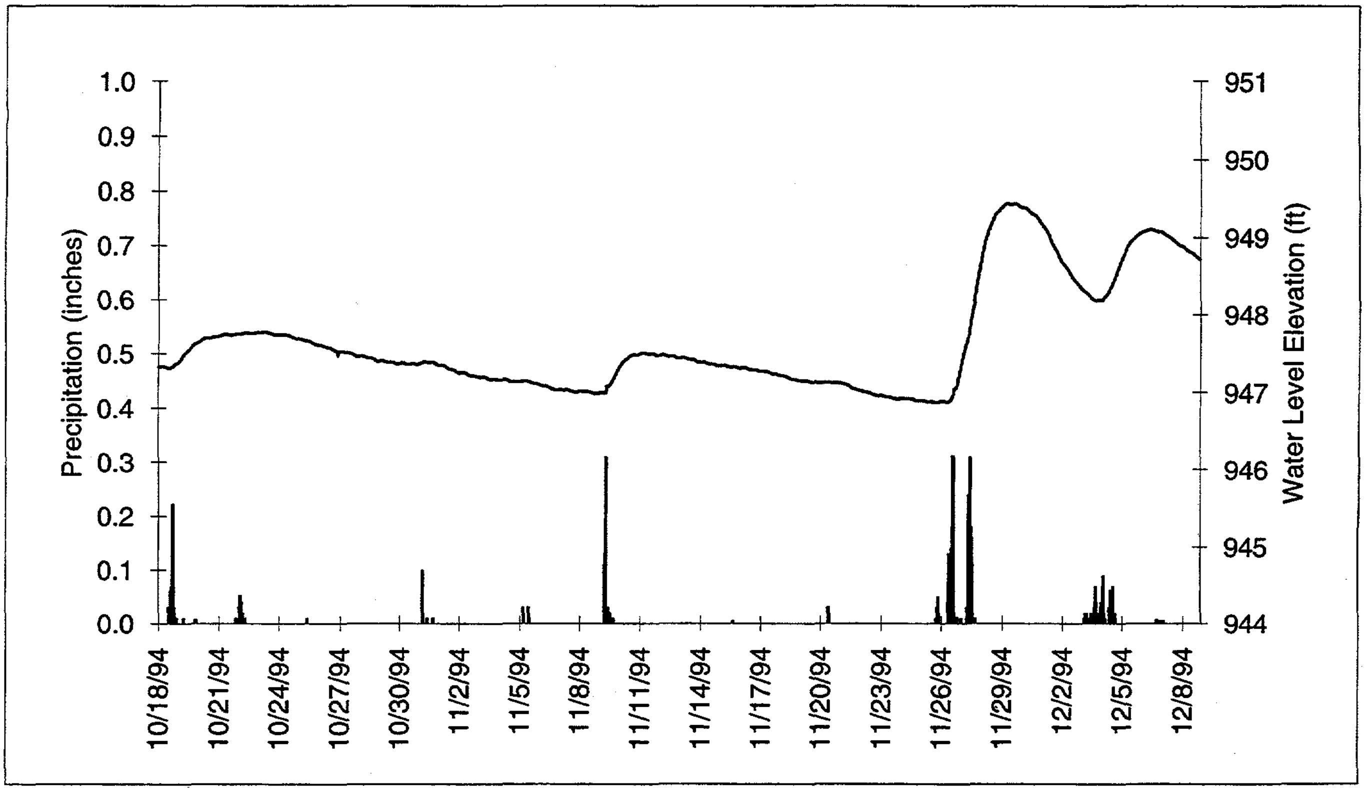

Figure A-32. Well hydrograph from GW-737.

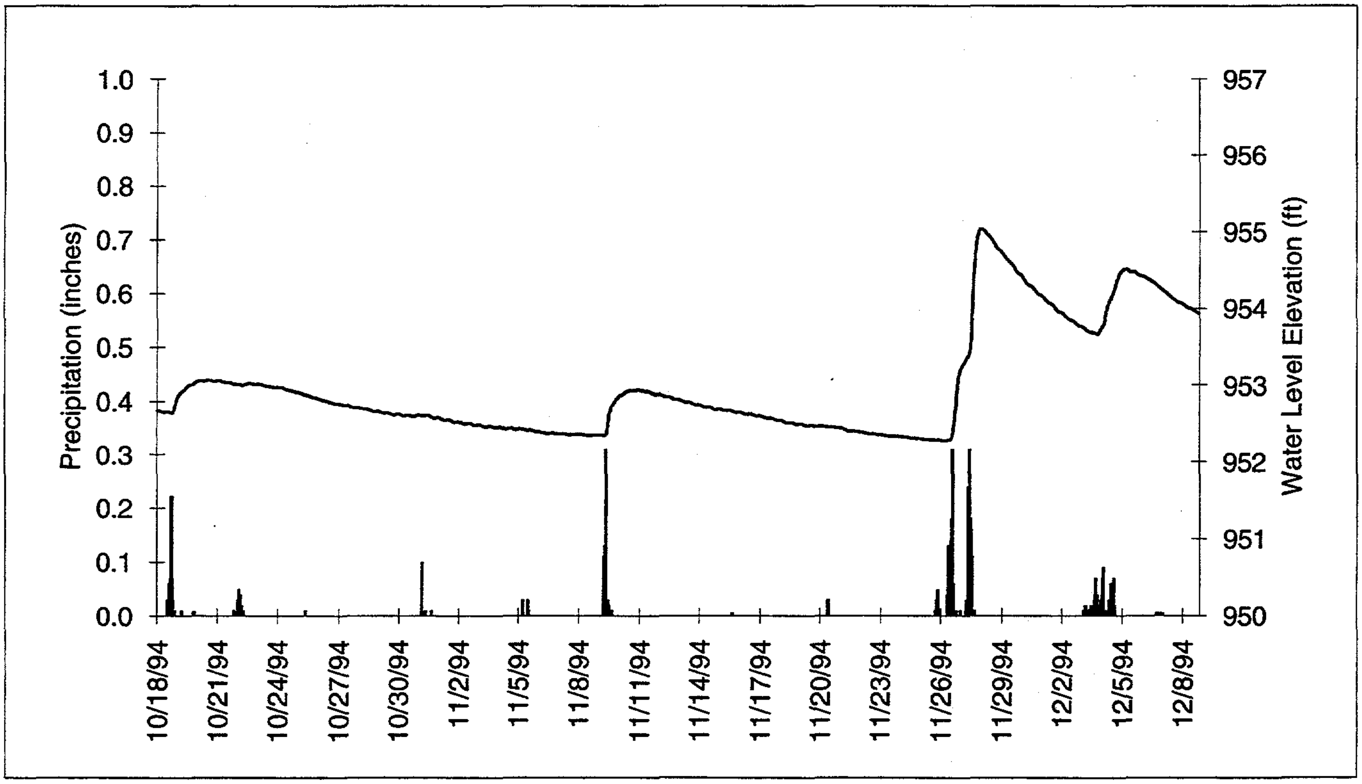

Figure A-33. Well hydrograph from GW-738.

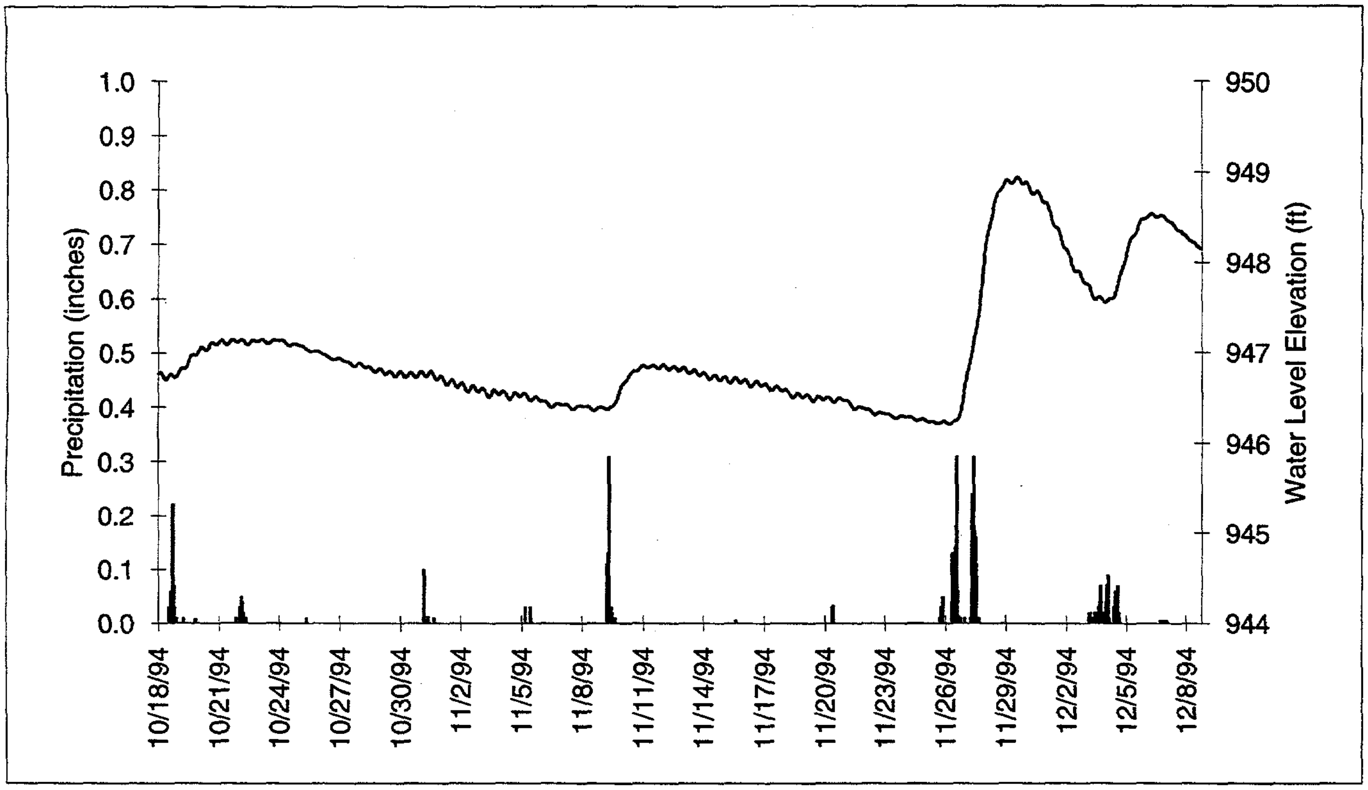

Figure A-34. Well hydrograph from GW-739.

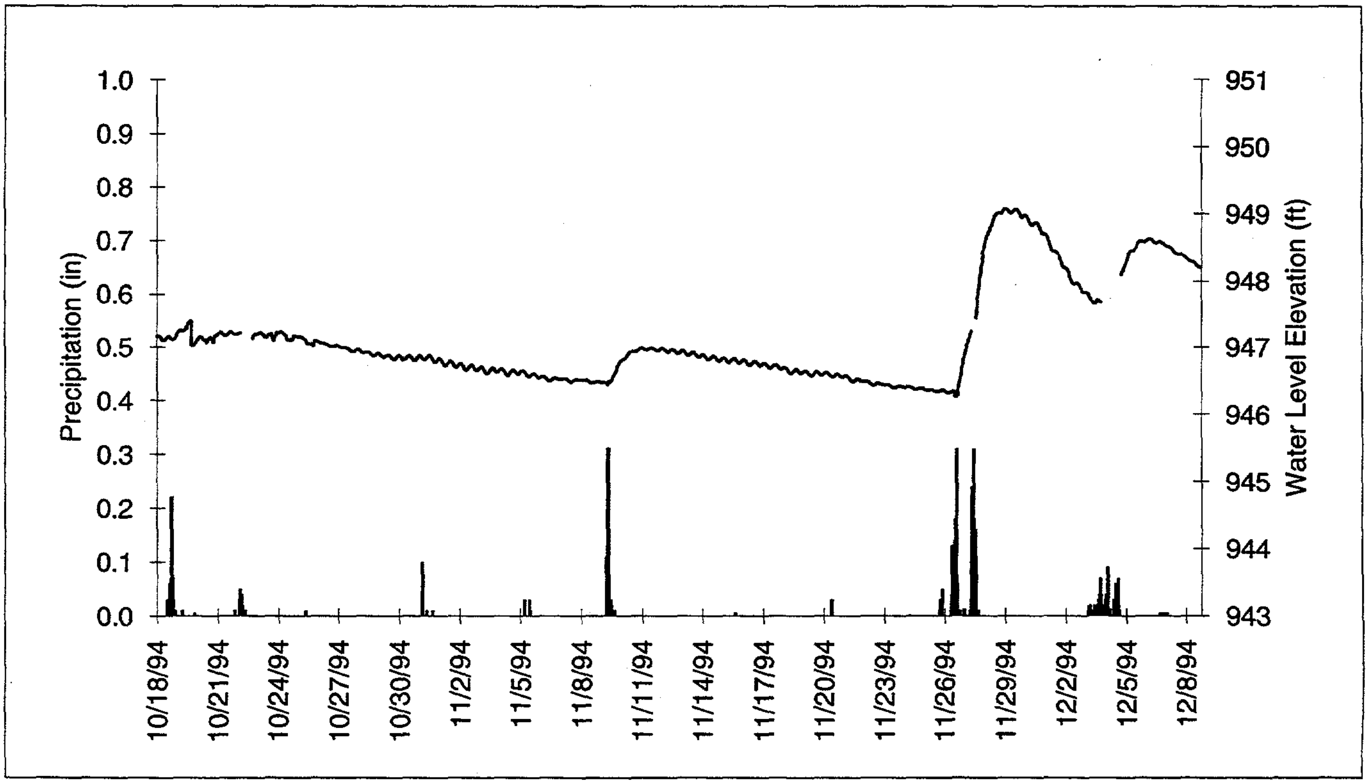

Figure A-35. Well hydrograph from GW-740.

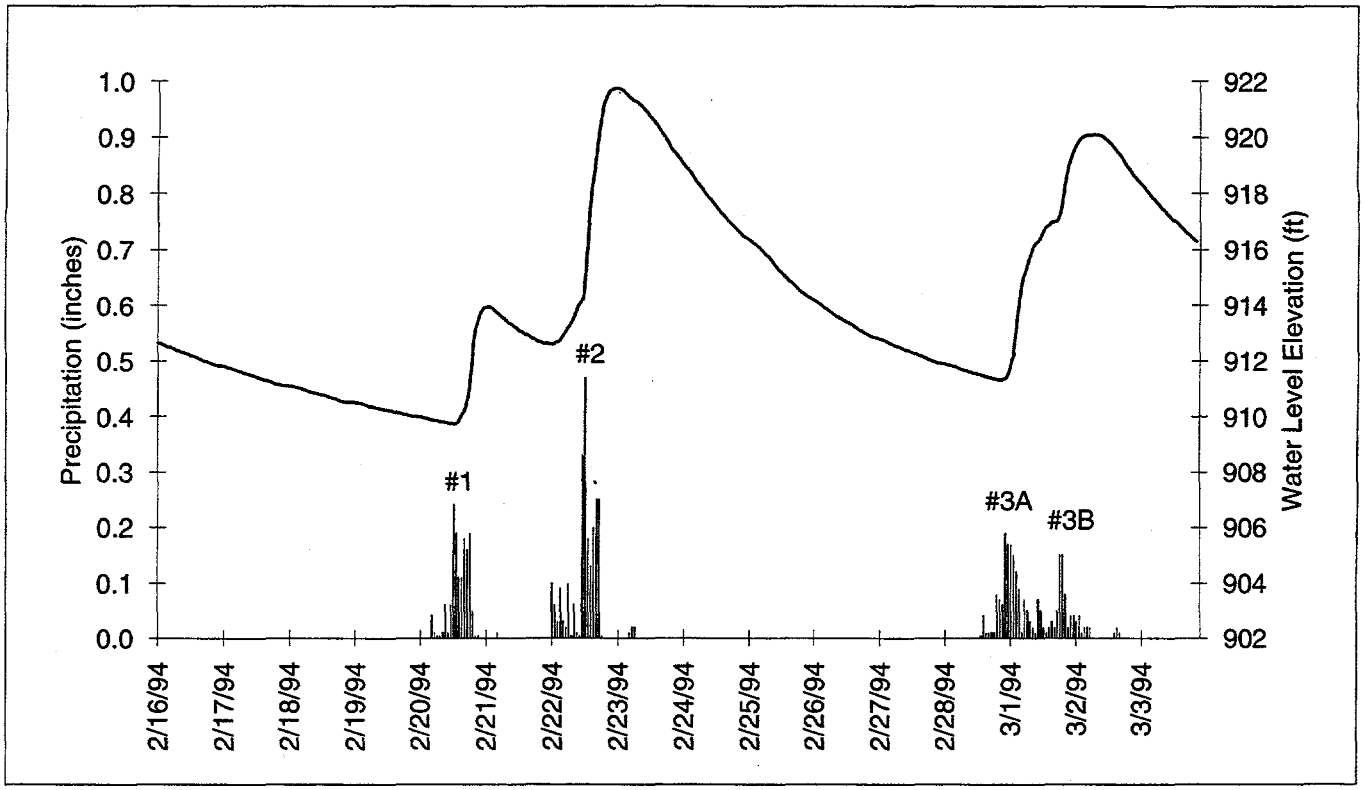

Figure A-36. Well hydrograph from GW-167.

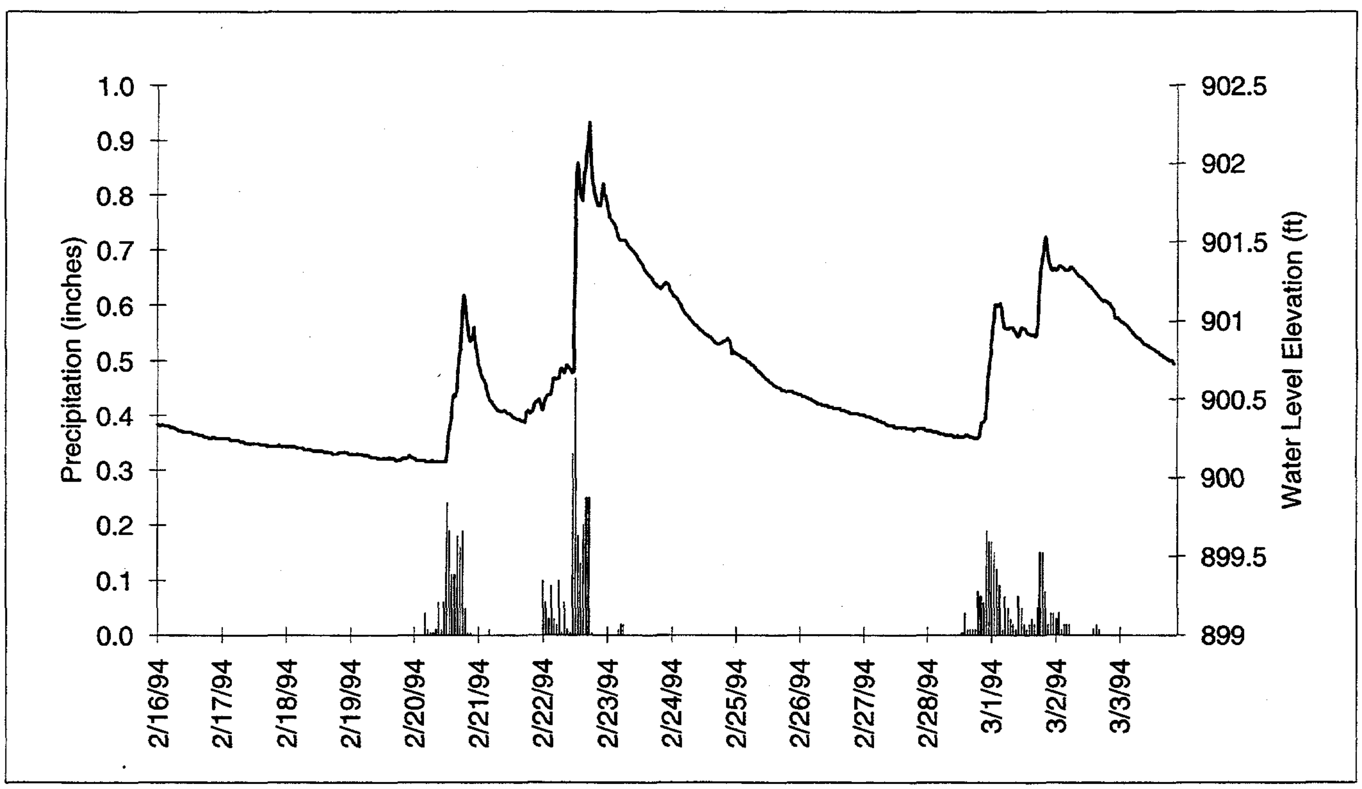

Figure A-37. Well hydrograph from GW-220.

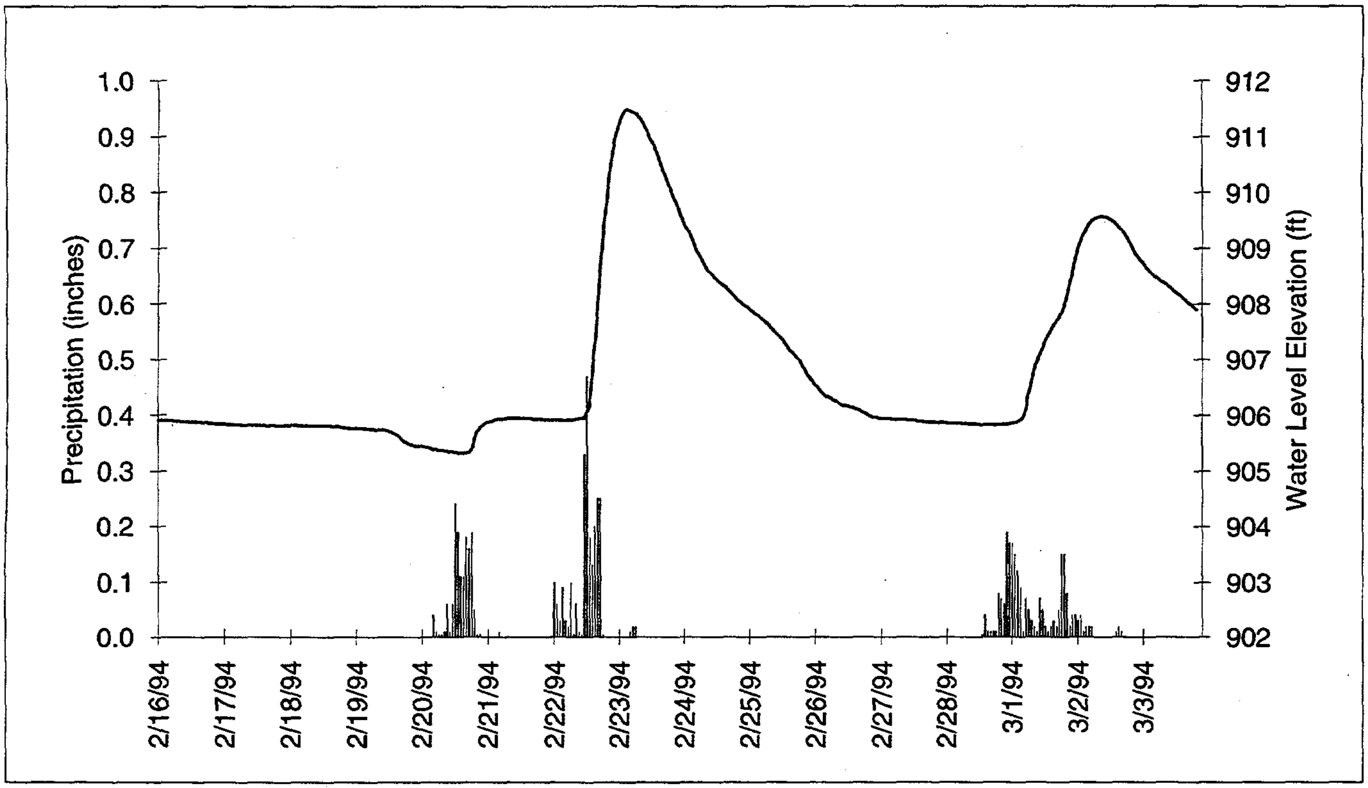

Figure A-38. Well hydrograph from GW-603.

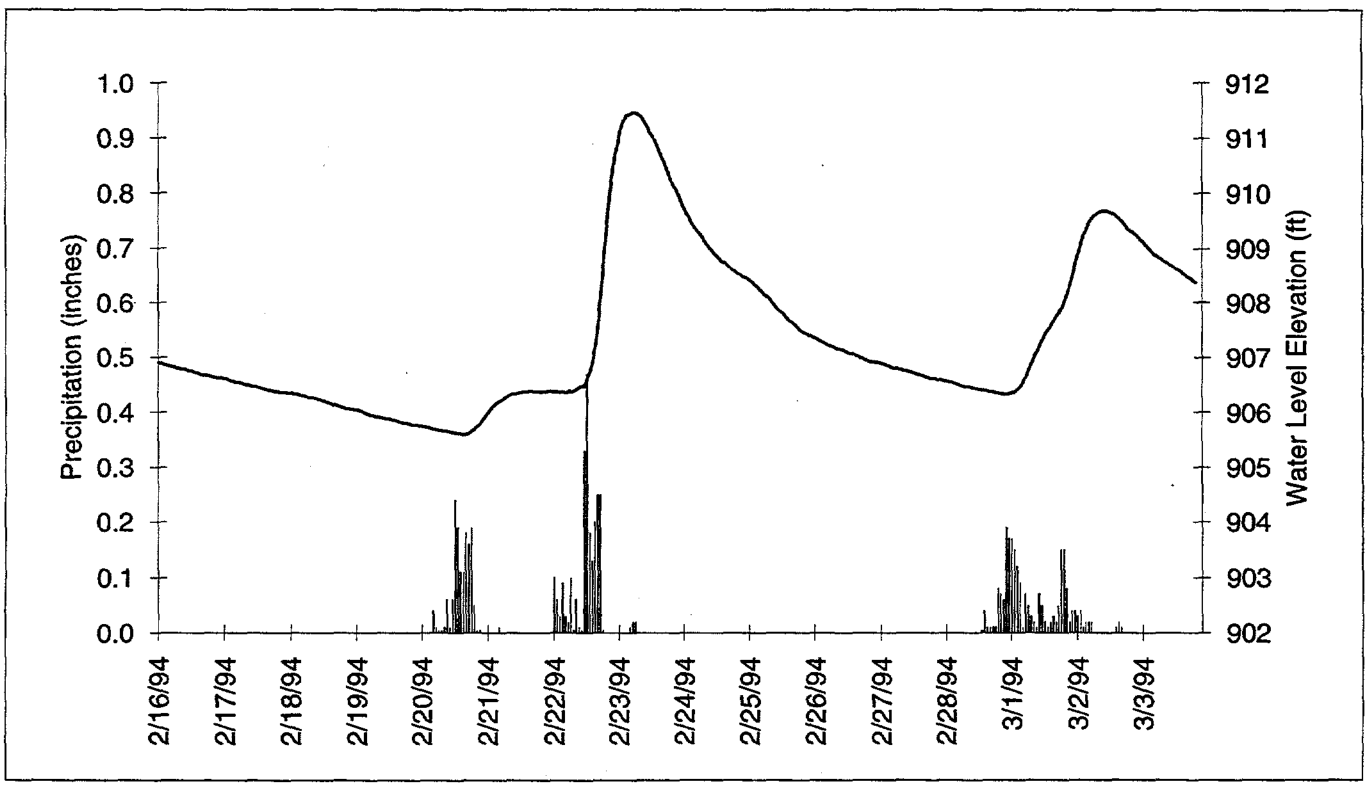

Figure A-39. Well hydrograph from GW-604.

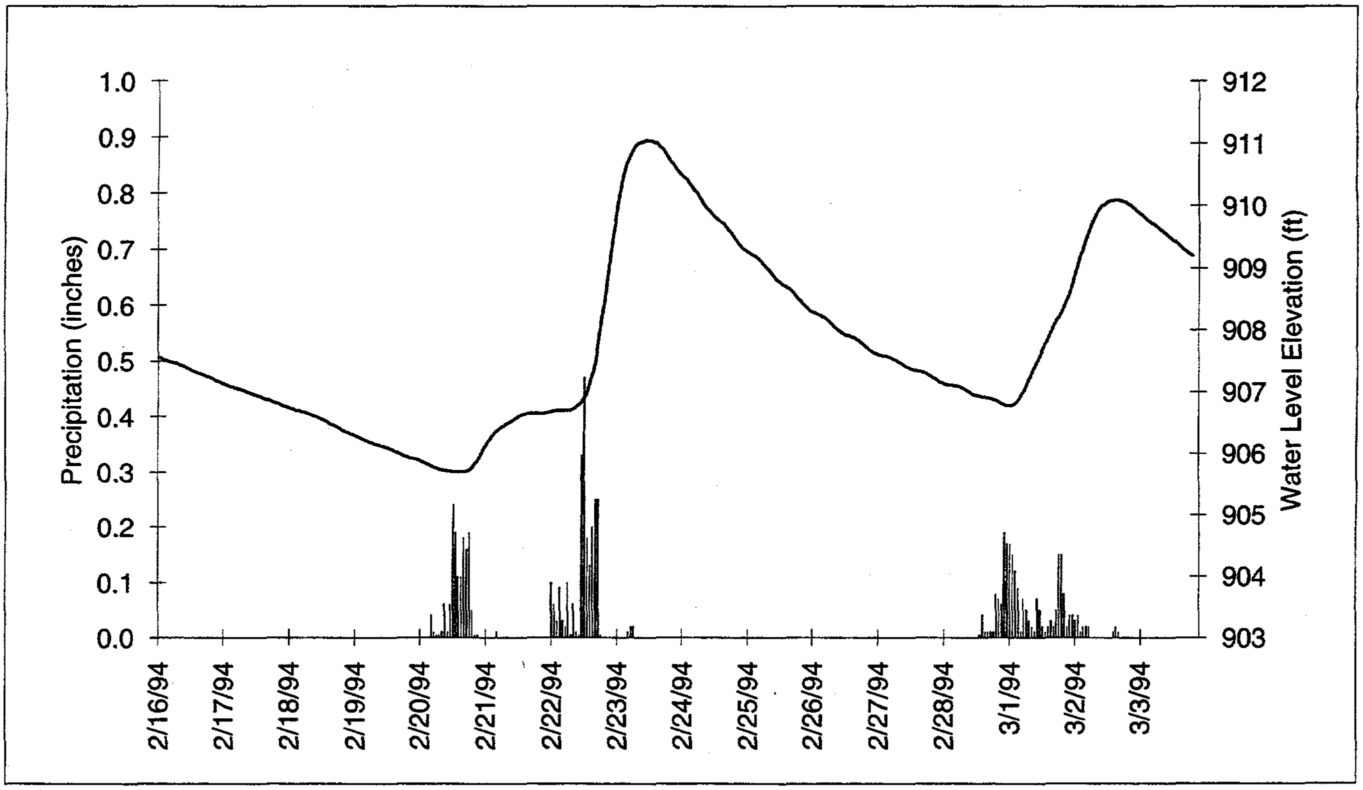

Figure A-40. Well hydrograph from GW-733.

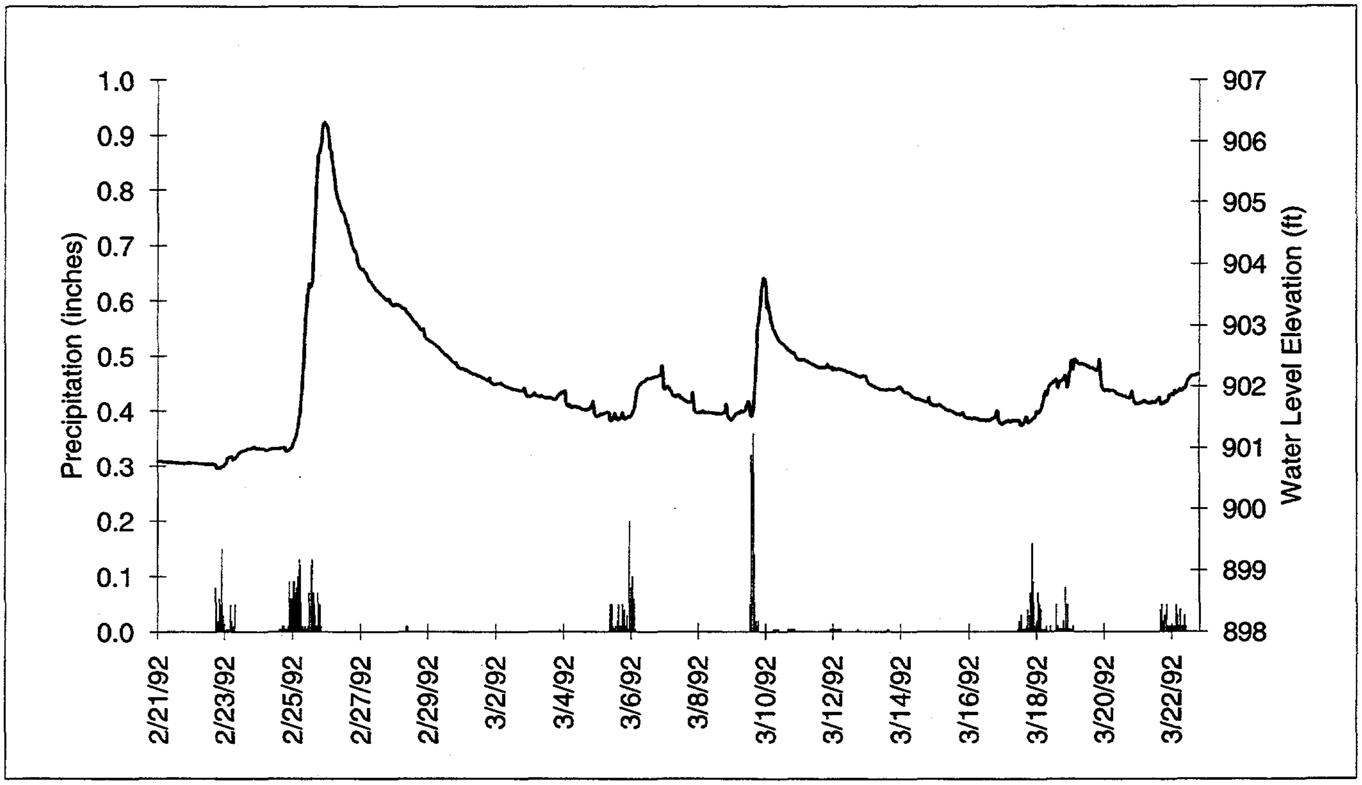

Figure A-41. Well hydrograph from GW-734 (1992 data).

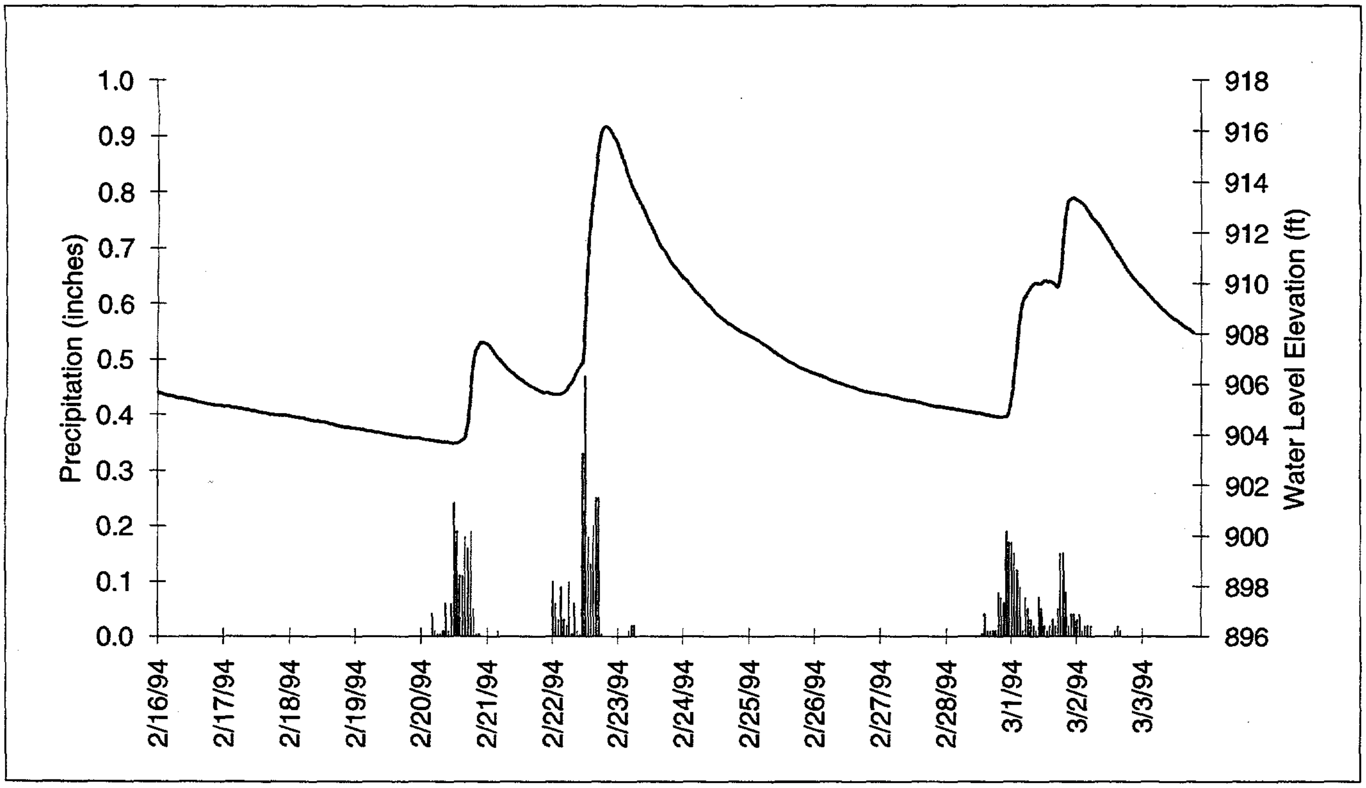

Figure A-42. Well hydrograph from GW-734 (1994 data).

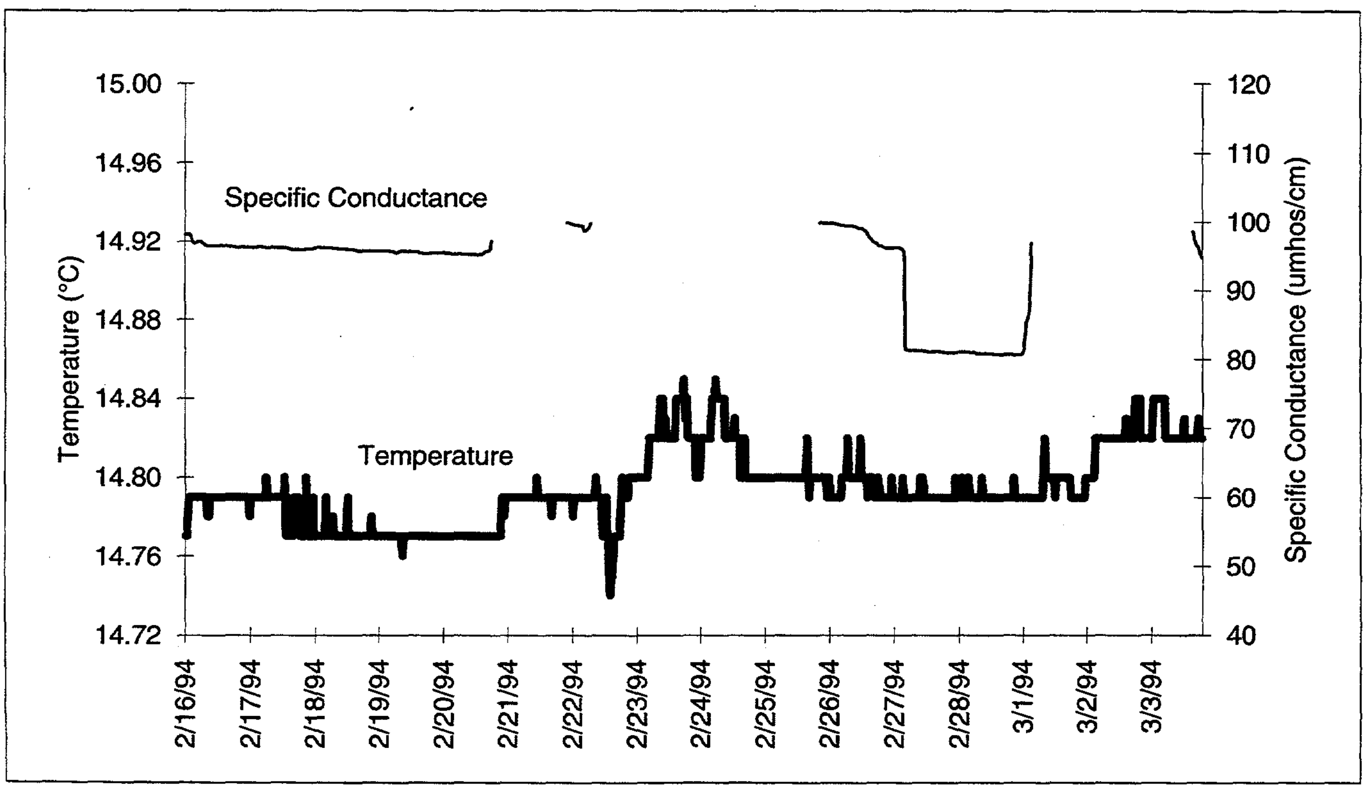

Figure A-43. Specific conductance and temperature from GW-734 (1994 data).

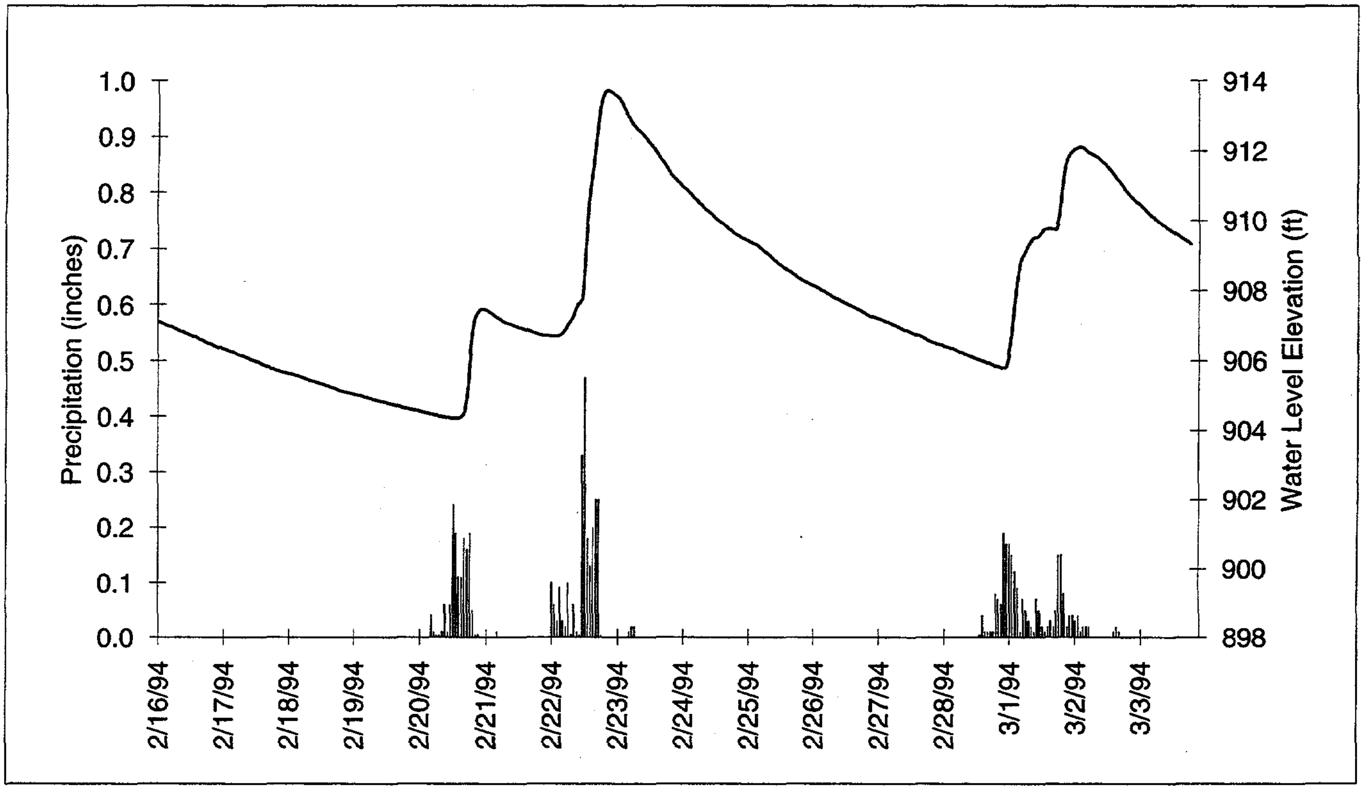

Figure A-44. Well hydrograph from GW-735.

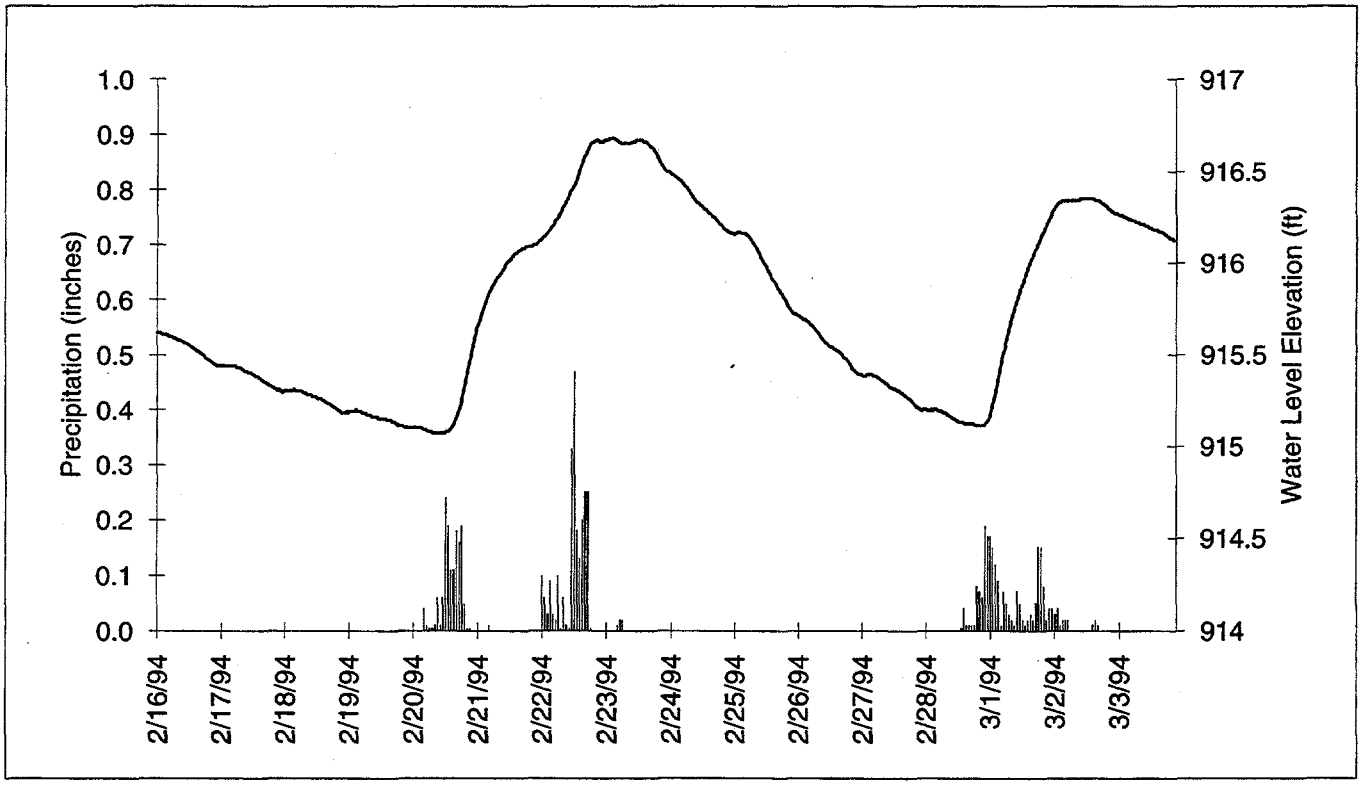

Figure A-45. Well hydrograph from GW-748.

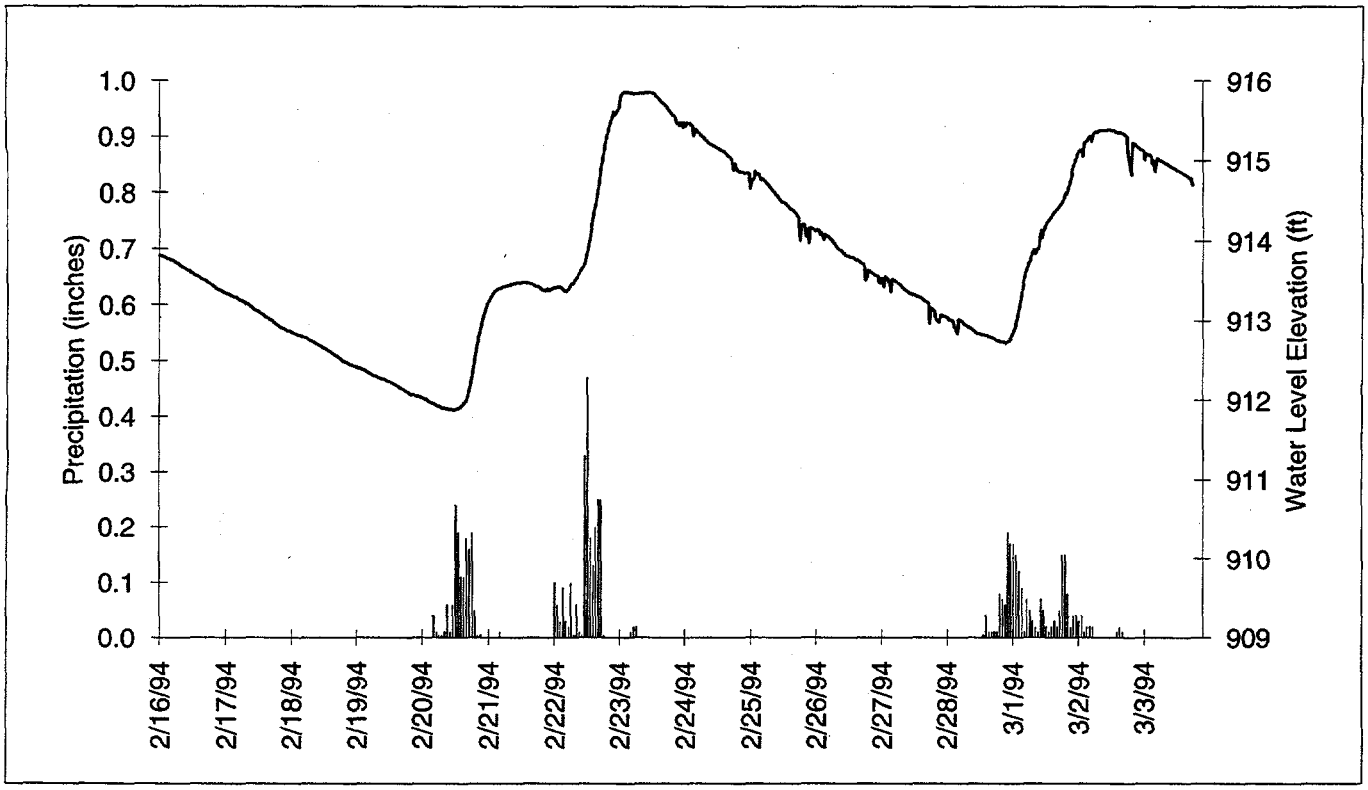

Figure A-46. Well hydrograph from GW-750.

APPENDIX B

Appendix B: Tables B-1 through B-46 of listing well hydrograph responses in Pickets W, A, B, C, and J.

Table B-1. GW-710 ambient monitoring data

	Storm 1	Storm 2	Storm 3	Storm 4	Storm 5	Storm 6
Start Precip.						
Date	12/20/93	12/28/93	1/2/94	1/7/94	1/11/94	1/17/94
Time	12:00	5:00	11:00	9:00	16:00	7:00
Stop Precip.						
Date	12/21/93	12/29/93	1/4/94	1/7/94	1/12/94	1/17/94
Time	4:00	2:00	2:00	18:00	6:00	16:00
Duration Precip. (hrs)	16	21	39	9	14	9
Max Hourly Precip. (in)	0.08	0.18 & 0.11	0.12 & 0.1	0.41	0.15	0.16
Date	12/20/93	12/28/93	1/3/94	1/7/94	1/12/94	1/17/94
Time	14:00 - 17:00	9 & 11:00	11 & 14:00	9:00	2:00	13:00
Total Storm Precip. (in)	0.67	1	0.91	1	1.14	0.81
Precip. Intensity (in/hr)	0.042	0.048	0.023	0.111	0.081	0.090
WL before Precip. (ft)	844.05	843.88	844.43	845.41	845.75	845.52*
Comment	WL drop	MD	WL drop	WL drop	WL drop	WL drop
Start WL rise time						
Date	12/20/93	12/28/93	1/3/94	1/7/94	1/12/94	1/18/94
Time	21:30	16:30	19:00	18:30	3:30	7:30
Delay WL from Start Precip.						
Date	12/20/93	12/28/93	1/3/94	1/7/94	1/12/94	1/18/94
Time (hrs)	9.5	11.5	8.0	9.5	11.5	24.5
Max WL (ft)	844.54	844.89	845.94	848.08	849.72	845.56
Date	12/22/93	12/30/93	1/5/94	1/9/94	1/13/94	1/18/94
Time	15:30	20:00	14:30	10:00	22:30	11:00
Water Level Change	0.49	1.01	1.51	2.67	3.97	0.30
Duration Peak (hrs)	2	1.5	2.0	5.5	9.5	2.5
Delay Peak WL from Peak Precip.						
Time (hrs)	49.5	51.0	48.5	49.0	44.5	22.0
Start Recession						
Date	12/22/93	12/30/93	1/5/94	1/9/94	1/14/94	1/18/94
Time	17:30	21:30	16:30	15:30	8:00	13:30
End Recession						
Date	12/28/93	1/3/94	1/7/94	1/12/94	1/18/94	1/25/94
Time	4:30	6:00	14:00	2:00	2:30	12:00
Duration Recession (hrs)	127	79.5	45.5	58.5	90.5	250.5
Recession Complete?	N	N	N	N	Y (?)	Y (?)
RECESSION - Segment 1						
t duration (hrs)	127	79.5	6	13	48	54
Y (ft) - Max	844.54	844.89	845.94	848.08	849.72	845.56
Y (ft) - Min	843.88	844.41	845.89	847.61	847.61	845.16
Ln Slope (1/hr)	-6.15E-06	-7.17E-06	-8.96E-06	-4.70E-05	-7.81E-05	-8.38E-06
Correlation	0.981	0.986, MD	0.961	0.987	0.992	0.989
RECESSION - Segment 2						
t (hrs)			39.5	45.5	42.5	196.5
Y (ft) - Max			845.89	847.61	847.61	845.16
Y (ft) - Min			845.37	845.74	845.52	844.43
Ln Slope (1/hr)			-1.78E-05	-5.02E-05	-3.49E-05	-8.10E-06
Correlation			0.989	0.987	0.945	0.986

MD = missing data

* water level just before water level began to rise

Table B-2. GW-711 ambient monitoring data

	Storm 1	Storm 2	Storm 3	Storm 4	Storm 5	Storm 6
Start Precip.						
Date	12/20/93	12/28/93	1/2/94	1/7/94	1/11/94	1/17/94
Time	12:00	5:00	11:00	9:00	16:00	7:00
Stop Precip.						
Date	12/21/93	12/29/93	1/4/94	1/7/94	1/12/94	1/17/94
Time	4:00	2:00	2:00	18:00	6:00	16:00
Duration Precip. (hrs)	16	21	39	9	14	9
Max Hourly Precip. (in)	0.08	0.18 & 0.11	0.12 & 0.1	0.41	0.15	0.16
Date	12/20/93	12/28/93	1/3/94	1/7/94	1/12/94	1/17/94
Time	14:00 - 17:00	9:00 & 11:00	11 & 14:00	9:00	2:00	13:00
Total Storm Precip. (in)	0.67	1	0.91	1	1.14	0.81
Precip. Intensity (in/hr)	0.042	0.048	0.023	0.111	0.081	0.090
WL before Precip. (ft)	839.48	839.31	840.11	841.38	841.51	No
Comment	Daily Fluc	Daily Fluc	Daily Fluc	Daily Fluc	WL drop	Response
Start WL rise time						
Date	12/20/93	12/28/93	1/2/94	1/7/94	1/12/94	
Time	13:00	5:00	11:30	9:30	1:30	
Delay WL from Start Precip.						
Date	12/20/93	12/28/93	1/2/94	1/7/94	1/12/94	
Time (hrs)	1.0	0.0	0.5	0.5	9.0	
Max WL (ft)	840.06	840.69	841.91	843.49	845.04	
Date	12/22/93	12/30/93	1/5/94	1/9/94	1/13/94	
Time	16:00	14:30	14:30	14:30	15:30	
Water Level Change	0.58	1.38	1.80	2.11	3.53	
Duration Peak (hrs)	0.5	0.5	0.5	0.5	0.5	
Delay Peak WL from Peak Precip.						
Time (hrs)	50.0	45.5	48.5	53.5	37.5	
Start Recession						
Date	12/22/93	12/30/93	1/5/94	1/9/94	1/13/94	
Time	16:30	14:30	15:00	14:30	16:00	
End Recession						
Date	12/26/93	1/2/94	1/7/94	1/12/94	1/25/94	
Time	0:30	5:00	20:00	1:00	1:30	
Duration Recession (hrs)	80	62.5	53	58.5	272	
Recession Complete?	Y	N	N	N	Y	
RECESSION - Segment 1						
t duration (hrs)	80			58.5	85	
Y (ft) - Max	840.06			843.46	845.04	
Y (ft) - Min	839.48			841.42	841.34	
Ln Slope (1/hr)*	-6.19E-06			-3.80E-05	-5.81E-05	
Correlation	0.8407, I	I, MD	I	0.953	0.979	
RECESSION - Segment 2						
t (hrs)					187	
Y (ft) - Max					841.34	
Y (ft) - Min					840.12	
Ln Slope (1/hr)					-7.29E-06	
Correlation					0.937	

MD = missing data; I irregular recession curve due to daily fluctuations

Daily fluctuation up to 0.34 ft

Rapid initial WL rises occur because WL was already increasing as a result of daily fluctuations

Table B-3. GW-712 ambient monitoring data

	Storm 1	Storm 2	Storm 3	Storm 4	Storm 5	Storm 6
Start Precip.						
Date	12/20/93	12/28/93	1/2/94	1/7/94	1/11/94	1/17/94
Time	12:00	5:00	11:00	9:00	16:00	7:00
Stop Precip.						
Date	12/21/93	12/29/93	1/4/94	1/7/94	1/12/94	1/17/94
Time	4:00	2:00	2:00	18:00	6:00	16:00
Duration Precip. (hrs)	16	21	39	9	14	9
Max Hourly Precip. (in)	0.08	0.18 & 0.11	0.12 & 0.1	0.41	0.15	0.16
Date	12/20/93	12/28/93	1/3/94	1/7/94	1/12/94	1/17/94
Time	14:00 - 17:00	9:00 & 11:00	11 & 14:00	9:00	2:00	13:00
Total Storm Precip. (in)	0.67	1	0.91	1	1.14	0.81
Precip. Intensity (in/hr)	0.042	0.048	0.023	0.111	0.081	0.090
WL before Precip. (ft)	843.49	843.36	843.93	844.72	845.13	844.98
Comment	WL drop	WL drop	WL drop	WL drop	WL drop	WL drop
Start WL rise time						
Date	12/20/93	12/28/93	1/3/94	1/7/94	1/11/94	1/17/94
Time	19:00	12:30	14:00	11:30	22:30	15:30
Delay WL from Start Precip.						
Date	12/20/93	12/28/93	1/3/94	1/7/94	1/11/94	1/17/94
Time (hrs)	7.0	7.5	27.0	2.5	6.5	8.3
Max WL (ft)	844.06	844.42	845.58	847.63	849.12	845.14
Date	12/22/93	12/30/93	1/5/94	1/9/94	1/13/94	1/18/94
Time	12:00	16:30	1:30	2:00	8:30	8:00
Water Level Change	0.57	1.06	1.65	2.91	3.99	0.30
Duration Peak (hrs)	2	2.5	3.0	1.5	1.5	1.5
Delay Peak WL from Peak Precip.						
Time (hrs)	46.0	47.5	35.5	41.0	30.5	19.0
Start Recession						
Date	12/22/93	12/30/93	1/5/94	1/9/94	1/13/94	1/18/94
Time	14:00	19:00	4:30	3:30	8:30	9:30
End Recession						
Date	12/27/93	1/3/94	1/7/94	1/11/93	1/18/94	1/24/94
Time	22:30	12:30	10:00	21:30	14:30	21:00
Duration Recession (hrs)	128.5	80	53.5	66	102	155.5
Recession Complete?	Y (?)	N	N	N	Y (?)	Y (?)
RECESSION - Segment 1						
t duration (hrs)	128.5	80	53.5	66	102	82
Y (ft) - Max	844.06	844.42	845.58	847.63	849.12	845.14
Y (ft) - Min	843.24	843.79	844.72	844.98	844.87	844.29
Ln Slope (1/hr)	-6.76E-06	-8.52E-06	-2.08E-05	-4.98E-05	-5.91E-05	-1.14E-05
Correlation	0.966	0.973, MD	0.985	0.980	0.974	0.995
RECESSION - Segment 2						
t (hrs)						73.5
Y (ft) - Max						844.29
Y (ft) - Min						843.82
Ln Slope (1/hr)						-7.23E-06
Correlation						0.946

MD = missing data

Daily fluctuations with 2 cycles occurring each day with 0.1 ft WL fluctuation

Table B-4. GW-713 ambient monitoring data

	Storm 1	Storm 2	Storm 3	Storm 4	Storm 5	Storm 6
Start Precip.						
Date	12/20/93	12/28/93	1/2/94	1/7/94	1/11/94	1/17/94
Time	12:00	5:00	11:00	9:00	16:00	7:00
Stop Precip.						
Date	12/21/93	12/29/93	1/4/94	1/7/94	1/12/94	1/17/94
Time	4:00	2:00	2:00	18:00	6:00	16:00
Duration Precip. (hrs)	16	21	39	9	14	9
Max Hourly Precip. (in)	0.08	0.18 & 0.11	0.12 & 0.1	0.41	0.15	0.16
Date	12/20/93	12/28/93	1/3/94	1/7/94	1/12/94	1/17/94
Time	14:00 - 17:00	9:00 & 11:00	11 & 14:00	9:00	2:00	13:00
Total Storm Precip. (in)	0.67	1	0.91	1	1.14	0.81
Precip. Intensity (in/hr)	0.042	0.048	0.023	0.111	0.081	0.090
WL before Precip. (ft)	843.77	842.62	844.24	845.02		
Comment	WL drop	WL drop	WL drop	WL drop	MD	MD
Start WL rise time						
Date	12/20/93	12/28/93	1/3/94	1/7/94		
Time	21:00	14:00	14:30	11:00		
Delay WL from Start Precip.						
Date	12/20/93	12/28/93	1/3/94	1/7/94		
Time (hrs)	9.0	9.0	27.5	2.0		
Max WL (ft)	844.36	844.76	845.9	847.93		
Date	12/22/93	12/30/93	1/5/94	1/9/94		
Time	2:30	7:00	2:00	2:30		
Water Level Change	0.59	2.14	1.66	2.91		
Duration Peak (hrs)	12	2.0	3.5	1.5		
Delay Peak WL from Peak Precip.						
Time (hrs)	36.5	38.0	36.0	41.5		
Start Recession						
Date	12/22/93	12/30/93	1/5/94	1/9/94		
Time	14:30	9:00	5:30	4:00		
End Recession						
Date	12/27/93	1/3/94	1/7/94	1/10/94		
Time	23:30	3:30	10:30	1:30		
Duration Recession (hrs)	129	90.5	53	21.5		
Recession Complete?	N	N	N	N, MD		
RECESSION - Segment 1						
t duration (hrs)	129	90.5	53	20		
Y (ft) - Max	844.36	844.89	845.9	847.93		
Y (ft) - Min	843.54	844.09	845.02	846.81		
Ln Slope (1/hr)	-6.89E-06	-8.70E-06	-2.15E-05	-6.18E-05		
Correlation	0.977	0.987	0.988	0.981		

MD = missing data

Water level fluctuates at 2 cycles per day, amplitude of about 0.07 ft

Table B-5. GW-714 ambient monitoring data

	Storm 1	Storm 2	Storm 3	Storm 4	Storm 5	Storm 6
Start Precip.						
Date	12/20/93	12/28/93	1/2/94	1/7/94	1/11/94	1/17/94
Time	12:00	5:00	11:00	9:00	16:00	7:00
Stop Precip.						
Date	12/21/93	12/29/93	1/4/94	1/7/94	1/12/94	1/17/94
Time	4:00	2:00	2:00	18:00	6:00	16:00
Duration Precip. (hrs)	16	21	39	9	14	9
Max Hourly Precip. (in)	0.08	0.18 & 0.11	0.12 & 0.1	0.41	0.15	0.16
Date	12/20/93	12/28/93	1/3/94	1/7/94	1/12/94	1/17/94
Time	14:00 - 17:00	9:00 & 11:00	11 & 14:00	9:00	2:00	13:00
Total Storm Precip. (in)	0.67	1	0.91	1	1.14	0.81
Precip. Intensity (in/hr)	0.042	0.048	0.023	0.111	0.081	0.090
WL before Precip. (ft)	845.17	845.04	845.65	846.78	MD	MD
Comment		WL drop	WL drop	WL drop		
Start WL rise time						
Date	12/20/93	12/28/93	1/3/94	1/7/94	No data	No data
Time	17:00	12:30	19:00	12:00		
Delay WL from Start Precip.						
Date	12/20/93	12/28/93	1/3/94	1/7/94		
Time (hrs)	5.0	7.5	8.0	3.0		
Max WL (ft)	846.31	846.9	848.53	851.72		
Date	12/21/93	12/29/93	1/5/94	1/8/94		
Time	19:00	17:00	1:00	17:00		
Water Level Change	1.14	1.86	2.88	4.94		
Duration Peak (hrs)	2.5	4.0	1.5	0.5		
Delay Peak WL from Peak Precip.						
Time (hrs)	29.0	24.0	35.0	32.0		
Start Recession						
Date	12/21/93	12/29/93	1/5/94	1/8/94		
Time	21:30	21:00	2:30	17:00		
End Recession						
Date	12/28/93	1/3/94	1/7/94	1/8/94		
Time	11:30	6:00	10:30	19:00		
Duration Recession (hrs)	158	105	56	2		
Recession Complete?	Y (?)	N, MD	N	N,MD		
RECESSION - Segment 1						
t duration (hrs)	49.5	105	46	2		
Y (ft) - Max	846.31	846.9	848.53	851.72		
Y (ft) - Min	845.77	845.65	846.76	850.62		
Ln Slope (1/hr)	-1.30E-05	-1.49E-05	-4.06E-05	-6.65E-04		
Correlation	0.976	0.993, MD	0.978	0.939		
RECESSION - Segment 2						
t (hrs)	108.5					
Y (ft) - Max	845.77					
Y (ft) - Min	845.02					
Ln Slope (1/hr)	-8.76E-06					
Correlation	0.989					

MD = missing data

Table B-6. GW-715 ambient monitoring data

	Storm 1	Storm 2	Storm 3	Storm 4	Storm 5	Storm 6
Start Precip.						
Date	12/20/93	12/28/93	1/2/94	1/7/94	1/11/94	1/17/94
Time	12:00	5:00	11:00	9:00	16:00	7:00
Stop Precip.						
Date	12/21/93	12/29/93	1/4/94	1/7/94	1/12/94	1/17/94
Time	4:00	2:00	2:00	18:00	6:00	16:00
Duration Precip. (hrs)	16	21	39	9	14	9
Max Hourly Precip. (in)	0.08	0.18 & 0.11	0.12 & 0.1	0.41	0.15	0.16
Date	12/20/93	12/28/93	1/3/94	1/7/94	1/12/94	1/17/94
Time	14:00 - 17:00	9:00 & 11:00	11 & 14:00	9:00	2:00	13:00
Total Storm Precip. (in)	0.67	1	0.91	1	1.14	0.81
Precip. Intensity (in/hr)	0.042	0.048	0.023	0.111	0.081	0.090
WL before Precip. (ft)	845.94	845.86	846.06	847.13	MD	MD
Comment		WL drop	WL drop	WL drop		
Start WL rise time						
Date	12/20/93	12/28/93	1/3/94	1/7/94	No data	No data
Time	16:00	10:30	10:30	10:00		
Delay WL from Start Precip.						
Time (hrs)	4.0	5.5	23.5	1.0		
Max WL (ft) - Peak 1	847.23	847.17	849.65	852.11		
Date	12/20/93	12/28/93	1/3/94	1/7/94		
Time	19:00	14:00	18:00	19:30		
Water Level Change	1.29	1.31	3.59	4.98		
Duration Peak (hrs)	0	0.0	0.0	0		
Max WL (ft) - Peak 2	848.52	849.5	849.8	853.73		
Date	12/21/93	12/29/93	1/4/94	1/8/94		
Time	2:30	0:30	4:00	18:00		
Water Level Change	2.58	3.59	3.74	6.6		
Duration Peak (hrs)	0	0.0	0.0	1.5		
Delay Peak WL from Peak Precip.						
Time (hrs)	9.5	13.5	14.0	33.0		
Start Recession						
Date	12/21/93	12/29/93	1/5/94	1/8/94		
Time	2:30	0:30	1:00	19:30		
End Recession						
Date	12/28/93	12/31/93	1/7/94	1/10/94		
Time	8:30	23:30	9:30	7:30		
Duration Recession (hrs)	174	71	62	34		
Recession Complete?	Y	Y (?)	N	N		
RECESSION - Segment 1			Peak 1	?		
t duration (hrs)	6	3.5	5.5	34		
Y (ft) - Max	848.52	849.45	849.65	853.73		
Y (ft) - Min	846.93	847.99	848.26	850.05		
Ln Slope (1/hr)	-3.43E-04	-5.34E-04	-3.13E-04	-1.37E-04		
Correlation	0.85	0.975	0.886	0.991		
RECESSION - Segment 2			Peak 3			
t (hrs)	28.5	7	21			
Y (ft) - Max	846.93	847.99	849.43			
Y (ft) - Min	846.59	847.67	848.35			
Ln Slope (1/hr)	-1.50E-05	-4.96E-05	-6.25E-05			
Correlation	9.78E-01	0.953	0.989			
RECESSION - Segment 3			Peak 3			
t (hrs)	139.5	60.5	35.5			
Y (ft) - Max	846.59	847.67	848.35			
Y (ft) - Min	845.86	846.43	847.12			
Ln Slope (1/hr)	-4.77E-06	-2.56E-05	-3.93E-05			
Correlation	0.818	0.996	0.992			

Table B-7. GW-715 water level, specific conductance and temperature data.

	Storm 1			Storm 2		
	Temp. (C)	SC (umhos/cm)	WL (ft)	Temp. (C)	SC (umhos/cm)	WL (ft)
Start Precip.						
Date	12/20/93	12/20/93	12/20/93	12/28/93	12/28/93	12/28/93
Time	12:00	12:00	12:00	5:00	5:00	5:00
Stop Precip.						
Date	12/21/93	12/21/93	12/21/93	12/29/93	12/29/93	12/29/93
Time	4:00	4:00	4:00	2:00	2:00	2:00
Duration Precip. (hrs)	16	16	16	21	21	21
Max Hourly Precip. (in)	0.08	0.08	0.08	0.18 & 0.11	0.18 & 0.11	0.18 & 0.11
Date	12/20/93	12/20/93	12/20/93	12/28/93	12/28/93	12/28/93
Time	14-17:00	14-17:00	14-17:00	9 & 11:00	9 & 11:00	9 & 11:00
Total Storm Precip. (in)	0.67	0.67	0.67	1	1	1
Precip. Intensity (in/hr)	0.042	0.042	0.042	0.048	0.048	0.048
Value before Precip.	13.45	622	845.94	13.5	612	845.86
Comment	one peak	one peak	one peak	Probe drift	Probe drift	WL drop
Start rise/fall						
Date	12/20/93	12/20/93	12/20/93	12/28/93	12/28/93	12/28/93
Time	17:30	19:00	16:00	11:30	20:00	10:30
Delay from Start Precip.	5.5	7	4	6.5	15?	5.5
Min/Max - Peak 1	13.53	617	847.23	13.58	605	847.17
Date	12/20/93	12/20/93	12/20/93	12/28/93	12/28/93	12/28/93
Time	19:30	20:00	19:00	14:00	17:30	14:00
Change in Value	0.08	-5.00	1.29	0.08	-7.00	1.31
Delay to Peak (hrs)*	5.5	6.0	5.0	5.0	8.5	5.0
Duration Peak (hrs)	0	1.5	0	0	0.0	0.0
Min/Max - Peak 2	13.57	610	848.52	13.62	577.0	849.5
Date	12/21/93	12/21/93	12/21/93	12/28/93	12/29/93	12/29/93
Time	3:00	4:30	2:30	22:00	4:00	0:30
Change in Value	0.12	-12	2.58	0.12	-35	3.59
Duration Peak (hrs)	1	2.5	0	4	0.0	0.0
Delay Peak 1 to 2 (hrs)	7.5	8.5	7.5	8	10.5	10.5
Delay from precip peak 2	13	14.5	12.5	11	17.0	13.5
Start Recession						
Date	12/21/93	12/21/93	12/21/93	12/29/93	12/29/93	12/29/93
Time	3:00	4:30	2:30	2:00	4:00	0:30
End Recession						
Date	12/21/93	12/22/93	12/28/93	12/29/93	12/30/93	12/31/93
Time	9:00	12:00	8:30	12:00	13:00	23:30
Duration Recession (hrs)	6	34.5?	174	10	33	71
Recession Complete?	Y	Probe drift	Y	Y	Y (?)	Y (?)

* delay time between first precipitation peak, and first peak in parameter value

Table B-7, continued

	Storm 3			Storm 4		
	Temp. (C)	SC (umhos/cm)	WL (ft)	Temp. (C)	SC (umhos/cm)	WL (ft)
Start Precip.						
Date	1/2/94	1/2/94	1/2/94		1/7/94	
Time	11:00	11:00	11:00		9:00	
Stop Precip.						
Date	1/4/94	1/4/94	1/4/94	1/7/94	1/7/94	1/7/94
Time	2:00	2:00	2:00	18:00	18:00	18:00
Duration Precip. (hrs)	39	39	39	9	9	9
Max Hourly Precip. (in)	0.12&0.11	0.12&0.11	0.12&0.11	0.41	0.41	0.41
Date	1/3/94	1/3/94	1/3/94	1/7/94	1/7/94	1/7/94
Time	11&14:00	11&14:00	11&14:00	9:00	9:00	9:00
Total Storm Precip. (in)	0.91	0.91	0.91	1	1	1
Precip. Intensity (in/hr)	0.023	0.023	0.023	0.111	0.111	0.111
Value before Precip.	13.48	612	846.06	13.5	607	847.13
Comment			WL drop			WL drop
Start rise/fall						
Date	1/3/94	1/3/94	1/3/94	1/7/94	1/7/94	1/7/94
Time	12:00	13:00	10:30	10:00	12:00	10:00
Delay from Start Precip.	25	25	23.5	1	3	1
Min/Max - Peak 1	13.63	604	849.65	13.66	589	852.11
Date	1/3/94	1/3/94	1/3/94	1/7/94	1/8/94	1/7/94
Time	17:30	17:00	18:00	19:00	6:00	19:30
Change in Value	0.15	-8.00	3.59	0.16	-18.00	4.98
Delay to Peak (hrs)*	6.5	6.0	7.0	10.0	21.0	
Duration Peak (hrs)	0.0	5.0	0.0	1.5	3	0
Min/Max - Peak 2	13.6	none	849.8	13.6	568	853.73
Date	1/4/94		1/4/94	1/8/94	1/9/94	1/8/94
Time	3:30		4:00	4:00	6:30	18:00
Change in Value	0.14		3.74	0.12	-39	6.6
Duration Peak (hrs)	2.0		0.0	3.0	8	1.5
Delay Peak 1 to 2 (hrs)	10.0		10.0	9.0	24.5	22.5
Delay from precip peak 2	13.5		14.0	no peak 2	no peak 2	no peak 2
Start Recession						
Date	1/4/94	none	1/5/94	1/8/94	1/9/94	1/8/94
Time	5:30		1:00	7:00	14:30	19:30
End Recession						
Date	1/4/94		1/7/94	?	?	1/10/94
Time	14:00		9:30			7:30
Duration Recession (hrs)	9.5		62			36
Recession Complete?	Y (?)		N	N	N	N

* delay time between first * delay time between first precipitation peak, and first peak in parameter val

Table B-8. GW-054 ambient monitoring data.

	Storm 1	Storm 2a	Storm 2b	Storm 3
Start Precip.				
Date	4/17/95	4/21/95	4/23/95	5/1/95
Time	11:00	1:00	7:00	13:00
Stop Precip.				
Date	4/17/95	4/21/95	4/23/95	5/1/95
Time	15:00	4:00	21:00	20:00
Duration Precip. (hrs)	4	3	14	7
Max Hourly Precip. (in)	0.3	0.42	0.11	0.72
Date	4/17/95	4/21/95	4/23/95	5/1/95
Time	14:00	3:00	8:00	19:00
Total Storm Precip. (in)	0.525	0.99	0.37	1.37
Precip. Intensity (in/hr)	0.131	0.330	0.026	0.196
WL before Precip. (ft)	882.649	882.757	883.232	882.82
Comment				
Start WL rise time				
Date	4/17/95	4/21/95	4/23/95	5/1/95
Time	13:30	2:30	11:00	14:30
Delay WL from Start Precip.				
Time (hrs)	2.5	1.5	4.0	1.5
Max WL (ft)	883.039	884.842	883.449	885.37
Date	4/17/95	4/21/95	4/24/95	5/1/95
Time	21:00	8:00	3:00	23:30
Water Level Change	0.39	2.09	0.22	2.55
Duration Peak (hrs)	0	0.0	1.0	0.0
Delay Peak WL from Peak Precip.				
Time (hrs)	7	5.0	19.0	4.5
Start Recession				
Date	4/17/95	4/21/95	4/24/95	5/1/95
Time	21:00	8:00	4:00	23:30
End Recession				
Date	4/20/95	4/23/95	5/1/95	5/9/95
Time	6:30	10:30	3:00	10:00
Duration Recession (hrs)	57.5	50.5	167	178.5
Recession Complete?	Y?	Y?	Y?	Y
RECESSION - Segment 1				
t duration (hrs)	15	14	?	16.5
Y (ft) - Max	883.04	884.84	883.45	885.37
Y (ft) - Min	882.9	883.992	883.15	884.37
Ln Slope (1/hr)	-1.03E-05	-7.12E-05	-1.21E-05	-7.26E-05
Correlation	0.993	0.994	0.993	0.994
RECESSION - Segment 2				
t (hrs)	25	15	?	48
Y (ft) - Max	882.90	883.99	883.15	884.37
Y (ft) - Min	882.79	883.539	882.93	883.4
Ln Slope (1/hr)	-5.24E-06	-3.44E-05	-3.56E-06	-2.18E-05
Correlation	0.967	0.983	0.977	0.98
RECESSION - Segment 3				
t (hrs)	17.5	21.5	58	114
Y (ft) - Max	882.79	883.539	882.93	883.4
Y (ft) - Min	882.12	883.232	892.12	882.84
Ln Slope (1/hr)	-2.39E-06	-1.59E-05	-1.85E-06	-5.47E-06
Correlation	0.796	0.969	0.911	0.957

Table B-8. GW-054 ambient monitoring data, continued

	Storm 4a	Storm 4b	Storm 5	Storm 6
Start Precip.				
Date	5/9/95	5/10/95	5/14/95	5/18/95
Time	15:00	22:00	7:00	20:00
Stop Precip.				
Date	5/9/95	5/10/95	5/14/95	5/19/95
Time	22:00	23:00	11:00	5:00
Duration Precip. (hrs)	7	1	4	9
Max Hourly Precip. (in)	0.76	0.28	0.28	0.36
Date	5/9/95	5/10/95	5/14/95	5/18/95
Time	20:00	22:00	7:00	21:00
Total Storm Precip. (in)	2.27	0.32	0.69	1.06
Precip. Intensity (in/hr)	0.324	0.320	0.173	0.118
WL before Precip. (ft)	882.84	884.89	883.79	883.42
Comment				
Start WL rise time				
Date	5/9/95	5/10/94	5/14/95	5/18/95
Time	15:00	23:00	8:30	21:30
Delay WL from Start Precip.				
Time (hrs)	0.0	0	1.5	1.5
Max WL (ft)	886.45	886.14	885.44	885.64
Date	5/10/95	5/11/95	5/14/95	5/19/95
Time	0:00	3:00	15:00	5:00
Water Level Change	3.61	1.25	1.65	2.22
Duration Peak (hrs)	0	0	0	0
Delay Peak WL from Peak Precip.				
Time (hrs)	4	5	8	9
Start Recession				
Date	5/10/95	5/11/95	5/14/95	5/19/95
Time	0:00	3:00	15:00	5:00
End Recession				
Date	5/10/95	5/14/95	5/18/95	5/28/95
Time	22:30	7:00	20:30	3:30
Duration Recession (hrs)	22.5	76.5	101.5	214.5
Recession Complete?	N	N	Y	Y
RECESSION - Segment 1				
t duration (hrs)	6	18	18	23
Y (ft) - Max	886.45	886.14	885.44	885.64
Y (ft) - Min	885.92	885.04	884.74	884.55
Ln Slope (1/hr)	-1.09E-04	-6.93E-05	-4.63E-05	-5.76E-05
Correlation	0.986	0.999	0.984	0.984
RECESSION - Segment 2				
t (hrs)	16.5	26.5	32	65
Y (ft) - Max	885.92	885.04	884.74	884.55
Y (ft) - Min	884.89	884.29	884.01	883.36
Ln Slope (1/hr)	-7.14E-05	-3.03E-05	-2.40E-05	-2.01E-05
Correlation	0.997	0.997	0.99	0.991
RECESSION - Segment 3				
t (hrs)		32	51.5	126.5
Y (ft) - Max		884.29	884.01	883.36
Y (ft) - Min		883.79	883.43	882.71
Ln Slope (1/hr)		-1.78E-05	-1.39E-05	-5.69E-06
Correlation		0.992	0.998	0.952

Table B-9. GW-056 ambient monitoring data.

	Storm 1	Storm 2a	Storm 2b	Storm 3
Start Precip.				
Date	4/17/95	4/21/95	4/23/95	5/1/95
Time	11:00	1:00	7:00	13:00
Stop Precip.				
Date	4/17/95	4/21/95	4/23/95	5/1/95
Time	15:00	4:00	21:00	20:00
Duration Precip. (hrs)	4	3	14	7
Max Hourly Precip. (in)	0.3	0.42	0.11	0.72
Date	4/17/95	4/21/95	4/23/95	5/1/95
Time	14:00	3:00	8:00	19:00
Total Storm Precip. (in)	0.525	0.99	0.37	1.37
Precip. Intensity (in/hr)	0.131	0.330	0.026	0.196
WL before Precip. (ft)	883.1	883.2	883.65	882.82
Comment				
Start WL rise time				
Date	4/17/95	4/21/95	4/23/95	5/1/95
Time	12:30	1:30	9:00	14:30
Delay WL from Start Precip.				
Time (hrs)	1.5	0.5	2.0	1.5
Max WL (ft)	883.41	884.43	883.84	884.64
Date	4/17/95	4/21/95	4/24/95	5/1/95
Time	19:00	6:30	2:00	22:00
Water Level Change	0.31	1.23	0.19	1.82
Duration Peak (hrs)	1	0.0	1.5	0.5
Delay Peak WL from Peak Precip.				
Time (hrs)	5	3.5	18.0	3.0
Start Recession				
Date	4/17/95	4/21/95	4/24/95	5/1/95
Time	20:00	6:30	3:30	22:30
End Recession				
Date	4/20/95	4/23/95	5/1/95	5/9/95
Time	11:00	8:30	11:00	12:00
Duration Recession (hrs)	74	50	175.5	180
Recession Complete?	N	N	Y	N
RECESSION - Segment 1				
t duration (hrs)	30	12	42	26
Y (ft) - Max	883.41	884.43	883.84	884.64
Y (ft) - Min	883.26	844.09	883.54	884.04
Ln Slope (1/hr)	-4.90E-06	-3.19E-05	-7.73E-06	-2.61E-05
Correlation	0.965	0.998	0.984	0.997
RECESSION - Segment 2				
t (hrs)	44	15	61	40
Y (ft) - Max	883.26	844.09	883.54	884.04
Y (ft) - Min	883.2	883.85	883.32	883.66
Ln Slope (1/hr)	-3.14E-06	-1.84E-05	-4.21E-06	-1.08E-05
Correlation	0.966	0.994	0.988	0.987
RECESSION - Segment 3				
t (hrs)		23	72.5	114
Y (ft) - Max		883.85	883.32	883.66
Y (ft) - Min		883.65	883.2	882.84
Ln Slope (1/hr)		-9.92E-06	-1.86E-06	-4.23E-06
Correlation		0.989	0.946	0.972

Table B-9. GW-056 ambient monitoring data, continued

	Storm 4a	Storm 4b	Storm 5	Storm 6
Start Precip.				
Date	5/9/95	5/10/95	5/14/95	5/18/95
Time	15:00	22:00	7:00	20:00
Stop Precip.				
Date	5/9/95	5/10/95	5/14/95	5/19/95
Time	22:00	23:00	11:00	5:00
Duration Precip. (hrs)	7	1	4	9
Max Hourly Precip. (in)	0.76	0.28	0.28	0.36
Date	5/9/95	5/10/95	5/14/95	5/18/95
Time	20:00	22:00	7:00	21:00
Total Storm Precip. (in)	2.27	0.32	0.69	1.06
Precip. Intensity (in/hr)	0.324	0.320	0.173	0.118
WL before Precip. (ft)	883.3	884.69	883.86	883.62
Comment				
Start WL rise time				
Date	5/9/95	5/10/94	5/14/95	5/18/95
Time	16:30	22:00	7:30	21:00
Delay WL from Start Precip.				
Time (hrs)	1.5	0	0.5	1
Max WL (ft)	885.52	885.29	884.79	884.75
Date	5/9/95	5/11/95	5/14/95	5/19/95
Time	23:00	1:00	13:30	3:30
Water Level Change	2.22	0.60	0.93	1.13
Duration Peak (hrs)	0	0	0.5	1
Delay Peak WL from Peak Precip.				
Time (hrs)	3	3	6.5	6.5
Start Recession				
Date	5/9/95	5/11/95	5/14/95	5/19/95
Time	23:00	1:00	14:00	4:30
End Recession				
Date	5/10/95	5/14/95	5/18/95	5/24/95
Time	22:00	7:00	19:30	14:30
Duration Recession (hrs)	23	78	101.5	130
Recession Complete?	N	N	Y	Y
RECESSION - Segment 1				
t duration (hrs)	3.5	22.5	27.5	27
Y (ft) - Max	885.52	885.29	884.79	884.75
Y (ft) - Min	885.29	884.61	884.19	884.15
Ln Slope (1/hr)	-7.80E-05	-3.36E-05	-2.48E-05	-2.82E-05
Correlation	0.988	0.997	0.998	0.987
RECESSION - Segment 2				
t (hrs)	19.5	20	23	40
Y (ft) - Max	885.29	884.61	884.19	884.15
Y (ft) - Min	884.69	884.2	883.91	883.71
Ln Slope (1/hr)	-3.46E-05	-2.34E-05	-1.31E-05	-1.21E-05
Correlation	0.999	0.998	0.989	0.982
RECESSION - Segment 3				
t (hrs)		35.5	51	63
Y (ft) - Max		884.2	883.91	883.71
Y (ft) - Min		883.86	883.62	883.35
Ln Slope (1/hr)		-1.06E-05	-7.76E-06	-6.31E-06
Correlation		0.992	0.989	0.979

Table B-10. GW-057 ambient monitoring data.

	Storm 1	Storm 2a	Storm 2b	Storm 3
Start Precip.				
Date	4/17/95	4/21/95	4/23/95	5/1/95
Time	11:00	1:00	7:00	13:00
Stop Precip.				
Date	4/17/95	4/21/95	4/23/95	5/1/95
Time	15:00	4:00	21:00	20:00
Duration Precip. (hrs)	4	3	14	7
Max Hourly Precip. (in)	0.3	0.42	0.11	0.72
Date	4/17/95	4/21/95	4/23/95	5/1/95
Time	14:00	3:00	8:00	19:00
Total Storm Precip. (in)	0.525	0.99	0.37	1.37
Precip. Intensity (in/hr)	0.131	0.330	0.026	0.196
WL before Precip. (ft)	883.35	883.59	884.27	883.49
Comment				
Start WL rise time				
Date	4/17/95	4/21/95	4/23/95	5/1/95
Time	13:00	2:00	9:00	14:30
Delay WL from Start Precip.				
Time (hrs)	2	1.0	2.0	1.5
Max WL (ft)	883.9	885.38	884.78	885.57
Date	4/17/95	4/21/95	4/24/95	5/2/95
Time	19:30	7:30	3:30	2:00
Water Level Change	0.55	1.79	0.51	2.08
Duration Peak (hrs)	1	0.0	0.0	0.5
Delay Peak WL from Peak Precip.				
Time (hrs)	5.5	4.5	19.5	7.0
Start Recession				
Date	4/17/95	4/21/95	4/24/95	5/2/95
Time	20:30	7:30	3:30	2:30
End Recession				
Date	4/20/95	4/23/95	5/1/95	5/9/95
Time	8:00	8:30	12:00	15:30
Duration Recession (hrs)	59.5	49	176.5	108
Recession Complete?	N	N	Y?	Y
RECESSION - Segment 1				
t duration (hrs)	30	12	39	20
Y (ft) - Max	883.90	885.38	884.78	885.57
Y (ft) - Min	883.66	884.98	884.16	884.87
Ln Slope (1/hr)	-9.31E-06	-4.13E-05	-1.81E-05	-4.31E-05
Correlation	0.997	0.948	0.99	0.994
RECESSION - Segment 2				
t (hrs)	20	14	58	28
Y (ft) - Max	883.66	884.98	884.16	884.87
Y (ft) - Min	883.55	884.62	883.74	884.34
Ln Slope (1/hr)	-6.02E-06	-2.83E-05	-8.15E-06	-2.16E-05
Correlation	0.989	0.994	0.996	0.991
RECESSION - Segment 3				
t (hrs)	9.5	23	79.5	60
Y (ft) - Max	883.55	884.62	883.74	884.34
Y (ft) - Min	883.54	884.27	883.49	883.81
Ln Slope (1/hr)	-1.61E-06	-1.70E-05	-3.56E-06	-9.98E-06
Correlation	0.953	0.99	0.967	0.993

Table B-10. GW-057 ambient monitoring data, continued

	Storm 4a	Storm 4b	Storm 5	Storm 6
Start Precip.				
Date	5/9/95	5/10/95	5/14/95	5/18/95
Time	15:00	22:00	7:00	20:00
Stop Precip.				
Date	5/9/95	5/10/95	5/14/95	5/19/95
Time	22:00	23:00	11:00	5:00
Duration Precip. (hrs)	7	1	4	9
Max Hourly Precip. (in)	0.76	0.28	0.28	0.36
Date	5/9/95	5/10/95	5/14/95	5/18/95
Time	20:00	22:00	7:00	21:00
Total Storm Precip. (in)	2.27	0.32	0.69	1.06
Precip. Intensity (in/hr)	0.324	0.320	0.173	0.118
WL before Precip. (ft)	883.49	885.43	883.34	884.07
Comment				
Start WL rise time				
Date	5/9/95	5/10/94	5/14/95	5/18/95
Time	16:30	22:00	7:00	21:00
Delay WL from Start Precip.				
Time (hrs)	1.5	0	0	1
Max WL (ft)	886.12	886.14	885.97	886.08
Date	5/9/95	5/11/95	5/14/95	5/19/95
Time	23:00	0:00	14:00	5:00
Water Level Change	2.63	0.71	2.63	2.01
Duration Peak (hrs)	0.5	0.5	3	0
Delay Peak WL from Peak Precip.				
Time (hrs)	3	2	7	8
Start Recession				
Date	5/9/95	5/11/95	5/14/95	5/19/95
Time	23:30	0:30	17:00	5:00
End Recession				
Date	5/10/95	5/14/95	5/18/95	5/31/95
Time	21:30	6:30	20:30	17:00
Duration Recession (hrs)	22.5	108.5	99.5	159.5
Recession Complete?	N	N	Y?	Y
RECESSION - Segment 1				
t duration (hrs)	22.5	49.5	23.5	32.5
Y (ft) - Max	886.12	886.14	885.97	886.08
Y (ft) - Min	885.43	885.5	885	884.75
Ln Slope (1/hr)	-3.55E-05	-3.67E-05	-4.96E-05	-5.03E-05
Correlation	0.968	0.968	0.989	0.979
RECESSION - Segment 2				
t (hrs)		22	22	54.5
Y (ft) - Max		885.50	885.00	884.75
Y (ft) - Min		884.82	884.52	883.98
Ln Slope (1/hr)		-3.52E-05	-2.21E-05	-1.53E-05
Correlation		0.999	0.993	0.991
RECESSION - Segment 3				
t (hrs)		37	54	72.5
Y (ft) - Max		884.82	884.52	883.98
Y (ft) - Min		884.34	884.07	883.51
Ln Slope (1/hr)		-1.37E-05	-1.10E-05	-7.61E-06
Correlation		0.995	0.964	0.983

Table B-11. GW-683 ambient monitoring data.

	Storm 3	Storm 4a	Storm 4b	Storm 5	Storm 6
Start Precip.					
Date	5/1/95	5/9/95	5/10/95	5/14/95	5/18/95
Time	13:00	15:00	22:00	7:00	20:00
Stop Precip.					
Date	5/1/95	5/9/95	5/10/95	5/14/95	5/19/95
Time	20:00	22:00	23:00	11:00	5:00
Duration Precip. (hrs)	7	7	1	4	9
Max Hourly Precip. (in)	0.72	0.76	0.28	0.28	0.36
Date	5/1/95	5/9/95	5/10/95	5/14/95	5/18/95
Time	19:00	20:00	22:00	7:00	21:00
Total Storm Precip. (in)	1.37	2.27	0.32	0.69	1.06
Precip. Intensity (in/hr)	0.196	0.324	0.320	0.173	0.118
WL before Precip. (ft)	883.67	883.81	885.88	884.34	884.06
Comment					
Start WL rise time					
Date	5/1/95	5/9/95	5/10/94	5/14/95	5/18/95
Time	15:30	16:30	22:30	7:30	21:00
Delay WL from Start Precip.					
Time (hrs)	2.5	1.5	0.5	0.5	1
Max WL (ft)	884.03	886.36	886.02	884.41	886.31
Date	5/2/95	5/10/95	5/11/95	5/14/95	5/19/95
Time	4:30	9:00	0:30	12:00	14:30
Water Level Change	0.36	2.55	0.14	0.07	2.25
Duration Peak (hrs)	5.5	0	0	4	4.5
Delay Peak WL from Peak Precip.					
Time (hrs)	9.5	13	2.5	5	18.5
Start Recession					
Date	5/3/95	5/10/95	5/11/95	5/14/95	5/19/95
Time	13:00	9:00	0:30	16:00	19:00
End Recession					
Date	5/7/95	5/10/95	5/14/95	5/18/95	5/27/95
Time	17:30	22:00	6:30	18:00	17:00
Duration Recession (hrs)	100.5	13	100	98	194.5
Recession Complete?	N	N	N	N	Y?
RECESSION - Segment 1					
t duration (hrs)	24.5	13	78	98	88.5
Y (ft) - Max	884.03	886.36	886.02	884.41	886.31
Y (ft) - Min	883.94	885.88	884.91	884.06	883.95
Ln Slope (1/hr)	-3.43E-06	-4.09E-05	-1.77E-05	-4.32E-06	-5.22E-06
Correlation	0.999	0.966	0.988	0.973	0.982
RECESSION - Segment 2					
t (hrs)	52.50		22		106
Y (ft) - Max	883.94		884.91		883.95
Y (ft) - Min	883.84		884.82		883.76
Ln Slope (1/hr)	-2.28E-06		-3.52E-05		-1.83E-06
Correlation	0.994		0.999		0.99
RECESSION - Segment 3					
t (hrs)	23.5				
Y (ft) - Max	883.84				
Y (ft) - Min	883.82				
Ln Slope (1/hr)	-8.10E-07				
Correlation	0.827				

Table B-12. GW-684 ambient monitoring data.

	Storm 2a	Storm 3	Storm 4a	Storm 4b	Storm 5	Storm 6
Start Precip.						
Date	4/21/95	5/1/95	5/9/95	5/10/95	5/14/95	5/18/95
Time	1:00	13:00	15:00	22:00	7:00	20:00
Stop Precip.						
Date	4/21/95	5/1/95	5/9/95	5/10/95	5/14/95	5/19/95
Time	4:00	20:00	22:00	23:00	11:00	5:00
Duration Precip. (hrs)	3	7	7	1	4	9
Max Hourly Precip. (in)	0.42	0.72	0.76	0.28	0.28	0.36
Date	4/21/95	5/1/95	5/9/95	5/10/95	5/14/95	5/18/95
Time	3:00	19:00	20:00	22:00	7:00	21:00
Total Storm Precip. (in)	0.99	1.37	2.27	0.32	0.69	1.06
Precip. Intensity (in/hr)	0.330	0.196	0.324	0.320	0.173	0.118
WL before Precip. (ft)	883.36	883.39	Missing	884.97	883.82	883.6
Comment			Data			
Start WL rise time						
Date	4/21/95	5/1/95		5/10/94	5/14/95	5/18/95
Time	1:30	14:30		22:00	7:00	21:00
Delay WL from Start Precip.						
Time (hrs)	0.5	7.5		0	0	1
Max WL (ft)	883.55	883.70	885.16	885.03	883.88	883.79
Date	4/21/95	5/2/95	5/10/95	5/11/95	5/14/95	5/19/95
Time	5:30	5:00	14:00	1:00	12:30	11:00
Water Level Change	0.19	0.31	?	0.06	0.06	0.19
Duration Peak (hrs)	0.5	2.5	?	0	4.5	11
Delay Peak WL from Peak Precip.						
Time (hrs)	2.5	12.5	?	3	0	14
Start Recession						
Date	4/21/95	5/2/95	5/10/95	5/11/95	5/14/95	5/19/95
Time	6:00	7:30	15:00	1:00	15:00	22:00
End Recession						
Date	5/1/95	5/3/95	5/10/95	5/14/95	5/18/95	5/30/95
Time	11:00	12:00	21:30	6:30	18:30	20:00
Duration Recession (hrs)	245	28.5	6.5	77.5	99.5	262
Recession Complete?	N	N	N	Y	Y	Y
RECESSION - Segment 1						
t duration (hrs)	100	28.5	6.5	45	99.5	79
Y (ft) - Max	883.55	883.70	885.16	885.03	883.88	883.79
Y (ft) - Min	883.43	883.61	884.97	884.19	883.6	883.51
Ln Slope (1/hr)	-1.11E-06	-3.25E-06	-3.35E-05	-2.27E-05	-3.36E-06	-4.41E-06
Correlation	0.917	0.979	0.993	0.985	0.975	0.992
RECESSION - Segment 2						
t (hrs)	145			32.5		183
Y (ft) - Max	883.43			884.19		883.51
Y (ft) - Min	883.39			883.82		883.29
Ln Slope (1/hr)	-3.19E-07			-1.26E-05		-1.23E-06
Correlation	0.892			0.992		0.972

Table B-13. GW-685 ambient monitoring data.

	Storm 1	Storm 2a	Storm 2b	Storm 3
Start Precip.				
Date	4/17/95	4/21/95	4/23/95	5/1/95
Time	11:00	1:00	7:00	13:00
Stop Precip.				
Date	4/17/95	4/21/95	4/23/95	5/1/95
Time	15:00	4:00	21:00	20:00
Duration Precip. (hrs)	4	3	14	7
Max Hourly Precip. (in)	0.3	0.42	0.11	0.72
Date	4/17/95	4/21/95	4/23/95	5/1/95
Time	14:00	3:00	8:00	19:00
Total Storm Precip. (in)	0.525	0.99	0.37	1.37
Precip. Intensity (in/hr)	0.131	0.330	0.026	0.196
WL before Precip. (ft)	883.58	884.01	884.28	883.73
Comment				
Start WL rise time				
Date	4/17/95	4/21/95	4/23/95	5/1/95
Time	13:30	4:00	10:00	18:00
Delay WL from Start Precip.				
Time (hrs)	2.5	3.0	3.0	5.0
Max WL (ft)	883.89	884.89	884.44	885.11
Date	4/17/95	4/21/95	4/24/95	5/2/95
Time	20:00	10:00	4:00	2:30
Water Level Change	0.31	0.88	0.16	1.38
Duration Peak (hrs)	3.5	1.5	1.5	2.0
Delay Peak WL from Peak Precip.				
Time (hrs)	7	1.0	20.0	7.5
Start Recession				
Date	4/17/95	4/21/95	4/24/95	5/2/95
Time	23:30	11:30	5:30	4:30
End Recession				
Date	4/20/95	4/23/95	5/1/95	5/9/95
Time	7:30	7:00	13:30	11:00
Duration Recession (hrs)	56	43.5	176	174.5
Recession Complete?	N	N	Y?	N
RECESSION - Segment 1				
t duration (hrs)	40	19	45	31
Y (ft) - Max	883.89	884.89	884.44	885.11
Y (ft) - Min	883.73	884.55	884.14	884.57
Ln Slope (1/hr)	-4.32E-06	-2.09E-05	-7.78E-06	-2.03E-05
Correlation	0.986	0.998	0.997	0.994
RECESSION - Segment 2				
t (hrs)	16	24.5	60	53
Y (ft) - Max	883.73	884.55	884.14	884.57
Y (ft) - Min	883.71	883.539	883.88	884.14
Ln Slope (1/hr)	-1.23E-06	-1.14E-05	-4.56E-06	-8.75E-06
Correlation	0.908	0.987	0.994	0.991
RECESSION - Segment 3				
t (hrs)			71	90.5
Y (ft) - Max			883.88	884.14
Y (ft) - Min			883.73	883.78
Ln Slope (1/hr)			-2.59E-06	-4.48E-06
Correlation			0.984	0.993

Table B-13. GW-685 ambient monitoring data, continued.

	Storm 4a	Storm 4b	Storm 5	Storm 6
Start Precip.				
Date	5/9/95	5/10/95	5/14/95	5/18/95
Time	15:00	22:00	7:00	20:00
Stop Precip.				
Date	5/9/95	5/10/95	5/14/95	5/19/95
Time	22:00	23:00	11:00	5:00
Duration Precip. (hrs)	7	1	4	9
Max Hourly Precip. (in)	0.76	0.28	0.28	0.36
Date	5/9/95	5/10/95	5/14/95	5/18/95
Time	20:00	22:00	7:00	21:00
Total Storm Precip. (in)	2.27	0.32	0.69	1.06
Precip. Intensity (in/hr)	0.324	0.320	0.173	0.118
WL before Precip. (ft)	883.77	885.59	884.64	884.26
Comment				
Start WL rise time				
Date	5/9/95	5/10/94	5/14/95	5/18/95
Time	16:30	22:30	8:00	21:00
Delay WL from Start Precip.				
Time (hrs)	1.5	0.5	1	1
Max WL (ft)	886.01	886.06	885.48	885.42
Date	5/10/95	5/11/95	5/14/95	5/19/95
Time	3:30	3:30	17:30	8:00
Water Level Change	2.24	0.47	0.84	1.16
Duration Peak (hrs)	0.5	0.5	1	1
Delay Peak WL from Peak Precip.				
Time (hrs)	7.5	5.5	10.5	11
Start Recession				
Date	5/10/95	5/11/95	5/14/95	5/19/95
Time	4:00	4:00	18:30	9:00
End Recession				
Date	5/10/95	5/14/95	5/18/95	5/27/95
Time	22:00	7:00	19:30	22:30
Duration Recession (hrs)	18	75	97	205.5
Recession Complete?	N	N	Y	Y
RECESSION - Segment 1				
t duration (hrs)	18	28.5	31	33.5
Y (ft) - Max	886.01	886.06	885.48	885.42
Y (ft) - Min	885.59	885.32	884.82	884.7
Ln Slope (1/hr)	-2.72E-05	-3.06E-05	-2.55E-05	-2.49E-06
Correlation	0.983	0.998	0.996	0.993
RECESSION - Segment 2				
t (hrs)		10	66	53
Y (ft) - Max		885.32	884.82	884.70
Y (ft) - Min		885.09	884.26	884.18
Ln Slope (1/hr)		-2.48E-05	-9.20E-06	-1.11E-05
Correlation		0.998	0.991	0.995
RECESSION - Segment 3				
t (hrs)		36.5		119
Y (ft) - Max		885.09		884.18
Y (ft) - Min		884.64		883.66
Ln Slope (1/hr)		-1.34E-05		-4.80E-06
Correlation		0.987		0.978

Table B-14. GW-685 water level, specific conductance, and temperature data.

	Storm 4			Storm 5		
	Temp. (C)	SC (umhos/cm)	WL (ft)	Temp. (C)	SC (umhos/cm)	WL (ft)
Start Precip.						
Date	5/9/95	5/9/95	5/9/95	5/14/95	5/14/95	5/14/95
Time	15:00	15:00	15:00	7:00	7:00	7:00
Stop Precip.						
Date	5/9/95	5/9/95	5/9/95	5/14/95	5/14/95	5/14/95
Time	22:00	22:00	22:00	11:00	11:00	11:00
Duration Precip. (hrs)	7	7	7	4	4	4
Max Hourly Precip. (in)	0.76	0.76	0.76	0.28	0.28	0.28
Date	5/9/95	5/9/95	5/9/95	5/14/95	5/14/95	5/14/95
Time	20:00	20:00	20:00	7:00	7:00	7:00
Total Storm Precip. (in)	2.27	2.27	2.27	0.69	0.69	0.69
Precip. Intensity (in/hr)	0.324	0.324	0.324	0.173	0.173	0.173
Value before Precip.	13.76	752	883.77	13.76	803	884.64
Comment						
Start rise/fall						
Date	No	5/9/95	5/9/95	No	5/14/95	5/14/95
Time	Response	18:30	16:30	Response	7:30	8:00
Delay from Start Precip.		3.5	1.5		0.5	1
Min/Max		794	886.01		816	885.48
Date		5/9/95	5/10/95		5/14/95	5/14/95
Time		18:30	3:30		8:30	17:30
Change in Value		42	2.24		13.00	0.84
Duration Peak (hrs)		5.5	0.5		1.5	1
Start Recession						
Date		5/10/95	5/10/95		5/14/95	5/14/95
Time		0:00	4:00		9:30	18:30
End Recession						
Date		5/10/95	5/10/95		5/14/95	5/18/95
Time		21:30	22:00		10:00	19:30
Duration Recession (hrs)		21.5	18		1.5	97
Recession Complete?		N	N		Y	Y

Table B-14. GW-685 water level, specific conductance, and temperature data, continued.

	Storm 6		
	Temp. (C)	SC (umhos/cm)	WL (ft)
Start Precip.			
Date	5/18/95	5/18/95	5/18/95
Time	20:00	20:00	20:00
Stop Precip.			
Date	5/19/95	5/19/95	5/19/95
Time	5:00	5:00	5:00
Duration Precip. (hrs)	9	9	9
Max Hourly Precip. (in)	0.36	0.36	0.36
Date	5/18/95	5/18/95	5/18/95
Time	21:00	21:00	21:00
Total Storm Precip. (in)	1.06	1.06	1.06
Precip. Intensity (in/hr)	0.118	0.118	0.118
Value before Precip.	13.76	801	884.26
Comment			
Start rise/fall			
Date	No	5/18/95	5/18/95
Time	Response	20:00	21:00
Delay from Start Precip.		0	1
Min/Max		770	885.42
Date		5/18/95	5/19/95
Time		22:00	8:00
Change in Value		-31	1.2
Duration Peak (hrs)		0	1
Start Recession			
Date		5/18/95	5/19/95
Time		22:30	9:00
End Recession			
Date		5/19/95	5/27/95
Time		15:30	22:30
Duration Recession (hrs)		17	205.5
Recession Complete?		N	Y

Table B-15. GW-728 ambient monitoring data.

	Storm 1	Storm 2a	Storm 2b	Storm 3
Start Precip.				
Date	4/17/95	4/21/95	4/23/95	5/1/95
Time	11:00	1:00	7:00	13:00
Stop Precip.				
Date	4/17/95	4/21/95	4/23/95	5/1/95
Time	15:00	4:00	21:00	20:00
Duration Precip. (hrs)	4	3	14	7
Max Hourly Precip. (in)	0.3	0.42	0.11	0.72
Date	4/17/95	4/21/95	4/23/95	5/1/95
Time	14:00	3:00	8:00	19:00
Total Storm Precip. (in)	0.525	0.99	0.37	1.37
Precip. Intensity (in/hr)	0.131	0.330	0.026	0.196
WL before Precip. (ft)	Poor	888.64	889.46	888.44
Comment	Response			
Start WL rise time				
Date		4/21/95	4/23/95	5/1/95
Time		2:00	11:00	18:30
Delay WL from Start Precip.				
Time (hrs)		1.0	4.0	5.5
Max WL (ft)		890.23	889.53	891.07
Date		4/21/95	4/23/95	5/2/95
Time		10:00	18:30	1:30
Water Level Change		1.59	0.07	2.63
Duration Peak (hrs)		0.0	0.0	1.5
Delay Peak WL from Peak Precip.				
Time (hrs)		7.0	10.5	6.5
Start Recession				
Date		4/21/95	4/23/95	5/2/95
Time		10:00	18:30	2:30
End Recession				
Date		4/23/95	5/1/95	5/9/95
Time		7:30	6:30	15:30
Duration Recession (hrs)		45.5	179.5	157
Recession Complete?		N	N	Y
RECESSION - Segment 1				
t duration (hrs)		27	163	33.5
Y (ft) - Max		890.23	889.53	891.07
Y (ft) - Min		889.6	888.48	889.95
Ln Slope (1/hr)		-2.64E-05	-6.55E-06	-3.87E-05
Correlation		0.997	0.986	0.994
RECESSION - Segment 2				
t (hrs)		18.5	16.5	77
Y (ft) - Max		889.60	888.48	889.95
Y (ft) - Min		889.46	888.43	889.18
Ln Slope (1/hr)		-7.69E-06	-2.02E-06	-1.03E-05
Correlation		0.976	0.85	0.989
RECESSION - Segment 3				
t (hrs)				46.5
Y (ft) - Max				889.18
Y (ft) - Min				889
Ln Slope (1/hr)				-3.58E-06
Correlation				0.91

Table B-15. GW-728 ambient monitoring data, continued.

	Storm 4a	Storm 4b	Storm 5	Storm 6
Start Precip.				
Date	5/9/95	5/10/95	5/14/95	5/18/95
Time	15:00	22:00	7:00	20:00
Stop Precip.				
Date	5/9/95	5/10/95	5/14/95	5/19/95
Time	22:00	23:00	11:00	5:00
Duration Precip. (hrs)	7	1	4	9
Max Hourly Precip. (in)	0.76	0.28	0.28	0.36
Date	5/9/95	5/10/95	5/14/95	5/18/95
Time	20:00	22:00	7:00	21:00
Total Storm Precip. (in)	2.27	0.32	0.69	1.06
Precip. Intensity (in/hr)	0.324	0.320	0.173	0.118
WL before Precip. (ft)	888.81	895.14	891.01	890.26
Comment				
Start WL rise time				
Date	5/9/95	5/10/94	5/14/95	5/18/95
Time	16:30	22:30	8:00	21:00
Delay WL from Start Precip.				
Time (hrs)	1.5	0.5	1	1
Max WL (ft)	895.69	895.47	891.85	891.91
Date	5/10/95	5/11/95	5/14/95	5/19/95
Time	9:30	1:30	15:00	6:30
Water Level Change	6.88	0.33	0.84	1.65
Duration Peak (hrs)	0	0	0.5	0
Delay Peak WL from Peak Precip.				
Time (hrs)	13.5	3.5	8	9.5
Start Recession				
Date	5/10/95	5/11/95	5/14/95	5/19/95
Time	9:30	1:30	15:30	6:30
End Recession				
Date	5/10/95	5/14/95	5/18/95	5/28/95
Time	21:30	6:30	18:00	3:30
Duration Recession (hrs)	11.5	77	98.5	213
Recession Complete?	N	N	N	Y
RECESSION - Segment 1				
t duration (hrs)	11.5	58.5	48.5	41.5
Y (ft) - Max	895.69	895.47	891.85	891.91
Y (ft) - Min	895.14	891.81	890.8	890.88
Ln Slope (1/hr)	-5.36E-05	-7.52E-05	-2.40E-05	-2.93E-05
Correlation	0.98	0.997	0.998	0.998
RECESSION - Segment 2				
t (hrs)		18.5	50	50
Y (ft) - Max		891.81	890.80	890.88
Y (ft) - Min		891.01	890.28	890.16
Ln Slope (1/hr)		-4.69E-05	-1.29E-05	-1.63E-05
Correlation		0.997	0.989	0.985
RECESSION - Segment 3				
t (hrs)				121.5
Y (ft) - Max				890.16
Y (ft) - Min				888.99
Ln Slope (1/hr)				-1.04E-05
Correlation				0.965

Table B16. GW-058 ambient monitoring data.

	Storm 1	Storm 2	Storm 3	Storm 4
Start Precip.				
Date	1/15/95	1/28/95	2/15/95	2/27/95
Time	14:00	0:00	0:00	10:00
Stop Precip.				
Date	1/16/95	1/29/95	2/16/95	2/28/95
Time	3:00	1:00	17:00	6:00
Duration Precip. (hrs)	13	25	41	20
Max Hourly Precip. (in)	0.15	0.25	0.26	0.14
Date	1/15/96	11/28/95	2/15/95	2/27/95
Time	16:00	21:00	7:00	14:00 & 16:00
Total Storm Precip. (in)	0.53	1.26	2.28	0.78
Precip. Intensity (in/hr)	0.041	0.050	0.056	0.039
WL before Precip. (ft)	?	892.05	891.78	892.12
Comment				
Start WL rise time				
Date	No data	1/28/95	2/15/95	2/27/95
Time		0:30	1:00	14:00
Delay WL from Start Precip.				
Date		1/28/95	2/15/95	2/27/95
Time (hrs)		0.5	1.0	4.0
Max WL (ft)		893.71	898.08	893.06
Date		1/29/95	2/16/95	2/28/95
Time		1:30	18:00	15:30
Water Level Change	?	1.66	6.30	0.94
Duration Peak (hrs)		0.0	0.0	1.5
Delay Peak WL from Peak Precip.				
Time (hrs)	?	4.5	35.0	25.5
Start Recession				
Date	1/17/95	1/29/95	2/16/95	2/28/95
Time	12:30	2:00	18:00	17:00
End Recession				
Date	1/27/95	2/8/95	2/27/95	
Time	23:30	23:00	8:30	
Duration Recession (hrs)	251	261	254.6	
Recession Complete?	?	Y	N	
RECESSION - Segment 1				
t duration (hrs)	34	261	54.5	
Y (ft) - Max	896.39	893.71	898.01	
Y (ft) - Min	849.2	892.05	894.37	
Ln Slope (1/hr)	-7.58E-05	-6.30E-06	-7.42E-05	
Correlation	0.994	0.962	0.998	
RECESSION - Segment 2				
t (hrs)	85	See Text	81	
Y (ft) - Max	849.2		894.37	
Y (ft) - Min	892.8		892.68	
Ln Slope (1/hr)	-1.80E-05		-2.21E-05	
Correlation	0.993		0.983	
RECESSION - Segment 3				
t (hrs)	132		119	
Y (ft) - Max	892.8		892.68	
Y (ft) - Min	892.05		892.12	
Ln Slope (1/hr)	-6.70E-06		-5.09E-06	
Correlation	0.997		0.99	

Table B-17. GW-059 ambient monitoring data.

	Storm 1	Storm 2	Storm 3	Storm 4
Start Precip.				
Date	1/15/95	1/28/95	2/15/95	2/27/95
Time	14:00	0:00	0:00	10:00
Stop Precip.				
Date	1/16/95	1/29/95	2/16/95	2/28/95
Time	3:00	1:00	17:00	6:00
Duration Precip. (hrs)	13	25	41	20
Max Hourly Precip. (in)	0.15	0.25	0.26	0.14
Date	1/15/96	11/28/95	2/15/95	2/27/95
Time	16:00	21:00	7:00	14:00 & 16:00
Total Storm Precip. (in)	0.53	1.26	2.28	0.78
Precip. Intensity (in/hr)	0.041	0.050	0.056	0.039
WL before Precip. (ft)	?	892.16	891.9	892.24
Comment				
Start WL rise time				
Date	No data	1/28/95	2/15/95	2/27/95
Time		0:30	2:30	13:30
Delay WL from Start Precip.				
Date		1/28/95	2/15/95	2/27/95
Time (hrs)		0.5	2.5	3.5
Max WL (ft)		893.78	896.38	893.14
Date		1/29/95	2/16/95	2/28/95
Time		1:00	8:00	15:30
Water Level Change	?	1.62	4.48	0.90
Duration Peak (hrs)		0.5	?	1.5
Delay Peak WL from Peak Precip.				
Time (hrs)	?	4.0	25.0	25.5
Start Recession				
Date	1/17/95	1/29/95	2/17/95	2/28/95
Time	12:30	2:00	12:00	17:00
End Recession				
Date	1/27/95	2/8/95	2/27/95	
Time	23:30	21:30	8:30	
Duration Recession (hrs)	251	259.5	236.5	
Recession Complete?	?	Y	N	
RECESSION - Segment 1				
t duration (hrs)	30	260	40	
Y (ft) - Max	896.38	893.78	896.38	
Y (ft) - Min	894.34	892.05	894.18	
Ln Slope (1/hr)	-8.02E-05	-6.04E-06	-6.94E-05	
Correlation	0.997	892.16	0.991	
RECESSION - Segment 2				
t (hrs)	87	See Text	85	
Y (ft) - Max	894.34		894.18	
Y (ft) - Min	892.9		892.71	
Ln Slope (1/hr)	-1.75E-05		-1.93E-05	
Correlation	0.992		0.983	
RECESSION - Segment 3				
t (hrs)	134		111.5	
Y (ft) - Max	892.9		892.71	
Y (ft) - Min	892.16		892.24	
Ln Slope (1/hr)	-6.45E-06		-4.65E-06	
Correlation	0.998		0.995	

Table B-18. GW-225 ambient monitoring data.

	Storm 1	Storm 2	Storm 3	Storm 4
Start Precip.				
Date	1/15/95	1/28/95	2/15/95	2/27/95
Time	14:00	0:00	0:00	10:00
Stop Precip.				
Date	1/16/95	1/29/95	2/16/95	2/28/95
Time	3:00	1:00	17:00	6:00
Duration Precip. (hrs)	13	25	41	20
Max Hourly Precip. (in)	0.15	0.25	0.26	0.14
Date	1/15/96	1/28/95	2/15/95	2/27/95
Time	16:00	21:00	7:00	14:00 & 16:00
Total Storm Precip. (in)	0.53	1.26	2.28	0.78
Precip. Intensity (in/hr)	0.041	0.050	0.056	0.039
WL before Precip. (ft)	?	928.55	926.92	928.41
Comment				
Start WL rise time				
Date	No data	1/28/95	2/15/95	2/27/95
Time		0:30	2:30	14:30
Delay WL from Start Precip.				
Date		1/28/95	2/15/95	2/27/95
Time (hrs)		0.5	2.5	4.5
Max WL (ft)		932.46	935.99	929.89
Date		1/30/95	2/18/95	3/1/95
Time		18:00	8:30	6:30
Water Level Change	?	3.91	9.07	1.48
Duration Peak (hrs)		12.0	1.5	1.5
Delay Peak WL from Peak Precip.				
Time (hrs)	?	45.0	73.5	38.5
Start Recession				
Date	1/18/95	1/31/95	2/18/95	3/1/95
Time	11:30	6:00	10:00	8:00
End Recession				
Date	1/27/95	2/7/95	2/27/95	
Time	23:30	11:00	13:00	
Duration Recession (hrs)	228	173	219	
Recession Complete?	?	Y	N	
RECESSION - Segment 1				
t duration (hrs)	128	173	171	
Y (ft) - Max	936.81	932.46	935.99	
Y (ft) - Min	931.08	928.55	930.8	
Ln Slope (1/hr)	-4.88E-05	-2.55E-05	-4.32E-05	
Correlation	0.998	0.995	0.978	
RECESSION - Segment 2				
t (hrs)	100		79	
Y (ft) - Max	931.08		930.8	
Y (ft) - Min	928.55		928.38	
Ln Slope (1/hr)	-2.81E-05		-3.25E-05	
Correlation	0.987		0.985	

Table B-19. GW-226 ambient monitoring data.

	Storm 1	Storm 2	Storm 3	Storm 4
Start Precip.				
Date	1/15/95	1/28/95	2/15/95	2/27/95
Time	14:00	0:00	0:00	10:00
Stop Precip.				
Date	1/16/95	1/29/95	2/16/95	2/28/95
Time	3:00	1:00	17:00	6:00
Duration Precip. (hrs)	13	25	41	20
Max Hourly Precip. (in)	0.15	0.25	0.26	0.14
Date	1/15/96	1/28/95	2/15/95	2/27/95
Time	16:00	21:00	7:00	14:00 & 16:00
Total Storm Precip. (in)	0.53	1.26	2.28	0.78
Precip. Intensity (in/hr)	0.041	0.050	0.056	0.039
WL before Precip. (ft)	?	927.74	926.26	927.83
Comment				
Start WL rise time				
Date	No data	1/28/95	2/15/95	2/27/95
Time		1:30	3:30	15:30
Delay WL from Start Precip.				
Date		1/28/95	2/15/95	2/27/95
Time (hrs)		1.5	3.5	5.5
Max WL (ft)		931.9	935.97	930.19
Date		1/30/95	2/18/95	2/28/95
Time		5:30	1:00	20:30
Water Level Change	?	4.16	9.71	2.36
Duration Peak (hrs)		4.5	5.5	0.5
Delay Peak WL from Peak Precip.				
Time (hrs)	?	32.5	66.0	28.5
Start Recession				
Date	1/18/95	1/30/95	2/18/95	2/28/95
Time	11:30	9:00	6:30	21:00
End Recession				
Date	1/27/95	2/9/95	2/27/95	
Time	23:30	6:00	12:30	
Duration Recession (hrs)	228	237	222	
Recession Complete?	?	Y	N	
RECESSION - Segment 1				
t duration (hrs)	228	50	85	
Y (ft) - Max	936.73	929.81	935.97	
Y (ft) - Min	931.08	928.3	930.5	
Ln Slope (1/hr)	-4.51E-05	-3.43E-05	-5.78E-05	
Correlation	0.934	0.999	0.998	
RECESSION - Segment 2				
t (hrs)		69.5	97	
Y (ft) - Max		928.3	930.5	
Y (ft) - Min		927	928.38	
Ln Slope (1/hr)		-2.03E-05	-3.00E-05	
Correlation		0.995	927.83	

Table B-20. GW-621 ambient monitoring data.

	Storm 1	Storm 2	Storm 3	Storm 4
Start Precip.				
Date	1/15/95	1/28/95	2/15/95	2/27/95
Time	14:00	0:00	0:00	10:00
Stop Precip.				
Date	1/16/95	1/29/95	2/16/95	2/28/95
Time	3:00	1:00	17:00	6:00
Duration Precip. (hrs)	13	25	41	20
Max Hourly Precip. (in)	0.15	0.25	0.26	0.14
Date	1/15/96	1/28/95	2/15/95	2/27/95
Time	16:00	21:00	7:00	14:00 & 16:00
Total Storm Precip. (in)	0.53	1.26	2.28	0.78
Precip. Intensity (in/hr)	0.041	0.050	0.056	0.039
WL before Precip. (ft)	?	912.52	912.01	912.56
Comment				
Start WL rise time				
Date	No data	1/28/95	2/15/95	2/27/95
Time		1:00	1:30	13:00
Delay WL from Start Precip.				
Date		1/28/95	2/15/95	2/27/95
Time (hrs)		1.0	1.5	3.0
Max WL (ft)		915.9	919.18	914.07
Date		1/29/95	2/16/95	3/1/95
Time		5:00	10:30	3:30
Water Level Change	?	3.38	7.17	1.51
Duration Peak (hrs)		1.5	0.0	2.5
Delay Peak WL from Peak Precip.				
Time (hrs)	?	8.0	27.5	35.5
Start Recession				
Date	1/17/95	1/29/95	2/16/95	3/1/95
Time	14:30	6:30	10:30	6:00
End Recession				
Date	1/28/95	2/8/95	2/27/95	
Time	0:30	0:30	12:00	
Duration Recession (hrs)	250	258	265.5	
Recession Complete?	?	Y	N	
RECESSION - Segment 1				
t duration (hrs)	75	120	50	
Y (ft) - Max	918.19	915.9	919.18	
Y (ft) - Min	915.23	913.55	916.94	
Ln Slope (1/hr)	-3.92E-05	-2.16E-05	-5.12E-05	
Correlation	0.991	0.995	0.998	
RECESSION - Segment 2				
t (hrs)	115	138	90	
Y (ft) - Max	915.23	913.55	916.94	
Y (ft) - Min	913.08	912.52	914.3	
Ln Slope (1/hr)	-2.07E-05	-7.97E-06	-3.17E-05	
Correlation	0.988	0.987	0.995	
RECESSION - Segment 3				
t (hrs)	60		125.5	
Y (ft) - Max	913.08		914.3	
Y (ft) - Min	912.52		912.56	
Ln Slope (1/hr)	-1.25E-05		-1.52E-05	
Correlation	0.859		0.98	

Table B-21. GW-694 ambient monitoring data

	Storm 1	Storm 2	Storm 3	Storm 4
Start Precip.				
Date		1/28/95	2/15/95	2/27/95
Time		0:00	0:00	10:00
Stop Precip.				
Date		1/29/95	2/16/95	2/28/95
Time		1:00	17:00	6:00
Duration Precip. (hrs)		25	41	20
Max Hourly Precip. (in)		0.25	0.26	0.14
Date		1/28/95	2/15/95	2/27/95
Time		21:00	7:00	14:00 & 16:00
Total Storm Precip. (in)		1.26	2.28	0.78
Precip. Intensity (in/hr)		0.050	0.056	0.039
WL before Precip. (ft)		913.45	912.25	912.99
Comment				
Start WL rise time				
Date		1/28/95	2/15/95	2/27/95
Time		1:00	1:00	14:30
Delay WL from Start Precip.				
Date		1/28/95	2/15/95	2/27/95
Time (hrs)		1.0	1.0	4.5
Max WL (ft)		916.41	918.69	914.17
Date		1/30/95	2/17/95	3/1/95
Time		9:00	6:30	8:00
Water Level Change		2.96	6.44	1.18
Duration Peak (hrs)		1.5	2.0	0
Delay Peak WL from Peak Precip.				
Time (hrs)		36.0	47.5	40
Start Recession				
Date	1/18/95	1/30/95	2/17/95	3/1/95
Time	10:00	9:00	8:00	8:00
End Recession				
Date	1/27/95	2/6/95	2/27/95	
Time	18:30	2:00	10:00	
Duration Recession (hrs)	224.5	161	242	
Recession Complete?	?	Y	N	
RECESSION - Segment 1				
t duration (hrs)	170	322	200	
Y (ft) - Max	917.88	916.41	918.69	
Y (ft) - Min	914.18	913.45	913.66	
Ln Slope (1/hr)	-2.37E-05	-2.05E-05	-2.95E-05	
Correlation	0.996	0.994	0.998	
RECESSION - Segment 2				
t (hrs)	100		42	
Y (ft) - Max	914.18		913.66	
Y (ft) - Min	913.43		913	
Ln Slope (1/hr)	-1.61E-05		-1.70E-05	
Correlation	0.986		0.981	

Table B-22. GW-694 water level and specific conductance data.

	Storm 1		Storm 2	
	SC (umhos/cm)	WL (ft)	SC (umhos/cm)	WL (ft)
Start Precip.				
Date	1/15/95		1/28/95	1/28/95
Time	14:00		0:00	0:00
Stop Precip.				
Date	1/16/95		1/29/95	1/29/95
Time	3:00		1:00	1:00
Duration Precip. (hrs)	13		25	25
Max Hourly Precip. (in)	0.15		0.25	0.25
Date	1/15/96		1/28/95	1/28/95
Time	16:00		21:00	21:00
Total Storm Precip. (in)	0.53		1.26	1.26
Precip. Intensity (in/hr)	0.041		0.050	0.050
Value before Precip.	?		591	913.45
Comment				
Start rise/fall				
Date			1/28/95	1/28/95
Time			6:00	1:00
Delay from Start Precip.			6	1
Min/Max	535	917.88	708	916.41
Date	1/18/95	1/18/95	1/28/95	1/30/95
Time	10:00	10:00	16:00	9:00
Change in Value	?	?	117.00	2.96
Duration Peak (hrs)			1.5	1.5
Start Recession				
Date	1/18/95	1/18/95	1/28/95	1/30/95
Time	10:00	10:00	17:30	9:00
End Recession				
Date	1/21/95	1/27/95	1/29/95	2/6/95
Time	17:00	18:30	1:30	2:00
Duration Recession (hrs)	79	224.5	8	161
Final Value	592	913.43	591	913.45
Recession Complete?	?	?	Y	Y

Table B-22, Continued.

	Storm 3		Storm 4	
	SC (umhos/cm)	WL (ft)	SC (umhos/cm)	WL (ft)
Start Precip.				
Date	2/15/95	2/15/95	2/27/95	2/27/95
Time	0:00	0:00	10:00	10:00
Stop Precip.				
Date	2/16/95	2/16/95	2/28/95	2/28/95
Time	17:00	17:00	6:00	6:00
Duration Precip. (hrs)	41	41	20	20
Max Hourly Precip. (in)	0.26	0.26	0.14	0.14
Date	2/15/95	2/15/95	2/27/95	2/27/95
Time	7:00	7:00	14&16:00	14&16:00
Total Storm Precip. (in)	2.28	2.28	0.78	0.78
Precip. Intensity (in/hr)	0.056	0.056	0.039	0.039
Value before Precip.	558	912.25	545	912.99
Comment				
Start rise/fall				
Date	2/15/95	2/15/95	2/28/95	2/27/95
Time	6:30	1:00	7:00	14:30
Delay from Start Precip.	6.5	1	21*	4.5
Min/Max	701	918.69	624	914.17
Date	2//15/94	2/17/95	2/28/95	3/1/95
Time	21:00	6:30	12:00	8:00
Change in Value	143.00	6.44	79.00	1.18
Duration Peak (hrs)	0.0	2.0	1	0
Start Recession				
Date	2/15/95	2/17/95	2/28/95	3/1/95
Time	21:00	8:00	13:00	8:00
End Recession				
Date	2/16/95	2/27/95	?	?
Time	16:30	10:00		
Duration Recession (hrs)	19.5	242		
Final Value	554	913	609	
Recession Complete?	Y	N	N	N

Table B-23. GW-695 ambient monitoring data.

	Storm 1	Storm 2	Storm 3	Storm 4
Start Precip.				
Date	1/15/95	1/28/95	2/15/95	2/27/95
Time	14:00	0:00	0:00	10:00
Stop Precip.				
Date	1/16/95	1/29/95	2/16/95	2/28/95
Time	3:00	1:00	17:00	6:00
Duration Precip. (hrs)	13	25	41	20
Max Hourly Precip. (in)	0.15	0.25	0.26	0.14
Date	1/15/96	1/28/95	2/15/95	2/27/95
Time	16:00	21:00	7:00	14:00 & 16:00
Total Storm Precip. (in)	0.53	1.26	2.28	0.78
Precip. Intensity (in/hr)	0.041	0.050	0.056	0.039
WL before Precip. (ft)	?	912.17	911.13	912.3
Comment				
Start WL rise time				
Date	No data	1/28/95	2/15/95	2/27/95
Time		3:30	4:30	15:30
Delay WL from Start Precip.				
Date		1/28/95	2/15/95	2/27/95
Time (hrs)		3.5	4.5	5.5
Max WL (ft)		915.38	918.16	913.78
Date		1/30/95	2/17/95	3/1/95
Time		7:00	5:00	8:00
Water Level Change	?	3.21	7.03	1.48
Duration Peak (hrs)		3.0	3.5	3
Delay Peak WL from Peak Precip.				
Time (hrs)	?	34.0	46.0	40
Start Recession				
Date	1/18/95	1/30/95	2/17/95	3/1/95
Time	11:00	10:00	8:30	11:00
End Recession				
Date	1/27/95	2/8/95	2/27/95	
Time	3:36	4:30	14:30	
Duration Recession (hrs)	229.5	210.5	246	
Recession Complete?	?	Y	N	
RECESSION - Segment 1				
t duration (hrs)	130	105	185	
Y (ft) - Max	917.73	915.38	918.16	
Y (ft) - Min	913.82	913.53	913.43	
Ln Slope (1/hr)	-3.33E-05	-2.19E-05	-2.99E-05	
Correlation	0.999	0.982	0.994	
RECESSION - Segment 2				
t (hrs)	99.5	95.5	61	
Y (ft) - Max	913.82	913.53	913.43	
Y (ft) - Min	912.15	912.17	912.3	
Ln Slope (1/hr)	-1.83E-05	-1.58E-05	-2.06E-05	
Correlation	0.988	0.985	0.992	

Table B-24. GW-703 ambient monitoring data.

	Storm 1	Storm 2	Storm 3	Storm 4
Start Precip.				
Date	1/15/95	1/28/95	2/15/95	2/27/95
Time	14:00	0:00	0:00	10:00
Stop Precip.				
Date	1/16/95	1/29/95	2/16/95	2/28/95
Time	3:00	1:00	17:00	6:00
Duration Precip. (hrs)	13	25	41	20
Max Hourly Precip. (in)	0.15	0.25	0.26	0.14
Date	1/15/96	1/28/95	2/15/95	2/27/95
Time	16:00	21:00	7:00	14:00 & 16:00
Total Storm Precip. (in)	0.53	1.26	2.28	0.78
Precip. Intensity (in/hr)	0.041	0.050	0.056	0.039
WL before Precip. (ft)	?	914.24	913.01	No
Comment				Response
Start WL rise time				
Date	No data	1/28/95	2/16/95	
Time		18:30	2:30	
Delay WL from Start Precip.				
Date		1/28/95	2/16/95	
Time (hrs)		18.5	26.5	
Max WL (ft)	919.05	915.33	917.55	
Date	1/18/95	2/1/95	2/20/95	
Time	5:30	13:00	10:30	
Water Level Change	?	1.09	4.54	
Duration Peak (hrs)	5.5	11.0	10.5	
Delay Peak WL from Peak Precip.				
Time (hrs)	?	40.0	123.5	
Start Recession				
Date	1/18/95	2/2/95	2/20/95	
Time	10:30	0:00	21:00	
End Recession				
Date	1/28/95	2/8/95	3/1/95	
Time	16:00	4:30	13:00	
Duration Recession (hrs)	245.5	210.5	208	
Recession Complete?	?	Y	N	
RECESSION - Segment 1				
t duration (hrs)	245.5	152.5	208	
Y (ft) - Max	919.05	915.33	917.55	
Y (ft) - Min	914.24	914.24	915.25	
Ln Slope (1/hr)	-2.40E-05	-8.14E-06	-1.40E-05	
Correlation	0.995	0.99	0.988	

Table B-25. GW-704 ambient monitoring data.

	Storm 1	Storm 2	Storm 3	Storm 4
Start Precip.				
Date	1/15/95	1/28/95	2/15/95	2/27/95
Time	14:00	0:00	0:00	10:00
Stop Precip.				
Date	1/16/95	1/29/95	2/16/95	2/28/95
Time	3:00	1:00	17:00	6:00
Duration Precip. (hrs)	13	25	41	20
Max Hourly Precip. (in)	0.15	0.25	0.26	0.14
Date	1/15/96	1/28/95	2/15/95	2/27/95
Time	16:00	21:00	7:00	14:00 & 16:00
Total Storm Precip. (in)	0.53	1.26	2.28	0.78
Precip. Intensity (in/hr)	0.041	0.050	0.056	0.039
WL before Precip. (ft)	?	912.65	911.55	912.71
Comment				
Start WL rise time				
Date	No data	1/28/95	2/15/95	2/27/95
Time		0:00	2:00	14:00
Delay WL from Start Precip.				
Date		1/28/95	2/15/95	2/27/95
Time (hrs)		0.0	2.0	4.0
Max WL (ft)	920.3	916.49	919.65	914
Date	1/17/95	1/30/95	2/17/95	3/1/95
Time	16:00	17:00	20:00	7:00
Water Level Change	?	3.84	8.10	1.29
Duration Peak (hrs)		1.5	1.0	2
Delay Peak WL from Peak Precip.				
Time (hrs)	?	44.0	61.0	39
Start Recession				
Date	1/17/95	1/30/95	2/17/95	3/1/95
Time	16:00	18:30	21:00	9:30
End Recession				
Date	1/27/95	2/7/95	2/27/95	?
Time	23:00	21:30	12:00	
Duration Recession (hrs)	247	194.5	231	
Recession Complete?	?	Y	N	
RECESSION - Segment 1				
t duration (hrs)	145	85	155	
Y (ft) - Max	920.3	916.49	919.65	
Y (ft) - Min	914.62	914.36	914.49	
Ln Slope (1/hr)	-4.22E-05	-2.97E-05	-3.93E-05	
Correlation	0.998	0.983	0.991	
RECESSION - Segment 2				
t (hrs)	40	60	76	
Y (ft) - Max	914.62	914.36	914.49	
Y (ft) - Min	913.64	913.26	912.71	
Ln Slope (1/hr)	-2.69E-05	-1.93E-05	-2.49E-05	
Correlation	0.995	0.994	0.983	
RECESSION - Segment 3				
t (hrs)	62	50		
Y (ft) - Max	913.64	913.26		
Y (ft) - Min	912.65	912.65		
Ln Slope (1/hr)	-1.71E-05	-1.24E-05		
Correlation	0.984	0.983		

TableB-26. GW-704 water level and specific conductance data.

	Storm 2		Storm 3	
	SC (umhos/cm)	WL (ft)	SC (umhos/cm)	WL (ft)
Start Precip.				
Date	1/28/95	1/28/95	2/15/95	2/15/95
Time	0:00	0:00	0:00	0:00
Stop Precip.				
Date	1/29/95	1/29/95	2/16/95	2/16/95
Time	1:00	1:00	17:00	17:00
Duration Precip. (hrs)	25	25	41	41
Max Hourly Precip. (in)	0.25	0.25	0.26	0.26
Date	1/28/95	1/28/95	2/15/95	2/15/95
Time	21:00	21:00	7:00	7:00
Total Storm Precip. (in)	1.26	1.26	2.28	2.28
Precip. Intensity (in/hr)	0.050	0.050	0.056	0.056
Value before Precip.	585	912.65	571	911.55
Comment				
Start rise/fall				
Date	1/28/95	1/28/95	2/15/95	2/15/95
Time	8:00	0:00	4:00	2:00
Delay from Start Precip.	8	0	4	2
Min/Max	592	916.49	646	919.65
Date	1/29/95	1/30/95	2/17/95	2/17/95
Time	1:00	17:00	19:30	20:00
Change in Value	7.00	3.84	75.00	8.10
Duration Peak (hrs)	2.0	34704.0	15.0	1.0
Start Recession				
Date	1/29/95	1/30/95	2/18/95	2/17/95
Time	3:00	18:30	10:30	21:00
End Recession				
Date	1/29/95	2/7/95	2/21/95	2/27/95
Time	10:00	21:30	23:30	12:00
Duration Recession (hrs)	7	194.5	85	231
Final Value	587	912.65	554	912.71
Recession Complete?	N	Y	N(?)	N

Table B-27. GW-706 ambient monitoring data.

	Storm 1	Storm 2	Storm 3	Storm 4
Start Precip.				
Date	1/15/95	1/28/95	2/15/95	2/27/95
Time	14:00	0:00	0:00	10:00
Stop Precip.				
Date	1/16/95	1/29/95	2/16/95	2/28/95
Time	3:00	1:00	17:00	6:00
Duration Precip. (hrs)	13	25	41	20
Max Hourly Precip. (in)	0.15	0.25	0.26	0.14
Date	1/15/96	1/28/95	2/15/95	2/27/95
Time	16:00	21:00	7:00	14:00 & 16:00
Total Storm Precip. (in)	0.53	1.26	2.28	0.78
Precip. Intensity (in/hr)	0.041	0.050	0.056	0.039
WL before Precip. (ft)	?	913.38	912.25	912.96
Comment				
Start WL rise time				
Date	No data	1/28/95	2/15/95	2/27/95
Time		0:30	2:30	14:00
Delay WL from Start Precip.				
Date		1/28/95	2/15/95	2/27/95
Time (hrs)		0.5	2.5	4.0
Max WL (ft)	917.81	916.32	918.57	914.14
Date	1/18/95	1/30/95	2/17/95	3/1/95
Time	9:00	4:30	6:30	10:00
Water Level Change	?	2.94	6.32	1.18
Duration Peak (hrs)		0.0	1.0	0
Delay Peak WL from Peak Precip.				
Time (hrs)	?	7.5	47.5	42
Start Recession				
Date	1/18/95	1/30/95	2/17/95	3/1/95
Time	9:00	4:30	7:30	10:00
End Recession				
Date	1/17/95	2/6/95	2/27/95	?
Time	22:00	4:00	12:30	
Duration Recession (hrs)	229	167.5	245	
Recession Complete?	?	Y	N	
RECESSION - Segment 1				
t duration (hrs)	145	167.5	225	
Y (ft) - Max	917.81	916.32	918.57	
Y (ft) - Min	913.38	913.38	913.19	
Ln Slope (1/hr)	-2.19E-05	-2.00E-05	-2.86E-05	
Correlation	0.993	0.995	0.997	
RECESSION - Segment 2				
t (hrs)			20	
Y (ft) - Max			913.19	
Y (ft) - Min			912.96	
Ln Slope (1/hr)			-1.24E-05	
Correlation			0.982	

Table B-28. GW-724 ambient monitoring data.

	Storm 1	Storm 2	Storm 3	Storm 4
Start Precip.				
Date	10/19/94	11/9/94	11/27/94	12/3/94
Time	4:00	23:00	1:00	20:00
Stop Precip.				
Date	10/19/94	11/10/94	11/28/94	12/5/94
Time	13:00	9:00	9:00	9:00
Duration Precip. (hrs)	9	10	32	36
Max Hourly Precip. (in)	0.22	0.31	0.31	0.09
Date	10/19/94	11/10/94	11/27/94	12/4/94
Time	9:00	1:00	7:00	19:00
Total Storm Precip. (in)	0.53	0.66	2.41	0.83
Precip. Intensity (in/hr)	0.059	0.066	0.075	0.023
WL before Precip. (ft)	946.18	945.85	945.72	947.1
Comment				
Start WL rise time				
Date	10/19/94	11/9/94	11/27/94	12/4/94
Time	4:30	22:30	2:00	21:00
Delay WL from Start Precip.				
Date	10/19/94	11/9/94	11/27/94	12/4/94
Time (hrs)	0.5	0.0	1.5	24.0
Max WL (ft)	946.63	946.33	948.45	948.06
Date	10/23/94	11/12/94	11/30/94	12/6/94
Time	19:00	3:00	4:00	21:30
Water Level Change	0.45	0.48	2.73	0.96
Duration Peak (hrs)	2.5	2.5	4.0	4.5
Delay Peak WL from Peak Precip.				
Time (hrs)	106	50.0	69.0	51
Start Recession				
Date	10/23/94	11/12/94	11/30/94	12/7/94
Time	21:30	5:30	8:00	2:00
End Recession				
Date	11/2/94	11/22/94	12/4/94	12/9/94
Time	23:30	23:30	10:00	12:00
Duration Recession (hrs)	242	258	98	58
Recession Complete?	Y	Y	N	N
RECESSION - Segment 1				
t duration (hrs)	176.5	272	98	58
Y (ft) - Max	946.63	946.33	948.45	948.06
Y (ft) - Min	945.88	945.71	947.07	947.67
Ln Slope (1/hr)	-2.11E-06	-2.03E-06	-1.77E-05	-7.78E-06
Correlation	0.981	0.99	0.983	0.982

Table B-29. GW-725 ambient monitoring data.

	Storm 1	Storm 2	Storm 3	Storm 4
Start Precip.				
Date	10/19/94	11/9/94	11/27/94	12/3/94
Time	4:00	23:00	1:00	20:00
Stop Precip.				
Date	10/19/94	11/10/94	11/28/94	12/5/94
Time	13:00	9:00	9:00	9:00
Duration Precip. (hrs)	9	10	32	36
Max Hourly Precip. (in)	0.22	0.31	0.31	0.09
Date	10/19/94	11/10/94	11/27/94	12/4/94
Time	9:00	1:00	7:00	19:00
Total Storm Precip. (in)	0.53	0.66	2.41	0.83
Precip. Intensity (in/hr)	0.059	0.066	0.075	0.023
WL before Precip. (ft)	947.46	946.91	946.8	948.13
Comment				
Start WL rise time				
Date	10/19/94	11/9/94	11/27/94	12/4/94
Time	5:00	23:00	1:00	17:00
Delay WL from Start Precip.				
Date	10/19/94	11/9/94	11/27/94	12/4/94
Time (hrs)	1.0	0.0	0.0	20.0
Max WL (ft)	947.93	947.43	949.38	949.05
Date	10/22/94	11/11/94	11/29/94	12/7/94
Time	23:00	18:30	21:00	0:30
Water Level Change	0.47	0.52	2.58	0.92
Duration Peak (hrs)	1.5	1.0	2.0	2.5
Delay Peak WL from Peak Precip.				
Time (hrs)	86	41.5	62.0	53.5
Start Recession				
Date	10/22/94	11/11/94	11/29/94	12/7/94
Time	0:30	19:30	23:00	3:00
End Recession				
Date	Unknown	11/23/94	12/4/94	12/9/94
Time		3:30	17:00	12:30
Duration Recession (hrs)		272	114	57.5
Recession Complete?	N	Y	N	N
RECESSION - Segment 1				
t duration (hrs)		272	37	57.5
Y (ft) - Max		947.43	949.8	949.05
Y (ft) - Min		946.91	949.2	948.67
Ln Slope (1/hr)		-1.94E-06	-1.44E-05	-7.45E-06
Correlation		0.989	0.972	0.987

Table B-30. GW-736 ambient monitoring data.

	Storm 1	Storm 2	Storm 3	Storm 4
Start Precip.				
Date	10/19/94	11/9/94	11/27/94	12/3/94
Time	4:00	23:00	1:00	20:00
Stop Precip.				
Date	10/19/94	11/10/94	11/28/94	12/5/94
Time	13:00	9:00	9:00	9:00
Duration Precip. (hrs)	9	10	32	36
Max Hourly Precip. (in)	0.22	0.31	0.31	0.09
Date	10/19/94	11/10/94	11/27/94	12/4/94
Time	9:00	1:00	7:00	19:00
Total Storm Precip. (in)	0.53	0.66	2.41	0.83
Precip. Intensity (in/hr)	0.059	0.066	0.075	0.023
WL before Precip. (ft)	947.31	946.99	946.87	948.19
Comment				
Start WL rise time				
Date	10/19/94	11/9/94	11/27/94	12/4/94
Time	8:30	23:00	0:30	17:30
Delay WL from Start Precip.				
Date	10/19/94	11/9/94	11/27/94	12/4/94
Time (hrs)	4.5	0.5	0.0	20.5
Max WL (ft)	947.77	947.5	949.43	949.11
Date	10/23/94	11/11/94	11/29/94	12/7/94
Time	10:30	15:30	20:30	0:30
Water Level Change	0.46	0.51	2.56	0.92
Duration Peak (hrs)	17	6.5	5.5	2.5
Delay Peak WL from Peak Precip.				
Time (hrs)	97.5	39.5	61.5	53.5
Start Recession				
Date	10/24/94	11/11/94	11/30/94	12/7/94
Time	3:30	22:00	1:30	3:00
End Recession				
Date	11/2/94	11/22/94	12/4/94	12/9/94
Time	0:30	1:30	10:00	12:30
Duration Recession (hrs)	213	267.5	104.5	57.5
Recession Complete?	Y	Y	N	N
RECESSION - Segment 1				
t duration (hrs)	150	346	104.5	57.5
Y (ft) - Max	947.77	947.5	949.43	949.11
Y (ft) - Min	947.37	947.87	948.19	948.72
Ln Slope (1/hr)	-3.05E-06	-2.02E-06	-1.51E-05	-7.41E-06
Correlation	0.99	0.993	0.977	0.988
RECESSION - Segment 2				
t duration (hrs)	63		98	58
Y (ft) - Max	947.37		948.19	948.72
Y (ft) - Min	947.03		947.07	947.67
Ln Slope (1/hr)	-2.01E-06		-1.77E-05	-7.78E-06
Correlation	0.949		0.983	0.982

Table B-31. GW-737 ambient monitoring data.

	Storm 1	Storm 2	Storm 3	Storm 4
Start Precip.				
Date	10/19/94	11/9/94	11/27/94	12/3/94
Time	4:00	23:00	1:00	20:00
Stop Precip.				
Date	10/19/94	11/10/94	11/28/94	12/5/94
Time	13:00	9:00	9:00	9:00
Duration Precip. (hrs)	9	10	32	36
Max Hourly Precip. (in)	0.22	0.31	0.31	0.09
Date	10/19/94	11/10/94	11/27/94	12/4/94
Time	9:00	1:00	7:00	19:00
Total Storm Precip. (in)	0.53	0.66	2.41	0.83
Precip. Intensity (in/hr)	0.059	0.066	0.075	0.023
WL before Precip. (ft)	947.31	946.99	946.88	948.19
Comment				
Start WL rise time				
Date	10/19/94	11/9/94	11/27/94	12/4/94
Time	6:30	23:30	1:30	17:30
Delay WL from Start Precip.				
Date	10/19/94	11/9/94	11/27/94	12/4/94
Time (hrs)	2.5	0.5	0.5	20.5
Max WL (ft)	947.75	947.5	949.43	949.1
Date	10/21/94	11/11/94	11/29/94	12/6/94
Time	21:30	16:30	20:00	23:00
Water Level Change	0.44	0.51	2.55	0.91
Duration Peak (hrs)	4.5	5.5	13.5	6
Delay Peak WL from Peak Precip.				
Time (hrs)	60.5	39.5	61.0	52
Start Recession				
Date	10/22/94*	11/11/94	11/30/94	12/7/94
Time	2:00	23:00	9:30	5:00
End Recession				
Date	1/2/94	11/22/94	12/4/94	12/9/94
Time	1:30	23:30	5:30	13:00
Duration Recession (hrs)	217	264.5	92	56
Recession Complete?	Y	Y	N	N
RECESSION - Segment 1				
t duration (hrs)	217	264.5	92	56
Y (ft) - Max	947.75	947.5	949.43	949.1
Y (ft) - Min	947	946.99	948.2	948.72
Ln Slope (1/hr)	-2.12E-06	-1.95E-06	-1.60E-05	-7.47E-06
Correlation	0.979	0.99	0.985	0.991
RECESSION - Segment 2				
t duration (hrs)			98	58
Y (ft) - Max			948.2	948.72
Y (ft) - Min			947.07	947.67
Ln Slope (1/hr)			-1.77E-05	-7.78E-06
Correlation			0.983	0.982

* Recession started on 10/22/94 for storm 1. However, the subsequent small storm resulted in a small additional water level rise. Hence, recession was assumed to begin at 0:30 on 10/24/94.

Table B-32. GW-738 ambient monitoring data.

	Storm 1	Storm 2	Storm 3	Storm 4
Start Precip.				
Date	10/19/94	11/9/94	11/27/94	12/3/94
Time	4:00	23:00	1:00	20:00
Stop Precip.				
Date	10/19/94	11/10/94	11/28/94	12/5/94
Time	13:00	9:00	9:00	9:00
Duration Precip. (hrs)	9	10	32	36
Max Hourly Precip. (in)	0.22	0.31	0.31	0.09
Date	10/19/94	11/10/94	11/27/94	12/4/94
Time	9:00	1:00	7:00	19:00
Total Storm Precip. (in)	0.53	0.66	2.41	0.83
Precip. Intensity (in/hr)	0.059	0.066	0.075	0.023
WL before Precip. (ft)	952.64	952.35	952.28	953.66
Comment				
Start WL rise time				
Date	10/19/94	11/9/94	11/27/94	12/4/94
Time	10:30	23:30	3:00	10:30
Delay WL from Start Precip.				
Date	10/19/94	11/9/94	11/27/94	12/4/94
Time (hrs)	6.5	1.0	2.5	13.5
Max WL (ft)	953.07	952.94	955.03	954.51
Date	10/21/94	11/11/94	11/28/94	12/5/94
Time	3:30	13:00	14:00	18:00
Water Level Change	0.43	0.59	2.75	0.85
Duration Peak (hrs)	4	2.5	3.0	3
Delay Peak WL from Peak Precip.				
Time (hrs)	44.5	36.0	31.0	23
Start Recession				
Date	10/21/94	11/11/94	11/28/94	12/5/94
Time	7:30	15:30	17:00	21:00
End Recession				
Date	10/29/94	11/23/94	12/3/94	12/9/94
Time	19:30	19:00	19:30	11:00
Duration Recession (hrs)	204	291.5	122.5	86
Recession Complete?	Y	Y	N	N
RECESSION - Segment 1				
t duration (hrs)	204	88	43.5	61.5
Y (ft) - Max	953.07	952.94	955.03	954.51
Y (ft) - Min	952.64	952.69	954.45	954.08
Ln Slope (1/hr)	2.30E-06	-2.87E-06	-1.44E-05	-7.44E-06
Correlation	0.968	0.994	0.999	0.977
RECESSION - Segment 2				
t duration (hrs)		203.5	70	24.5
Y (ft) - Max		952.69	954.45	954.08
Y (ft) - Min		952.35	953.73	953.94
Ln Slope (1/hr)		-1.83E-06	-9.52E-06	-6.16E-05
Correlation		0.988	0.993	0.99

Table B-33. GW-739 ambient monitoring data.

	Storm 1	Storm 2	Storm 3	Storm 4
Start Precip.				
Date	10/19/94	11/9/94	11/27/94	12/3/94
Time	4:00	23:00	1:00	20:00
Stop Precip.				
Date	10/19/94	11/10/94	11/28/94	12/5/94
Time	13:00	9:00	9:00	9:00
Duration Precip. (hrs)	9	10	32	36
Max Hourly Precip. (in)	0.22	0.31	0.31	0.09
Date	10/19/94	11/10/94	11/27/94	12/4/94
Time	9:00	1:00	7:00	19:00
Total Storm Precip. (in)	0.53	0.66	2.41	0.83
Precip. Intensity (in/hr)	0.059	0.066	0.075	0.023
WL before Precip. (ft)	946.73	946.38	946.23	947.75
Comment				
Start WL rise time				
Date	10/19/94	11/10/94	11/27/94	12/4/94
Time	4:00	0:30	2:00	5:00
Delay WL from Start Precip.				
Date	10/19/94	11/10/94	11/27/94	12/4/94
Time (hrs)	0.0	2.5	1.0	9.0
Max WL (ft)	947.06	946.86	948.93	948.53
Date	10/20/94	11/11/94	11/30/94	12/6/94
Time	18:30	15:30	4:30	20:00
Water Level Change	0.33	0.48	2.70	0.78
Duration Peak (hrs)	0	2.0	1.5	2.5
Delay Peak WL from Peak Precip.				
Time (hrs)	33.5	38.5	69.5	49
Start Recession				
Date	10/21/94*	11/11/94	11/30/94	12/6/94
Time	9:00	17:30	6:00	22:30
End Recession				
Date	10/30/94	11/22/94	12/3/94	12/9/94
Time	22:00	2:30	18:30	10:30
Duration Recession (hrs)	229	248	84.5	60
Recession Complete?	Y	Y	N	N
RECESSION - Segment 1				
t duration (hrs)	229	248	84.5	60
Y (ft) - Max	947.12	946.86	948.93	948.53
Y (ft) - Min	946.73	946.38	947.75	948.15
Ln Slope (1/hr)	-2.06E-06	-1.91E-06	-1.65E-05	-7.29E-06
Correlation	0.886	0.968	0.971	0.975

* Recession started on 10/20/94 for storm 1. However, the subsequent small storm resulted in a small additional water level rise. Hence, recession was assumed to begin at 9:00 on 10/21/94.

Table B-34. GW-740 ambient monitoring data.

	Storm 1	Storm 2	Storm 3	Storm 4
Start Precip.				
Date	10/19/94	11/9/94	11/27/94	12/3/94
Time	4:00	23:00	1:00	20:00
Stop Precip.				
Date	10/19/94	11/10/94	11/28/94	12/5/94
Time	13:00	9:00	9:00	9:00
Duration Precip. (hrs)	9	10	32	36
Max Hourly Precip. (in)	0.22	0.31	0.31	0.09
Date	10/19/94	11/10/94	11/27/94	12/4/94
Time	9:00	1:00	7:00	19:00
Total Storm Precip. (in)	0.53	0.66	2.41	0.83
Precip. Intensity (in/hr)	0.059	0.066	0.075	0.023
WL before Precip. (ft)	947.15	946.47	946.33	947.8
Comment				Missing data
Start WL rise time				
Date	No	11/10/94	11/27/94	?
Time	Response	0:00	2:30	
Delay WL from Start Precip.				
Date		11/10/94	11/27/94	
Time (hrs)		1.0	1.5	
Max WL (ft)		946.99	949.06	948.6
Date		11/12/94	11/29/94	12/6/94
Time		14:00	14:30	11:00
Water Level Change		0.52	2.73	0.80
Duration Peak (hrs)		1.0	14.0	22
Delay Peak WL from Peak Precip.				
Time (hrs)		61.0	55.5	40
Start Recession				
Date		11/11/94	11/30/94	12/7/94
Time		15:00	4:30	9:00
End Recession				
Date		11/22/94	12/3/94	12/9/94
Time		21:30	18:00	10:30
Duration Recession (hrs)		270.5	85.5	50.5
Recession Complete?		Y	N	N
RECESSION - Segment 1				
t duration (hrs)		248	85.5	50.5
Y (ft) - Max		946.99	949.06	948.6
Y (ft) - Min		946.47	947.8	948.19
Ln Slope (1/hr)		-2.07E-06	-1.71E-05	-8.50E-06
Correlation		0.972	0.979	0.994

Table B-35. GW-167 ambient monitoring data.

	Storm 1	Storm 2	Storm 3A	Storm 3B
Start Precip.				
Date	2/20/94	2/22/94	3/1/94	3/1/94
Time	19:00	15:00	4:00	18:00
Stop Precip.				
Date	2/21/94	2/23/94	3/1/94	3/2/94
Time	10:00	8:00	17:00	20:00
Duration Precip. (hrs)	15	17	13	26
Max Hourly Precip. (in)	0.24	0.47	0.19	0.15
Date	2/21/94	2/23/94	3/1/94	3/2/94
Time	3:00	3:00	13:00	9:00 & 10:00
Total Storm Precip. (in)	1.44	2.33	1.1	1.17
Precip. Intensity (in/hr)	0.096	0.137	0.085	0.045
WL before Precip. (ft)	908.87	912.59	911.4	911.4
Comment	WL drop			
Start WL rise time				
Date	2/21/94	2/22/94	3/1/94	3/2/94
Time	4:30	15:30	13:00	8:00
Delay WL from Start Precip.				
Date	2/21/94	2/22/94	3/1/94	3/2/94
Time (hrs)	9.5	0.5	0.0	0.0
Max WL (ft)	913.93	921.74	917.02	920.1
Date	2/21/94	2/23/94	3/2/94	3/2/94
Time	15:00	14:00	7:00	21:00
Water Level Change	5.06	9.15	5.62	8.70
Duration Peak (hrs)	1	1.0 ?		1.5
Delay Peak WL from Peak Precip.				
Date	2/21/94	2/23/94	3/2/94	3/2/94
Time (hrs)	12	11.0	18.0	12
Start Recession				
Date	2/21/94	2/23/94	No	3/2/94
Time	16:00	15:00	Recession	23:30
End Recession				
Date	2/22/94	3/1/94		3/4/94
Time	15:00	10:30		11:00
Duration Recession (hrs)	23	139.5		35.5
Recession Complete?	N	Y (?)		N
RECESSION - Segment 1				
t duration (hrs)	23	71		36.5
Y (ft) - Max	913.93	921.74		920.1
Y (ft) - Min	912.59	914.22		916.29
Ln Slope (1/hr)	-6.78E-05	-1.21E-04		-1.29E-04
Correlation	0.974	0.994		0.984
RECESSION - Segment 2				
t (hrs)		69		
Y (ft) - Max		914.22		
Y (ft) - Min		911.32		
Ln Slope (1/hr)		-4.48E-05		
Correlation		0.979		

Table B-36. GW-220 ambient monitoring data.

	Storm 1	Storm 2	Storm 3A	Storm 3B
Start Precip.				
Date	2/20/94	2/22/94	3/1/94	3/1/94
Time	19:00	15:00	4:00	18:00
Stop Precip.				
Date	2/21/94	2/23/94	3/1/94	3/2/94
Time	10:00	8:00	17:00	20:00
Duration Precip. (hrs)	15	17	13	26
Max Hourly Precip. (in)	0.24	0.47	0.19	0.15
Date	2/21/94	2/23/94	3/1/94	3/2/94
Time	3:00	3:00	13:00	9:00 & 10:00
Total Storm Precip. (in)	1.44	2.33	1.1	1.17
Precip. Intensity (in/hr)	0.096	0.137	0.085	0.045
WL before Precip. (ft)	900.1	900.43	900.26	900.26
Comment				
Start WL rise time				
Date	2/21/94	2/22/94	3/1/94	3/2/94
Time	3:00	15:00	10:30	1:30
Delay WL from Start Precip.				
Date	2/21/94	2/22/94	3/1/94	3/2/94
Time (hrs)	8.0	0.0	7.5	7.5
Max WL (ft)	901.16	902.26	901.11	901.53
Date	2/21/94	2/23/94	3/1/94	3/2/94
Time	9:00	8:00	18:00	10:30
Water Level Change	1.06	1.83	0.85	1.27
Duration Peak (hrs)	0	0.0	?	0
Delay Peak WL from Peak Precip.				
Date	2/21/94	2/23/94	3/1/94	3/2/94
Time (hrs)	6	5.0	5.0	1.5
Start Recession				
Date	2/21/94	2/23/94	No	3/2/94
Time	13:30	13:00	Recession	10:30
End Recession				
Date	2/22/94	3/1/94		3/4/94
Time	8:00	4:30	3:30	11:00
Duration Recession (hrs)	19	135.5		48.5
Recession Complete?	N	Y(?)		N
RECESSION - Segment 1				
t duration (hrs)	2.5	7		3
Y (ft) - Max	901.16	902.26		901.53
Y (ft) - Min	900.66	901.51		901.32
Ln Slope (1/hr)	-1.34E-04	-5.65E-05		-8.40E-05
Correlation	0.967	0.956		0.923
t (hrs)	3	58		45.5
Y (ft) - Max	900.66	901.51		901.32
Y (ft) - Min	900.51	900.58		900.73
Ln Slope (1/hr)	-5.63E-05	-1.74E-05		-1.81E-05
Correlation	0.969	0.983		0.992
RECESSION - Segment 3				
t (hrs)	13.5	70.5		?
Y (ft) - Max	900.51	900.58		
Y (ft) - Min	900.35	900.26		
Ln Slope (1/hr)	-1.14E-05	-5.11E-06		
Correlation	0.947	0.974		

Note: Data for recession from storm 1 is taken from the second peak at 2/21/94, 13:30 AM.

Table B-37. GW-603 ambient monitoring data.

	Storm 1	Storm 2	Storm 3A	Storm 3B
Start Precip.				
Date	2/20/94	2/22/94	3/1/94	3/1/94
Time	19:00	15:00	4:00	18:00
Stop Precip.				
Date	2/21/94	2/23/94	3/1/94	3/2/94
Time	10:00	8:00	17:00	20:00
Duration Precip. (hrs)	15	17	13	26
Max Hourly Precip. (in)	0.24	0.47	0.19	0.15
Date	2/21/94	2/23/94	3/1/94	3/2/94
Time	3:00	3:00	13:00	9:00 & 10:00
Total Storm Precip. (in)	1.44	2.33	1.1	1.17
Precip. Intensity (in/hr)	0.096	0.137	0.085	0.045
WL before Precip. (ft)	905.38	905.91	905.83	905.83
Comment	WL drop			
Start WL rise time				
Date	2/21/94	2/22/94	3/1/94	?
Time	7:00	22:30	12:30	
Delay WL from Start Precip.				
Date	2/21/94	2/22/94	3/1/94	?
Time (hrs)	12.0	7.5	8.5	
Max WL (ft)	905.95	911.48		909.57
Date	2/22/94	2/23/94		3/2/94
Time	1:30	18:00		23:00
Water Level Change	0.57	5.57		3.74
Duration Peak (hrs)	3.5	0.5		2
Delay Peak WL from Peak Precip.				
Date	2/22/94	2/23/94		3/2/94
Time (hrs)	22.5	15.0		14.5
Start Recession				
Date	2/22/94	2/23/94	No	3/3/94
Time	4:00	18:00	Recession	0:30
End Recession				
Date	2/22/94	2/28/94		3/4/94
Time	15:00	9:00		10:30
Duration Recession (hrs)	11	111		34
Recession Complete?	N	Y		N
RECESSION - Segment 1				
t duration (hrs)	No	27		10.5
Y (ft) - Max	Recession	911.48		909.57
Y (ft) - Min		908.81		908.95
Ln Slope (1/hr)		-1.20E-04		-6.10E-05
Correlation		0.991		0.95
RECESSION - Segment 2				
t (hrs)		43		23.5
Y (ft) - Max		908.81		908.95
Y (ft) - Min		906.47		907.9
Ln Slope (1/hr)		-5.59E-05		-4.77E-05
Correlation		0.99		0.99
RECESSION - Segment 3				
t (hrs)		41		
Y (ft) - Max		906.47		
Y (ft) - Min		905.87		
Ln Slope (1/hr)		-1.40E-05		
Correlation		0.876		

Table B-38. GW-604 ambient monitoring data.

	Storm 1	Storm 2	Storm 3A	Storm 3B
Start Precip.				
Date	2/20/94	2/22/94	3/1/94	3/1/94
Time	19:00	15:00	4:00	18:00
Stop Precip.				
Date	2/21/94	2/23/94	3/1/94	3/2/94
Time	10:00	8:00	17:00	20:00
Duration Precip. (hrs)	15	17	13	26
Max Hourly Precip. (in)	0.24	0.47	0.19	0.15
Date	2/21/94	2/23/94	3/1/94	3/2/94
Time	3:00	3:00	13:00	9:00 & 10:00
Total Storm Precip. (in)	1.44	2.33	1.1	1.17
Precip. Intensity (in/hr)	0.096	0.137	0.085	0.045
WL before Precip. (ft)	905.59*	906.37	906.37	906.37
Comment	WL drop			
Start WL rise time				
Date	2/21/94	2/22/94	3/1/94	?
Time	7:00	22:30	16:00	
Delay WL from Start Precip.				
Date	2/21/94	2/22/94	3/1/94	?
Time (hrs)	12.0	7.5	8.0	
Max WL (ft)	906.37	911.46	No Max	909.68
Date	2/22/94	2/23/94		3/3/94
Time	4:00	20:30		0:00
Water Level Change	0.78	5.09		3.31
Duration Peak (hrs)	17.3?	0.0		1.5
Delay Peak WL from Peak Precip.				
Date	2/22/94	2/23/94		3/3/94
Time (hrs)	25	17.5		15
Start Recession				
Date	No	2/23/94	No	3/3/94
Time	Recession	20:30	Recession	1:30
End Recession				
Date		3/1/94		3/4/94
Time		10:30		10:00
Duration Recession (hrs)		134		32.5
Recession Complete?		Y		N
RECESSION - Segment 1				
t duration (hrs)		20		8
Y (ft) - Max		911.46		909.68
Y (ft) - Min		909.56		909.33
Ln Slope (1/hr)		-1.13E-04		-4.91E-05
Correlation		0.992		0.958
RECESSION - Segment 2				
t (hrs)		41		24.5
Y (ft) - Max		909.56		909.33
Y (ft) - Min		907.48		908.37
Ln Slope (1/hr)		-5.16E-05		-4.39E-05
Correlation		0.994		0.994
RECESSION - Segment 3				
t (hrs)		73		
Y (ft) - Max		907.48		
Y (ft) - Min		906.34		
Ln Slope (1/hr)		-1.64E-05		
Correlation		0.982		

* WL just before water level began to rise

Table B-39. GW-733 ambient monitoring data.

	Storm 1	Storm 2	Storm 3A	Storm 3B
Start Precip.				
Date	2/20/94	2/22/94	3/1/94	3/1/94
Time	19:00	15:00	4:00	18:00
Stop Precip.				
Date	2/21/94	2/23/94	3/1/94	3/2/94
Time	10:00	8:00	17:00	20:00
Duration Precip. (hrs)	15	17	13	26
Max Hourly Precip. (in)	0.24	0.47	0.19	0.15
Date	2/21/94	2/23/94	3/1/94	3/2/94
Time	3:00	3:00	13:00	9:00 & 10:00
Total Storm Precip. (in)	1.44	2.33	1.1	1.17
Precip. Intensity (in/hr)	0.096	0.137	0.085	0.045
WL before Precip. (ft)	905.71*	906.69	906.78	906.37
Comment	WL drop			
Start WL rise time				
Date	2/21/94	2/22/94	3/1/94	?
Time	8:00	21:00	16:00	
Delay WL from Start Precip.				
Date	2/21/94	2/22/94	3/1/94	?
Time (hrs)	13.0	6.0	8.0	
Max WL (ft)	906.69	911.04	No Max	910.09
Date	2/22/94	2/24/94		3/3/94
Time	16:30	1:00		5:30
Water Level Change	0.10	4.35		3.72
Duration Peak (hrs)	4	3.5		1.5
Delay Peak WL from Peak Precip.				
Date	2/22/94	2/24/94		3/3/94
Time (hrs)	37.5	22.0		20
Start Recession				
Date	No	2/24/94	No	3/3/94
Time	Recession	3:30	Recession	7:00
End Recession				
Date		3/1/94		3/4/94
Time		13:30		10:00
Duration Recession (hrs)		130		27
Recession Complete?		Y (?)		N
RECESSION - Segment 1				
t duration (hrs)		58		27
Y (ft) - Max		911.04		910.09
Y (ft) - Min		908.33		909.19
Ln Slope (1/hr)		-5.22E-05		-3.83E-05
Correlation		0.995		0.998
RECESSION - Segment 2				
t (hrs)		72		
Y (ft) - Max		908.33		
Y (ft) - Min		906.78		
Ln Slope (1/hr)		-2.32E-05		
Correlation		0.984		

* WL just before water level began to rise

Table B-40. GW-734 ambient monitoring data, 1992.

	Storm 1	Storm 2
Start Precip.		
Date	2/25/92	3/10/92
Time	7:00	3:00
Stop Precip.		
Date	2/26/92	3/10/92
Time	10:00	9:00
Duration Precip. (hrs)	27	6
Max Hourly Precip. (in)	0.13	0.36
Date	2/25/92	3/10/92
Time	19:00	5:00
Total Storm Precip. (in)	1.44	0.92
Precip. Intensity (in/hr)	0.053	0.153
WL before Precip. (ft)	901	901.53
Comment		WL drop
Start WL rise time		
Date	2/25/92	3/10/92
Time	9:08	4:08
Delay WL from Start Precip.		
Date	2/25/92	3/10/92
Time (hrs)	2.0	0.0
Max WL (ft)	906.3	903.77
Date	2/26/92	3/10/92
Time	12:08	12:08
Water Level Change	5.30	2.24
Duration Peak (hrs)	0	0.0
Delay Peak WL from Peak Precip.		
Date	2/26/92	3/10/92
Time (hrs)	17	7.0
Start Recession		
Date	2/26/92	3/10/92
Time	12:08	12:08
End Recession		
Date	3/5/92	3/16/92
Time	23:08	23:08
Duration Recession (hrs)	203	155
Recession Complete?	N	Y (?)
RECESSION - Segment 1		
t duration (hrs)	21	8.5
Y (ft) - Max	906.3	903.77
Y (ft) - Min	904.12	902.87
Ln Slope (1/hr)	-1.10E-04	-1.20E-04
Correlation	0.966	0.946
RECESSION - Segment 2		
t (hrs)	74	17
Y (ft) - Max	904.12	902.87
Y (ft) - Min	902.31	902.42
Ln Slope (1/hr)	-2.60E-05	-2.70E-05
Correlation	0.989	0.983
RECESSION - Segment 3		
t (hrs)	108	129.5
Y (ft) - Max	902.31	902.42
Y (ft) - Min	901.44	901.45
Ln Slope (1/hr)	-7.80E-06	-8.90E-06
Correlation	0.954	0.987

Table B-41. GW-734 ambient monitoring data, 1994.

	Storm 1	Storm 2	Storm 3A	Storm 3B
Start Precip.				
Date	2/20/94	2/22/94	3/1/94	3/1/94
Time	19:00	15:00	4:00	18:00
Stop Precip.				
Date	2/21/94	2/23/94	3/1/94	3/2/94
Time	10:00	8:00	17:00	20:00
Duration Precip. (hrs)	15	17	13	26
Max Hourly Precip. (in)	0.24	0.47	0.19	0.15
Date	2/21/94	2/23/94	3/1/94	3/2/94
Time	3:00	3:00	13:00	9:00 & 10:00
Total Storm Precip. (in)	1.44	2.33	1.1	1.17
Precip. Intensity (in/hr)	0.096	0.137	0.085	0.045
WL before Precip. (ft)	903.77	905.6	904.7	904.7
Comment	WL drop	WL drop	WL drop	
Start WL rise time				
Date	2/21/94	2/22/94	3/1/94	3/2/94
Time	4:30	18:00	13:00	8:30
Delay WL from Start Precip.				
Date	2/21/94	2/22/94	3/1/94	3/2/94
Time (hrs)	9.5	3.0	9.5	0.0
Max WL (ft)	907.66	916.16	910.12	913.36
Date	2/21/94	2/23/94	3/2/94	3/2/94
Time	12:30	10:30	3:30	14:00
Water Level Change	3.89	10.56	5.42	8.66
Duration Peak (hrs)	1	0.0	0.0	0
Delay Peak WL from Peak Precip.				
Date	2/21/94	2/23/94	3/2/94	3/2/94
Time (hrs)	9.5	7.5	14.5	5
Start Recession				
Date	2/21/94	2/23/94	3/2/94	3/2/94
Time	13:30	10:30	3:30	14:00
End Recession				
Date	2/22/94	3/1/94	3/2/94	3/4/94
Time	18:00	11:00	8:00	9:30
Duration Recession (hrs)	28.5	144.5	4.5	43.5
Recession Complete?	N	Y (?)	N	N
RECESSION - Segment 1				
t duration (hrs)	12	24		18
Y (ft) - Max	907.66	916.16		913.36
Y (ft) - Min	906.33	910.79		910.3
Ln Slope (1/hr)	-1.34E-04	-2.63E-04		-1.66E-04
Correlation	0.995	0.995		0.992
RECESSION - Segment 2				
t (hrs)	11	26		25.5
Y (ft) - Max	906.33	910.79		910.3
Y (ft) - Min	905.66	908.05		908.07
Ln Slope (1/hr)	-7.75E-05	-1.19E-04		-1.14E-04
Correlation	0.989	0.993		0.989
RECESSION - Segment 3				
t (hrs)	>5.5?	94.5		
Y (ft) - Max		908.05		
Y (ft) - Min		904.7		
Ln Slope (1/hr)		-3.68E-05		
Correlation		0.939		

Table B-42. GW-735 ambient monitoring data.

	Storm 1	Storm 2	Storm 3A	Storm 3B
Start Precip.				
Date	2/20/94	2/22/94	3/1/94	3/1/94
Time	19:00	15:00	4:00	18:00
Stop Precip.				
Date	2/21/94	2/23/94	3/1/94	3/2/94
Time	10:00	8:00	17:00	20:00
Duration Precip. (hrs)	15	17	13	26
Max Hourly Precip. (in)	0.24	0.47	0.19	0.15
Date	2/21/94	2/23/94	3/1/94	3/2/94
Time	3:00	3:00	13:00	9:00 & 10:00
Total Storm Precip. (in)	1.44	2.33	1.1	1.17
Precip. Intensity (in/hr)	0.096	0.137	0.085	0.045
WL before Precip. (ft)	904.33*	906.7	905.79*	905.81
Comment	WL drop		WL Drop	
Start WL rise time				
Date	2/21/94	2/22/94	3/1/94	?
Time	5:00	18:00	13:30	
Delay WL from Start Precip.				
Date	2/21/94	2/22/94	3/1/94	?
Time (hrs)	10.0	3.0	9.5	
Max WL (ft)	907.46	913.71	909.77	912.1
Date	2/21/94	2/23/94	3/2/94	3/2/94
Time	13:00	11:00	5:00	16:30
Water Level Change	3.13	7.01	3.98	6.29
Duration Peak (hrs)	1	0.5	0.5	0.5
Delay Peak WL from Peak Precip.				
Date	2/21/94	2/23/94	3/2/94	3/2/94
Time (hrs)	10	8.0	16.0	7.5
Start Recession				
Date	2/21/94	2/23/94	No	3/2/94
Time	14:00	11:30	Recession	17:00
End Recession				
Date	2/22/94	3/1/94		3/4/94
Time	14:00	12:30		9:00
Duration Recession (hrs)	24	145		40
Recession Complete?	N	Y		N
RECESSION - Segment 1				
t duration (hrs)	8	23.5		17
Y (ft) - Max	907.46	913.71		912.1
Y (ft) - Min	907.09	911.27		910.79
Ln Slope (1/hr)	-5.44E-05	-1.17E-04		-8.48E-05
Correlation	0.996	0.996		0.979
RECESSION - Segment 2				
t (hrs)	16	47		23
Y (ft) - Max	907.09	911.27		910.79
Y (ft) - Min	906.7	908.32		909.33
Ln Slope (1/hr)	-2.79E-05	-6.64E-05		-6.82E-05
Correlation	0.989	0.993		0.994
RECESSION - Segment 3				
t (hrs)		74.5		
Y (ft) - Max		908.32		
Y (ft) - Min		905.79		
Ln Slope (1/hr)		-3.73E-05		
Correlation		0.996		

* WL just before water level began to rise

Table B-43. GW-748 ambient monitoring data.

	Storm 1	Storm 2	Storm 3A	Storm 3B
Start Precip.				
Date	2/20/94	2/22/94	3/1/94	3/1/94
Time	19:00	15:00	4:00	18:00
Stop Precip.				
Date	2/21/94	2/23/94	3/1/94	3/2/94
Time	10:00	8:00	17:00	20:00
Duration Precip. (hrs)	15	17	13	26
Max Hourly Precip. (in)	0.24	0.47	0.19	0.15
Date	2/21/94	2/23/94	3/1/94	3/2/94
Time	3:00	3:00	13:00	9:00 & 10:00
Total Storm Precip. (in)	1.44	2.33	1.1	1.17
Precip. Intensity (in/hr)	0.096	0.137	0.085	0.045
WL before Precip. (ft)	915.09	916.09	915.12	915.12
Comment	WL drop			
Start WL rise time				
Date	2/21/94	?	3/1/94	?
Time	3:30		13:00	
Delay WL from Start Precip.				
Date	2/21/94	?	3/1/94	?
Time (hrs)	8.5		9.0	
Max WL (ft)	916.09	916.68	No Peak	916.35
Date	2/22/94	2/23/94		3/3/94
Time	8:30	16:00		0:30
Water Level Change	3.13	0.59		1.23
Duration Peak (hrs)	2.5	2.0		5
Delay Peak WL from Peak Precip.				
Date	2/21/94	2/23/94		3/3/94
Time (hrs)	22.5	13.0		15.5
Start Recession				
Date		2/23/94	No	3/3/94
Time		18:30	Recession	5:30
End Recession				
Date		3/1/94		3/4/94
Time		9:00		11:30
Duration Recession (hrs)		135		30
Recession Complete?		?		N
RECESSION - Segment 1				
t duration (hrs)		65		6
Y (ft) - Max		916.68		916.35
Y (ft) - Min		915.75		916.29
Ln Slope (1/hr)		-1.53E-05		-1.12E-05
Correlation		0.976		0.956
RECESSION - Segment 2				
t (hrs)		70		24
Y (ft) - Max		915.75		916.29
Y (ft) - Min		915.11		916.12
Ln Slope (1/hr)		-1.01E-05		-7.12E-06
Correlation		0.969		0.992

Table B-44. GW-750 ambient monitoring data.

	Storm 1	Storm 2	Storm 3A	Storm 3B
Start Precip.				
Date	2/20/94	2/22/94	3/1/94	3/1/94
Time	19:00	15:00	4:00	18:00
Stop Precip.				
Date	2/21/94	2/23/94	3/1/94	3/2/94
Time	10:00	8:00	17:00	20:00
Duration Precip. (hrs)	15	17	13	26
Max Hourly Precip. (in)	0.24	0.47	0.19	0.15
Date	2/21/94	2/23/94	3/1/94	3/2/94
Time	3:00	3:00	13:00	9:00 & 10:00
Total Storm Precip. (in)	1.44	2.33	1.1	1.17
Precip. Intensity (in/hr)	0.096	0.137	0.085	0.045
WL before Precip. (ft)	911.89	913.41	912.72	912.73
Comment	WL drop			
Start WL rise time				
Date	2/21/94	2/22/94	3/1/94	?
Time	3:30	19:30	12:30	
Delay WL from Start Precip.				
Date	2/21/94	2/22/94	3/1/94	?
Time (hrs)	8.5	4.5	8.5	
Max WL (ft)	913.48	915.86	No Peak	915.39
Date	2/22/94	2/23/94		3/3/94
Time	3:00	16:30		1:30
Water Level Change	3.13	2.45		2.66
Duration Peak (hrs)		1.5		0.5
Delay Peak WL from Peak Precip.				
Date	2/22/94	2/23/94		3/3/94
Time (hrs)	24	13.5		16.5
Start Recession				
Date	No	2/23/94	No	3/3/94
Time	Recession	18:00	Recession	2:00
End Recession				
Date		3/1/94		3/4/94
Time		10:30		8:30
Duration Recession (hrs)		128		30.5
Recession Complete?		N		N
RECESSION - Segment 1				
t duration (hrs)		128		9
Y (ft) - Max		915.86		915.39
Y (ft) - Min		912.73		915.32
Ln Slope (1/hr)		-2.72E-05		-1.14E-05
Correlation		0.990		0.937
RECESSION - Segment 2				
t (hrs)				21.5
Y (ft) - Max				915.32
Y (ft) - Min				914.7
Ln Slope (1/hr)				-2.09E-05
Correlation				0.923

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