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Controls on the Spatial Distribution of Ground-water Recharge in Washington County, Wisconsin

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ABSTRACT

Groundwater recharge has been measured indirectly by separating baseflow from streamflow hydrographs in 11 small watersheds in southeastern Wisconsin. Over a two year study period, observed recharge rates at these sites and additional test locations ranged from 3 to 25 cm/yr. The majority of observations fell in a smaller range, from 10 to 14 cm/yr.

The spatial distribution of recharge (R) was linked to independent topographic, hydrogeologic, land use and climatic conditions. The latter was eliminated by normalizing recharge to annual precipitation (P), as R/P. Normalized recharge for the study area ranged between 0.03 and 0.26 (3 to 26% of precipitation recharges the groundwater). The normalized values were then shown to vary directly with soil permeability, length of overland flow and the portion of the land surface remaining natural. It varies inversely with hillslope, depth to water table and amount of developed land use. The relation developed to predict R/P from these independent variables accounts for 91% of its spatial variation in Year 1 of the study, the year from which the relation was developed.

The relation was able to predict R/P at independent test sites for the same year to within $\pm$ 19%. The predictions were most accurate for drainage areas in the range of 3 to 225 km^2. Use of the relation for a second year of record required adjusting it for climatic differences between the years. After those adjustments, prediction was accurate to within $\pm$ 30% in the study area sites and $\pm$ 40% in outside test sites. The reduction in accuracy suggests that the climatic corrections need further refinement. All the testing has been done in southeastern Wisconsin, so it is not known whether the relation can be used elsewhere.

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INTRODUCTION

Hundreds of thousands of people in Wisconsin rely on ground water as their sole source of water supply. Yet the rate at which their ground-water resource is recharged is usually unknown. Recharge is a difficult flux to measure in the hydrologic system, because it's diffuse and variable in both space and time. Most estimates that are available stem either from calculation of recharge as the residual in a water budget analysis or from calibration of ground-water flow models. Both have inherent uncertainties. Water budgets frequently involve calculating small differences between large terms, resulting in substantial cumulative error in the residual term. Ground-water models, on the other hand, frequently assume that recharge is constant in space and/or time. Even today, when the best models use both head and flux targets to constrain their result, the calibration process cannot produce a unique recharge distribution.

In southeastern Wisconsin, recharge rates have been estimated as ranging between 1 and 25 cm/yr (Cherkauer and Bacon, 1978; Young and Batten, 1980; Wehrheim, 1989; Rovey, 1983; Nader, 1990; Clite, 1992; Mueller, 1992; Mulvey, 1995; Carlson, 1999). With the exception of the first three references, these estimates are all from ground-water flow models. Those models done before Carlson (1999) had no flux targets to use; their calibrations are based only on matching heads, which is now known to produce strong uncertainty in the recharge values.

The range of recharge estimates from these earlier studies is overly broad. For the sake of proper management of ground-water resources in the areas around Milwaukee, it is incumbent to have better measures of the amount of recharge which occurs and also a way to extrapolate those values to areas where the measurements have not been made.

OBJECTIVES

This report presents the results of a project which was undertaken to fill the need described above. Specifically it had three objectives:

1. For a representative area, obtain a reliable measure of the actual ground-water recharge rate,
2. Determine what independent factors control the spatial distribution of that recharge, and
3. Test the relations between recharge and independent factors to determine their reliability and extrapolatability to areas outside the study area.

If at all possible, it was desired that the independent factors used in the study should be readily measurable, so that the results of the study could be used as widely as possible.

METHODS

The direct measurement of recharge is generally highly site-specific(Wu, et al., 1996; Mau and Winter, 1997). In an effort to quantify recharges over broader areas, this project has therefore used the indirect method of baseflow separation from total stream discharge. This procedure has been shown to be a viable means of estimating recharge (Arnold and Allen, 1999). It uses the stream drainage system to integrate a hydrologic response over the entire drainage basin, thus reducing the problem of site-specificity.

The baseflow separation method is based on the following. A simple ground-water budget equation for a small watershed can be written as:

$$I + GW_{in} = Q_{bf} + GW_{out} + ET + NP + S/t, \quad (1)$$

where:
- I = infiltration to the system (total recharge),
- Gw_{in} = ground-water influx to the watershed through aquifers,
- Q_{bf} = ground-water discharge to stream baseflow,
- Gw_{out} = ground-water efflux beneath the surface divide through aquifers
- ET = evapotranspiration losses from the watershed,
- NP = net pumpage of ground water by humans into or out of the watershed,
- S/t = the rate of change of ground-water storage with respect to time.

If watersheds can be selected where, $GW_{in} = GW_{out} = NP = S/t = 0$, and if net ground-water recharge is defined as (I - ET), then equation (1) degenerates to:

$$\text{Net recharge} = Q_{bf} = \text{Stream baseflow}. \quad (2)$$

In order to meet these conditions, a watershed should have coincident surface and ground-water divides, no human transfers of water across those divides and ground-water storages which don't change significantly from year to year. If these conditions are met, then recharge can be obtained indirectly by separating the baseflow component from total streamflow. Hydrograph separation inherently assumes that direct surface runoff and ground-water discharge are the only components of streamflow. Thus watersheds with significant surface storage locations (lakes, wetlands) must also be avoided.

The procedures used in this study were then:

1. Select field measurement sites which meet the basic criteria listed above,
2. Monitor streamflow at the sites to obtain an annual hydrograph for each watershed,
3. Monitor precipitation at relevant sites to allow quantification across the study watersheds,
4. Separate baseflow (ground-water discharge) from total streamflow,

5. Link the spatial variability of that baseflow to topographic, hydrogeologic and anthropogenic properties of each watershed, and
6. Test the reliability of the relations developed in Step 5.

Site Selection

Southern Washington County was chosen as the primary focus of the study. It is traversed by the Kettle Moraine, which provides sufficient local topographic relief that surface and ground-water drainage divides generally coincide. It is underlain by a shallow aquifer system which is either sand and gravel in the glacial deposits or Silurian dolomite or both. The shallow aquifer is separated from a deeper sandstone aquifer by the Maquoketa Shale, which serves as a base to the shallow system. With the exception of the southern portions of the Village of Germantown, all residents obtain their water from wells in the shallow aquifer and return treated wastewater to that same aquifer via septic systems. Hence there is no significant human transfer of water into or out of the area. In addition, water levels in local wells show no long term changes (Cherkauer, 1999) (personal observation).

A total of ten contiguous watersheds on five small streams (Figure 1) were selected for study. Comparisons of topographic and water table (Young and Batten, 1980) maps show that the surface and subsurface divides are largely coincident. Only very small portions of two of the watersheds drain the parts of Germantown served by sanitary sewers. Several sets of these watersheds are nested along the same stream, which allows determination of how baseflow changes downstream.

These ten watersheds are in an area where land use is primarily agricultural, residential or low-density commercial or industrial. In order to extend the recharge analysis to more urban land uses, an additional watershed, the Kinnickinnic in eastern Milwaukee County, was added to the list of study watersheds. It's monitored continuously for streamflow by the US Geological Survey. Water table maps for this watershed are quite dated, so it has not been possible to check it for coincidence of divides. However, there is no significant ground-water pumpage or artificial recharge in the watershed, so it's believed that it meets the selection criteria reasonably well.

Streamflow Monitoring

Monitoring sites within the watersheds of interest were selected based on the availability of access to the stream. Many are in the public right-of-way along highways, but some required access permission from private landowners. The actual gaging site was selected in accordance with the criteria presented in Buchanon and Somers (1969). At each site, a staff gage was established. In many cases this was a permanent point on a bridge abutment or culvert; in others, a pipe was driven into the stream bed.

Water levels were measured on the staff gage between one and three times each week. Frequency varied with the season, with measurements made only weekly in the winter months when the ground was frozen, biweekly in the summer and fall and as often as three times a week during the spring and early summer. Flow at the monitoring site was gaged using a pygmy Price

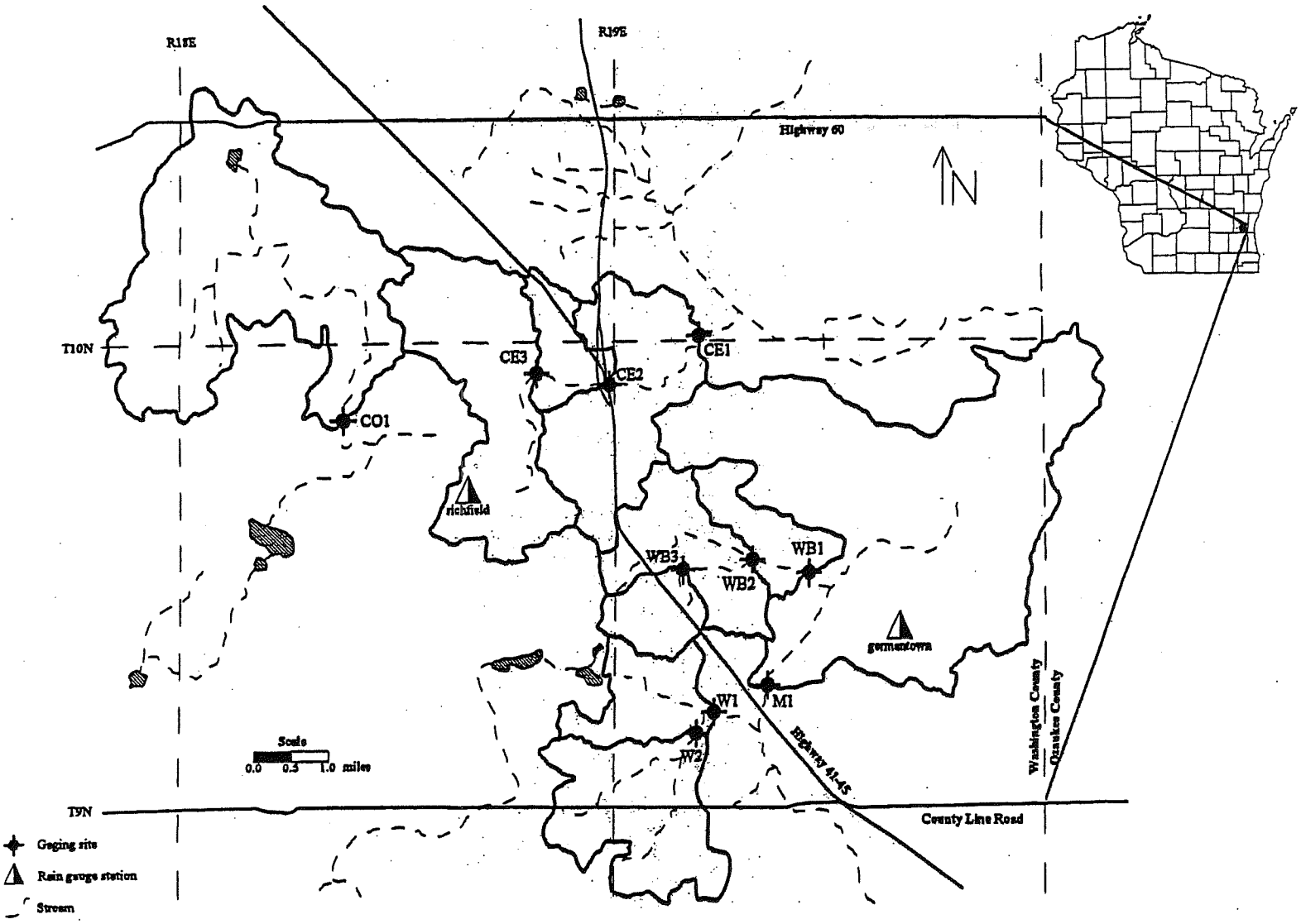

Figure 1. Location map of the study watersheds. Dashed lines are streams with gaging sites shown. Solid lines are drainage divides, and cross-hatched areas are lakes. Precipitation stations at Richfield and Germantown are shown; Hartford is approximately 2 km west of the map on Highway 60. The Kinnickinnic watershed is 40 km to the southeast and not shown.

meter and following USGS gaging standards (Buchanon and Somers, 1969). The full gagings were done as frequently as needed to establish a consistent and reproducible rating curve for the site. At most sites, the rating curve changed seasonally, particularly when trees dropped their foliage in the fall. Typically a full gaging was done at each site between 20 and 35 times each year.

With establishment of a rating curve, discharge at a site could be calculated from the gage height reading for those dates when a full gaging was not done. A discharge was then calculated for each monitoring date and plotted against time as a stream hydrograph. The rating curves, monitoring data and hydrographs for each site are provided in Appendix I, II and III, respectively. It should be noted that these hydrographs are not the result of continuous recording; discharges have been interpolated between actual monitoring dates, which are three to seven days apart.

Precipitation Monitoring

Precipitation provides the amount of water available to become ground-water recharge. Because precipitation does not occur uniformly in space, it's necessary to measure it at a number of locations around the study area and then interpolate values between the recording stations. In this study, data from four sites were used. For the ten contiguous watersheds in Washington County, precipitation from NOAA stations at Hartford and Germantown and a private site maintained by the PI and shown on Figure 1 were used. For the Kinnickinnic River site, data from the NOAA site at General Mitchell International Airport in Milwaukee were used.

Measurements were made daily and recorded as 24 hour totals. Snowfall has been expressed as its water equivalent. One problem with the precipitation monitoring system is that only measures new snowfall. The water equivalent of snow on the ground was not recorded, so there was no way to assess how much water may have been available for recharge during a single snowmelt event.

Values for the precipitation in each study watershed were interpolated from the recording stations using the Thiessen polygon method (Fetter, 1994). The weights applied to each recording station's value are listed in Table 1.

Hydrograph Separation

Baseflow has been separated from total streamflow presented in the hydrographs both manually and using a computer-automated technique. The manual method was presented by Linsley et al (1982) and is depicted in Figure 2. It was developed for single events and has been modified here for use with an entire year's hydrograph. The hydrograph is plotted semi-logarithmically (log discharge plotted against time on an arithmetic scale). A persistent baseflow recession rate (slope of the hydrograph) is identified by looking at the distribution of observed discharge minima. This recession rate is then maintained throughout the year by drawing parallel recession curves through discharge minima. For each streamflow event that represents a recharge event (significant flow peak at times when the ground is not frozen), the post-event recession is extrapolated backward in time to a point N days after the streamflow peak. [N is

Table 1. Thiessen polygon weights for calculation of mean precipitation in study watersheds.

Watershed	Germantown	Watershed	Germantown	Richfield
Cedar 1	0.00	0.00	0.00	1.00
Cedar 2	0.00	0.00	0.00	1.00
Cedar 3	0.00	0.00	0.00	1.00
Coney	0.00	0.45	0.00	0.55
Kinnickinnic	0.00	0.00	1.00	0.00
Menomonee	0.80	0.00	0.00	0.20
W. Branch 1	0.60	0.00	0.00	0.40
W. Branch 2	0.50	0.00	0.00	0.50
W. Branch 3	0.30	0.00	0.00	0.70
Willow 1	0.60	0.00	0.00	0.40
Willow 2	0.70	0.00	0.00	0.30

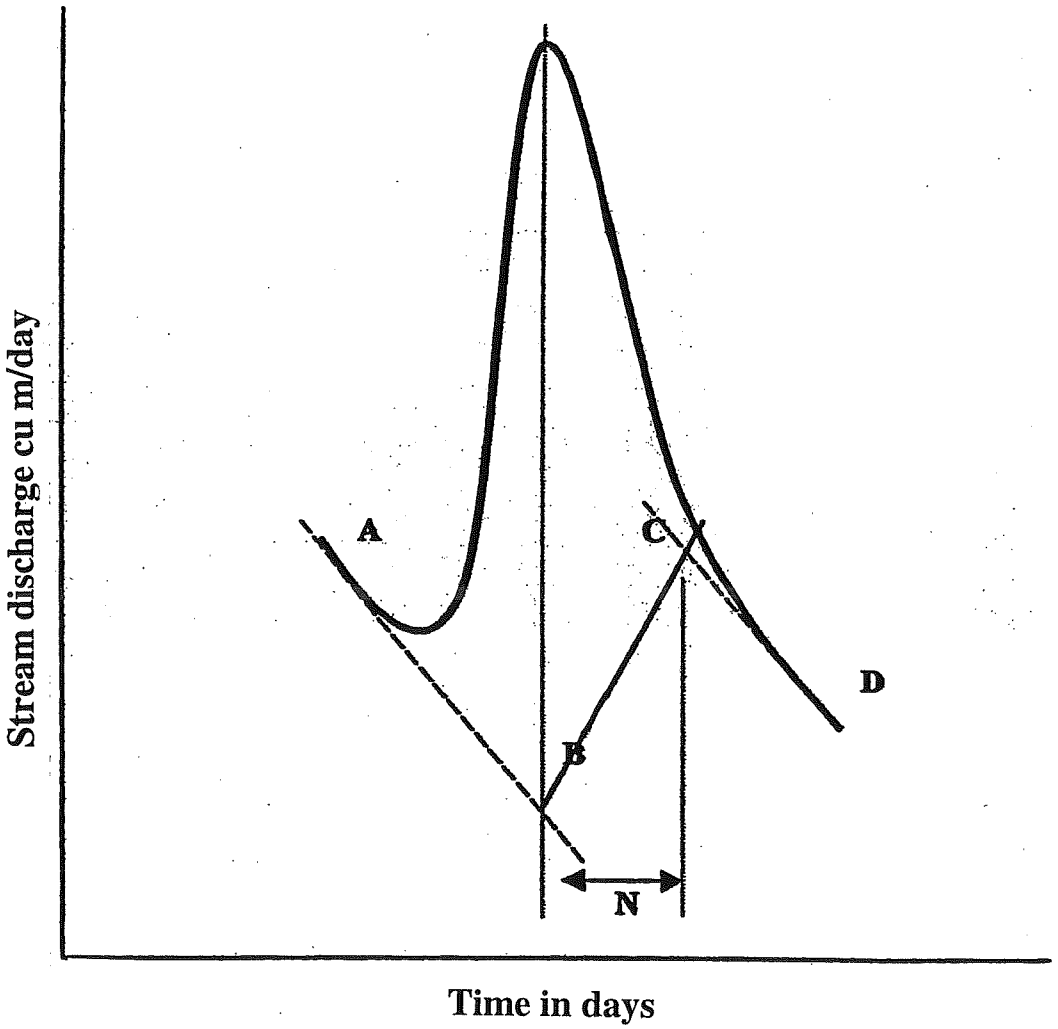

Figure 2. Depiction of process used for manual separation of stream hydrograph. For each recharge event (precipitation > 1 cm in non-frozen months), the pre-event recession is continued to the time of the flow peak (segment AB), the post-event recession is extrapolated back to a point N days after the peak (CD) and CB is joined linearly. $N = A_d^{0.2}$ (adapted from Linsley et al., 1982).

defined as $N = A_d^{0.2}$, where A_d is the drainage area in mi^2.] The pre-event baseflow recession is extrapolated forward in time to the point under the flood peak, and the two extrapolated curves are then joined as shown on Figure 2. The application of the method to the Menomonee River site's hydrograph is shown in Figure 3a. The area under the separation line is the total baseflow for the year. Transformation of the baseflow recession line to arithmetic scale allows direct measurement of the annual baseflow (area under the curve in Figure 3b).

The automated procedure is based on the recession curve displacement method developed by Rorabaugh (1964) and modified by Daniel (1996). Recently, Rutledge (1993, 1997) has computerized the process, which is depicted in Figure 4. The programs provided with Rutledge (1993) require the input of daily streamflows, so daily values for each monitoring site were interpolated from the manual hydrographs. The procedure used for the study watersheds is fully described in Ansari (1999). There is some disagreement over whether the Rutledge programs overestimate baseflow. Mayer and Jones (1996) argue that it does, while Arnold and Allen (1999) indicate it does not. The automated values will be compared to the manual values in this study to resolve that issue.

The study watersheds meet the criteria required for the establishment of Equation 2. Therefore, the baseflow separated at each site will be equated to the ground-water recharge which has occurred in each watershed draining to the monitoring site. From this point on in the report, the baseflow from each site will be referred to as recharge.

Relation of Recharge to Controlling Parameters

The amount of recharge which occurs within a watershed should be dependent upon a number of independent controlling factors. For example, it's intuitive that recharge should increase as rainfall increases. In addition, the nature of the underlying geologic materials, the topographic configuration of the watershed and the land use within the watershed should all exert some control on how much of the precipitation can actually infiltrate to become recharge. The collection of the precipitation data has already been addressed. Determination of the topographic, hydrogeologic and land use information follows. Once these measurement were made, they were treated as independent variables and linked to recharge (as the dependent variable) using multiple regression.

The watersheds are treated as serially-linked, independent land areas. The topography and other controlling factors have been measured for the drainage area contributing to the stream between the station of interest and the next one upstream. Similarly the streamflows (both total and baseflow) have been calculated as the gain from the upstream site to the one of interest.

Topography

Within each watershed drainage area and density, average hillslope, total relief and the length and gradient of the main channel were measured from 1:24,000 topographic maps. On the topographic map, the surface drainage divide and all channels which show up as crenulations in the contours were drawn. Drainage area, the area inside the divide, was then measured with a

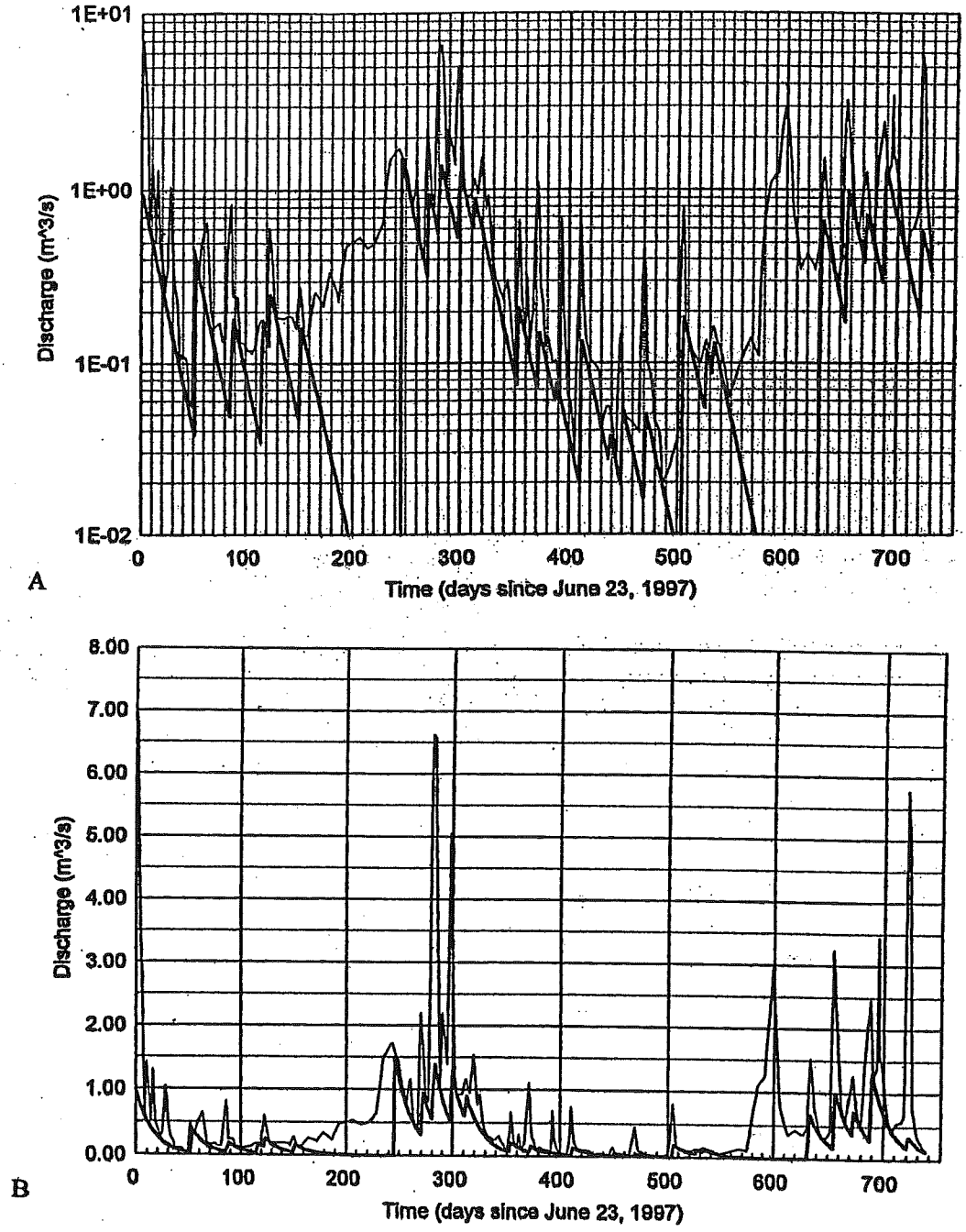

Figure 3. Two year hydrograph for the Menomonee River site showing separation. A. Semi-log plot with total discharge as the light line and baseflow as the dark. B. Transformation of A to arithmetic axes. The two periods of very low baseflow are when the ground was frozen.

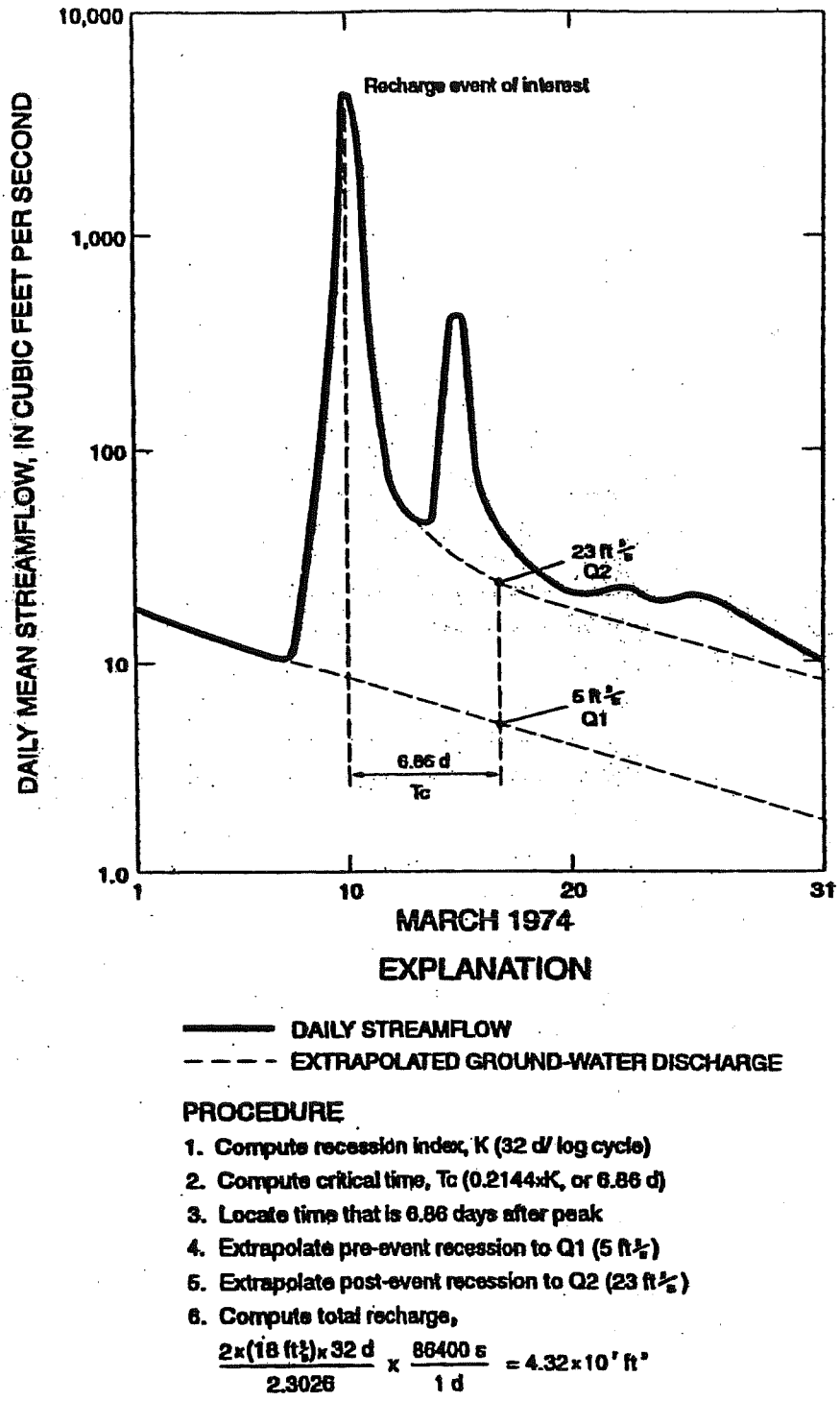

Figure 4. Recession-curve displacement method used by program RORA to separate baseflow. Baseflow is assumed to equate to recharge (Rutledge, 1993).

compensating polar planimeter. The main channel length and the total length of all channels were measured with a map wheel. Drainage density was calculated as the ratio of the total length of stream channels to the drainage area (km/km^2).

A watershed's total relief is the difference in elevation between its highest point and its outlet. Main channel gradient is the change in elevation along the main channel divided by its length. Hillslope was measured (as change in elevation divided by distance along slope) at between 15 and 20 randomly selected locations within each watershed; the individual measurements were then averaged to provide a single representative value. The accuracy of all these parameters are constrained by the ten-foot contour interval of the maps.

Hydrogeology

The rate at which ground-water is recharged should be related to the permeability of the surface sediments, the thickness of the unsaturated zone through which infiltration must travel, and the ability of the primary aquifer to transmit the recharge away from the recharge sites. To estimate these controls, the permeability of the surface soil and underlying material, and the depths to the water table and to bedrock have been obtained.

The distribution of soil types across each study watershed has been mapped by the US Soil Conservation Service (Parker, et al, 1970; Steingraeber and Johnson, 1971). The vertical permeability (K_v) of each horizon of each soil has also been measured by the SCS using percolation tests. A representative K_v of each soil has been calculated as the mean of the soils horizon values weighted by the horizon's thickness. As an example, the Casco Loam typically has two horizons; the upper averages 17 inches thick with a mean K_v of 1.12 in/hr, while the lower averages 43 inches thick with a mean K_v of 20 in/hr. The Casco thus has a representative K_v of 14.85 in/hr [{(1.12*17)+(43*20)}/(20+17)].

All the soils within the study area watersheds were then grouped into three categories based on their measured K_vs: high (range of 8.4 to 17.5 in/hr), moderate (2.6 to 5.2 in/hr) and low K_v (0.5 to 1.1 in/hr). For each category, the geometric mean of the range of observed values was calculated, producing 12.1 in/hr for high, 3.7 in/hr for moderate and 0.7 in/hr for low K_v. Finally, the area of each watershed covered by soils within each K_v category was measured and the effective soil K_v for the watershed calculated as the areally weighted mean. Thus if a watershed contains 25% high K_v soils, 10% moderate and 65% low, its effective soil K_v is 3.9 in/hr [(.25*12.1)+(.10*3.7)+(.65*0.7) = 3.9]. After the calculations were completed, the units of K_v were converted to cm/hr. Details of the soil distributions are in Ansari (1999).

The horizontal hydraulic conductivities of the geologic materials within the saturated zone were calculated from well specific capacities using the method of Bradbury and Rothschild (1985). The specific capacities are available on well construction reports, along with the depth to bedrock and to the water table at the time of well construction. Over 150 private wells were located on the topographic maps, and their construction reports were used to generate bedrock and water table surface contour maps and isopachous maps of the thickness of the unsaturated zone and of the unconsolidated sediments.

Land use

Land use maps have been developed for the study area by the Southeast Wisconsin Regional Planning Commission (SEWRPC). They subdivide land use into many categories. For the purpose of this study, the SEWRPC categories have been combined into five: natural land (woodlands, wetlands, parks, golf courses), agricultural, developed (residential, commercial, industrial and extractive), extractive (quarry and aggregate operations) and open water. The areas within each watershed covered by each category were measured with the planimeter.

Testing the Observed Relation of Recharge to Controls

A link between recharge and independent control parameters will be established by multiple regression using the first year of record. It'll then be necessary to test it, and three levels of testing will be used. First the relation will be used to calculate the recharge rates within the study watersheds for the first year of record. These predicted values can then be compared to the observed, with the differences a measure of the internal consistency of the data set. Second, the relation will be used to calculate the expected recharge rates at sites outside the set of study watersheds. Comparison to observed values will determine if the relation is spatially extrapolatable. Finally, the relation will be used to predict recharge rates within the study watersheds for the second year of record. Again, the calculated values will be compared to those measured to test whether the relation is time-invariant.

For the second test process, recharge and the independent variables will be obtained at six additional locations. Five are USGS gaging sites on larger watersheds around the outside of the ten contiguous sites. They are the Menomonee River at both the Menomonee Falls and Wauwatosa gaging sites, the Fox River gaging stations both above and at Waukesha, and the Cedar Creek station above Cedarburg (USGS gaging stations 04087030, 04087120, 05543800, 05543830 and 04086500, respectively). The sixth site will be the southeastern quadrant of the City of Mequon, Wisconsin, for which Cherkauer and Bacon (1978) determined recharge using a water budget.

For multiple gaging sites on a given stream, the subwatersheds will be considered to be non-overlapping as was explained for the nested basins in the study area. The topographic, hydrogeologic and land use conditions of these test areas will be obtained in similar fashion to the study watersheds. Some differences in measurement will occur because these test watersheds are much larger than the study ones. The differences are defined in Ansari (1999). Precipitation will be obtained from additional NOAA sites which provide the coverage for these watersheds.

RESULTS

Characteristics of the Study Watersheds

The hydrogeologic, topographic, and land use properties of the study watersheds are presented in Table 2. For the nested watersheds, the values presented in Table 2 are those representing the drainage area between two consecutive monitoring sites. Thus the values for station Cedar 1 are those for the land area below the Cedar 2 station and above Cedar 1. The values listed for the Menomonee station are for the land area draining into the Menomonee above the monitoring station, but excluding the watershed's west branch (which area is included under the three West Branch stations).

Drainage areas range from 3 up to 48.7 km^2, although all but three of the sites are less than 14 km^2. Soil permeabilities range from 0.7 m/day to 4.1 m/day, with a mean value of 1.45. For the study watersheds in Washington County, the dominant land use is agriculture (Table 2), although the total amount of development ranges up to 38%. The Kinnickinnic River watershed was included in the study to provide a more urban end member, and that watershed is 88% developed.

The study area traverses a variety of hydrogeologic conditions. Perhaps the most apparent feature is a deep bedrock valley which lies under the western watersheds (Figure 5). This produces a situation in which the depth to bedrock in the western watersheds is over 40 m, while that in the east is as little as 2 m (Table 2, Figure 6). In those western watersheds, the dominant underlying aquifer material is coarse outwash filling the bedrock valley. In contrast, Silurian dolomite is the aquifer beneath the eastern and southern watersheds in Washington County. Clay-rich glacial till is the uppermost unit beneath the Kinnickinnic watershed, and it's underlain by Silurian dolomite.

The topography also varies considerably across the study area. Western watersheds, which lie in the heart of the Kettle Moraine, have steep hillslopes and channel gradients. Those toward the south and east (West Branch, Menomonee, Cedar 1), which lie below the Kettle Moraine, have much flatter topographies (Table 2). The water table configuration (Figure 7) reflects the surface topography, with more relief to the west and north. As a general rule, depths to the water table vary inversely with the local relief (Figure 8). They're much greater in the north and west watersheds in Washington County (Table 2). Depth to the water table in the Kinnickinnic watershed is great because of its proximity to Lake Michigan (as a sink) and the abrupt lake bluff which causes the ground surface to be topographically high.

The range of conditions observable within the study area is representative of most of southeastern Wisconsin. Coupled with the proximity among the study watersheds, this makes them an ideal set for examining the spatial variability of recharge.

Table 2. Properties of the study watersheds.

Watershed	Drainage area (km2)	Hydrogeology			Land Use			Topography			
		Effective Soil K (m/day)	Depth to water table (m)	Depth to bedrock (m)	Agriculture (%)	Natural (%)	Developed (%)	Drainage density (km/km2)	Channel length (km)	Channel gradient (m/m)	Average hillslope (m/m)
Coney	25.0	2.44	32.6	52.4	66.3	26.9	6.2	8.7	12000	0.0067	0.082
Menomonee	36.5	0.91	10.1	13.4	59.0	26.7	13.5	10.7	11000	0.003	0.029
W Branch 1	3.9	0.91	11.3	7.3	80.3	9.6	9.8	5.9	1500	0.002	0.029
W Branch 2	6.6	0.91	9.1	9.8	73.9	11.5	14.0	7.4	4000	0.003	0.038
W Branch 3	2.9	4.14	14.0	21.9	45.6	15.2	38.3	6.4	2200	0.0153	0.044
Willow 1	4.6	2.68	9.8	37.8	45.9	22.8	30.0	9.5	3700	0.0221	0.068
Willow 2	9.0	0.73	9.4	15.5	55.6	17.4	26.3	6.7	6100	0.0056	0.044
Cedar 1	10.9	1.22	11.3	31.1	71.7	12.9	15.0	8.5	2900	0.0007	0.04
Cedar 2	3.0	1.10	10.7	44.2	65.9	8.0	25.8	11.6	2000	0.0057	0.042
Cedar 3	13.2	0.55	15.8	52.4	57.5	22.2	19.3	9.4	4200	0.0143	0.056
Kinnickinnic	48.7	0.59	12.2	45.7	0.0	12.3	87.7	25.0	10500	0.0017	0.015

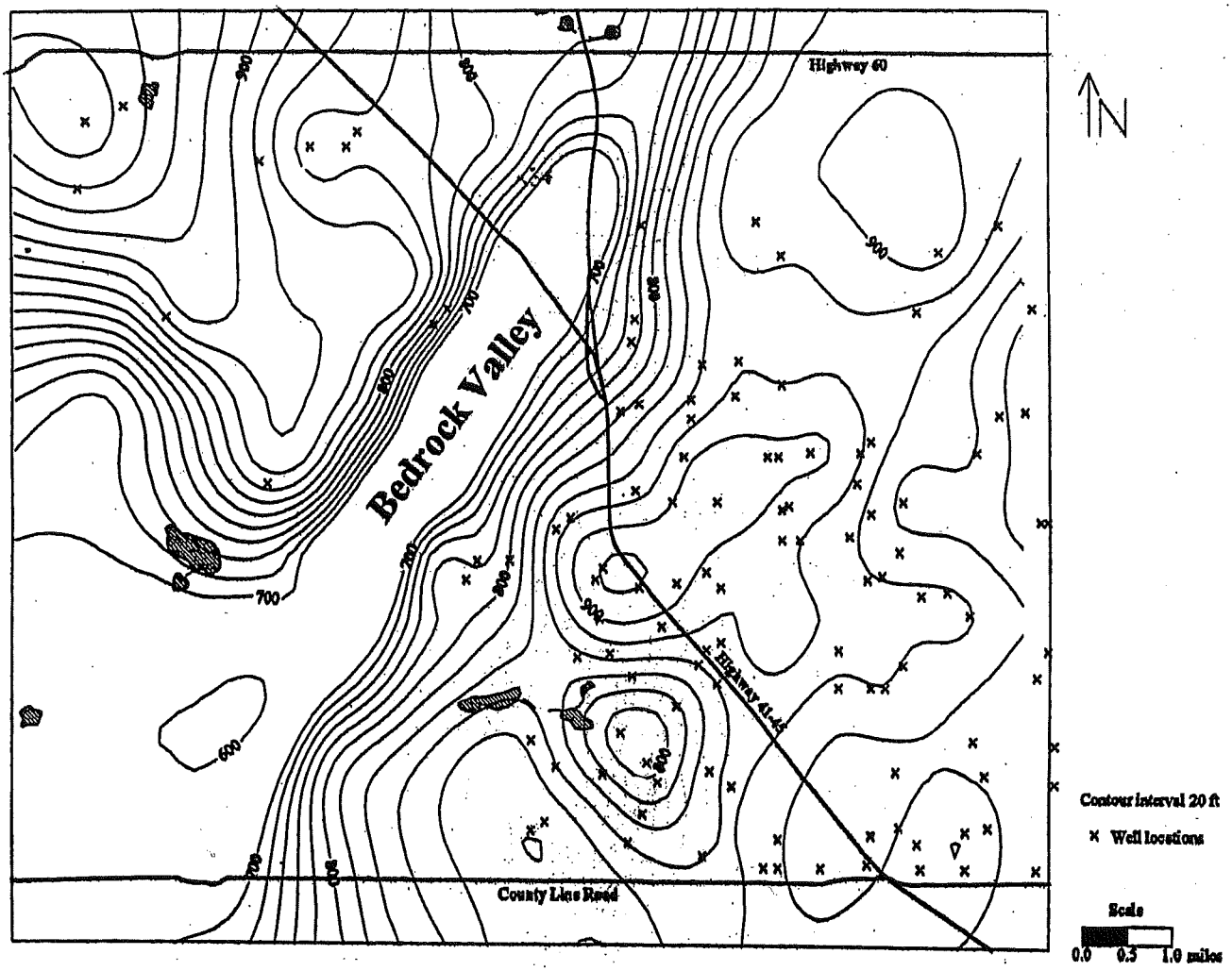

Figure 5. Bedrock surface elevation map for the study area.

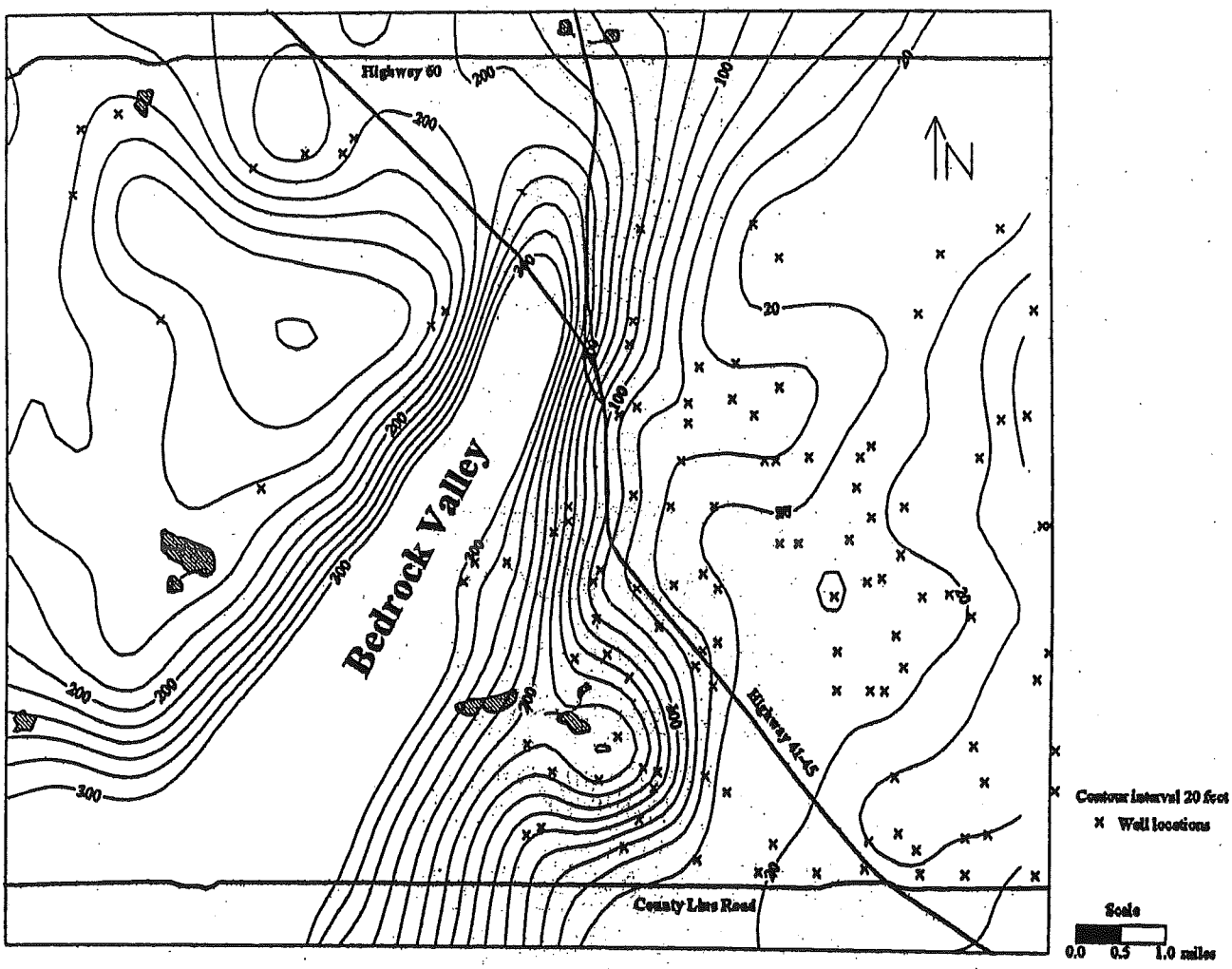

Figure 6. Contour map of depth to bedrock in the study area.

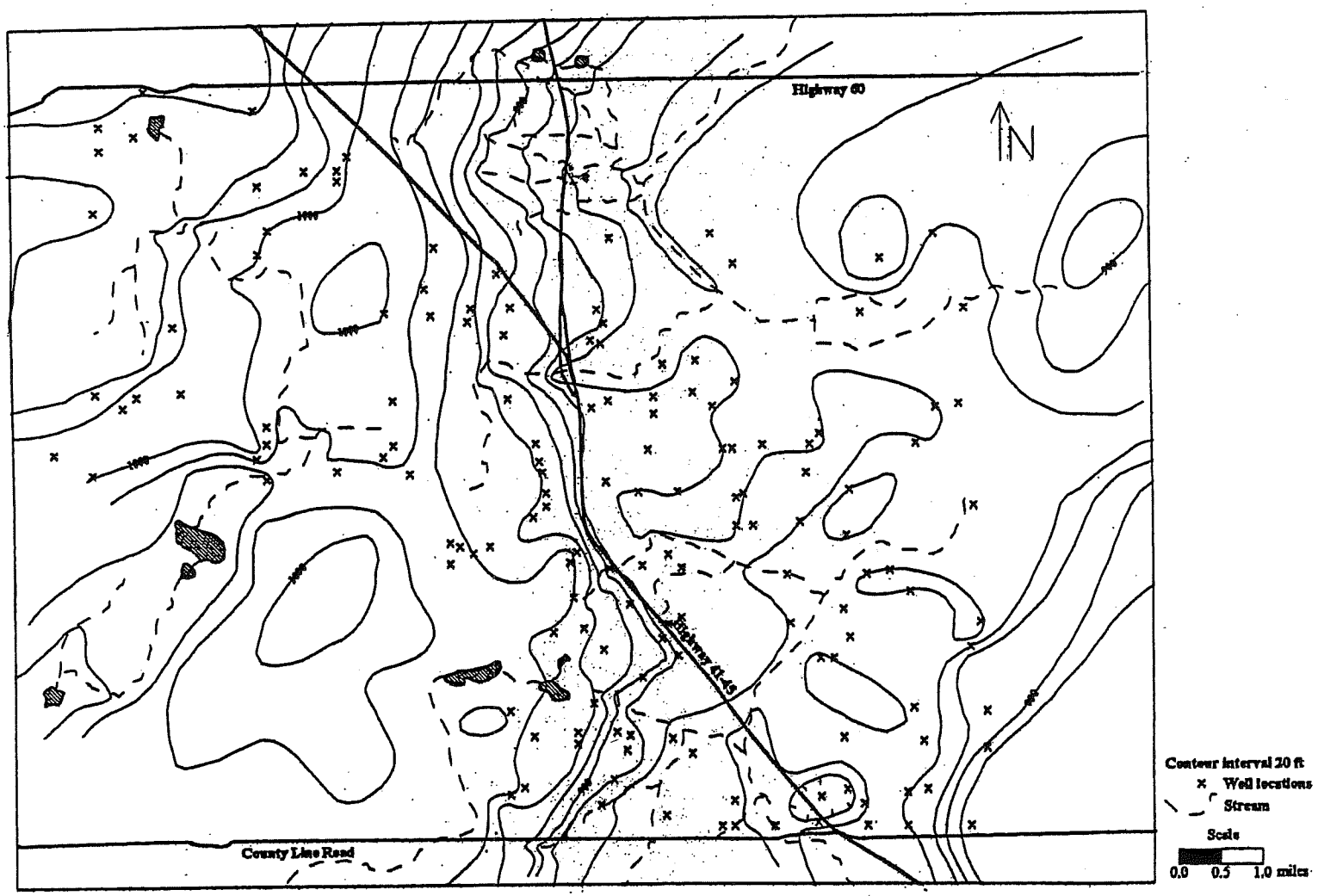

Figure 7. Water table elevation map for the study area. Dashed lines are principle streams from Figure 1.

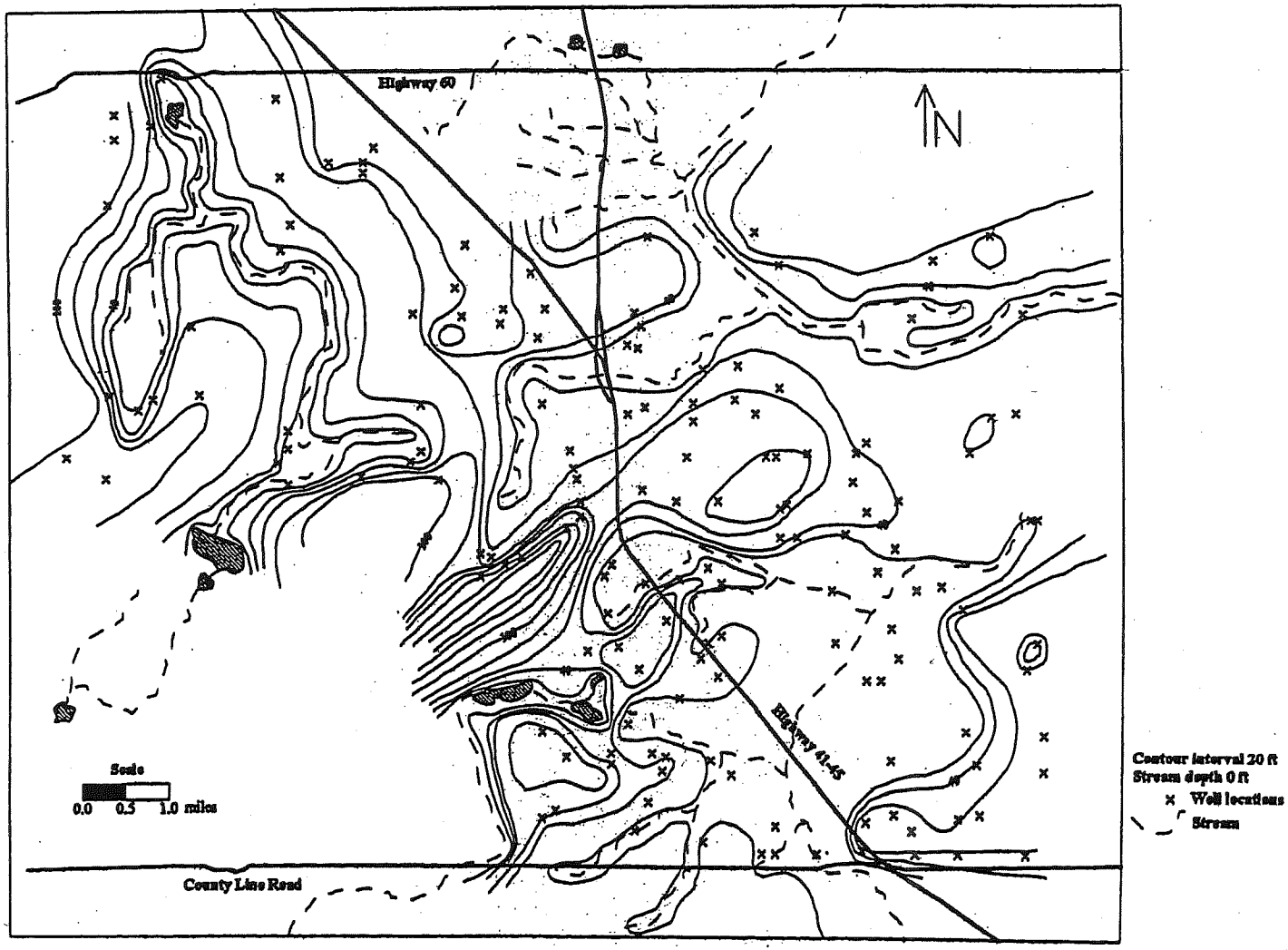

Figure 8. Contour map of depth to water table for study area. Dashed lines are principle streams from Figure 1. Depth decreases to 0 at each stream.

Precipitation

Monthly observations from four sites have been used to calculate the precipitations falling in each study watershed (Table 3). The observations have been weighted using the Thiessen polygon method, and the annual totals are listed in Table 3. Snowfall has been converted to water equivalent. It's included in the values provided even though much of it falls when the ground is frozen, because at least some of it is available for recharge during the spring thaw. Total recharges in the watersheds will vary partially in response to the spatial variability of the precipitation. To eliminate this source of variability, recharges will be normalized to total annual precipitation amounts and expressed as a ratio (recharge per unit precipitation, or R/P) for the remainder of this report. These values can be read as the annual recharge efficiency; a value of R/P = 0.15 means that 15% of the annual precipitation in a watershed infiltrates as ground-water recharge and then makes its way to a stream as baseflow.

Logistically, direct measurement of recharge across the study area with piezometers or infiltrometers was beyond the scope of this study. One site was instrumented with piezometers, however, to provide confirmation to the indirect observations made on the streams. A nest of four piezometers was constructed in a wooded kettle 30 m northeast of the Richfield rain gage (Figure 1). A shallow perched aquifer system exists beneath this kettle. From the spring thaw until July of each year, the perched water table's response to rainfall events has been monitored. After July, the perched system dries up until the following year's thaw.

The piezometers' response to 25 individual recharge events has been observed (Figure 9). The responses have been grouped into four categories, recharge resulting from: snow melt (on thawed ground), from gentle rainfall before and after the trees have become active (listed as pre and post-leafing), and from intense rainfalls. The latter category is somewhat unique to this monitoring site, because intense rainfall (greater than 0.3 cm/hr) produces some overland flow and depression focused recharge. This category is not considered relevant to the remainder of the study area.

For the remaining events, Figure 9 shows that water levels in the piezometer respond to any amount of snow melt. Recharge occurs to this perched system whenever snow melts on thawed ground. In contrast, rainfall must exceed about 0.5 or 1.5 cm in the pre-leafing and post-leafing periods, respectively, before recharge occurs. These observations are considered to be upper limits on recharge response because the monitored site is more heavily wooded than any of the study watersheds. Thus while vegetation is active (late spring until the leaves fall in autumn), it will be assumed that a minimum rainfall of 1 cm is necessary to produce recharge in the study area. Before the leaves are out each spring and after they have fallen each autumn, it's assumed that any rainfall exceeding 0.5 cm will produce recharge.

Baseflows

The hydrographs for each of the watersheds for the two year study period are presented in Appendix III. Baseflow separation has been conducted in two stages. First the annual total baseflow for the first year was separated both manually and with the automated Rorabaugh

Table 3. Precipitation in the study watersheds.

Watershed	Annual precipitation		Spring precipitation	
	Year I	Year II	Year I	Year II
Cedar 1	93.47	96.94	48.61	51.19
Cedar 2	93.47	96.94	48.61	51.19
Cedar 3	93.47	96.94	48.61	51.19
Coney	88.26	90.17	44.05	47.63
Kinnickinnic	97.92	99.94	47.97	45.20
Menomonee	93.47	95.39	52.40	47.59
W.Branch 1	99.98	95.78	51.45	48.49
W.Branch 2	98.90	95.97	50.98	48.94
W.Branch 3	96.73	96.36	50.03	49.84
Willow 1	99.98	95.78	51.45	48.49
Willow 2	101.06	95.58	51.93	48.04

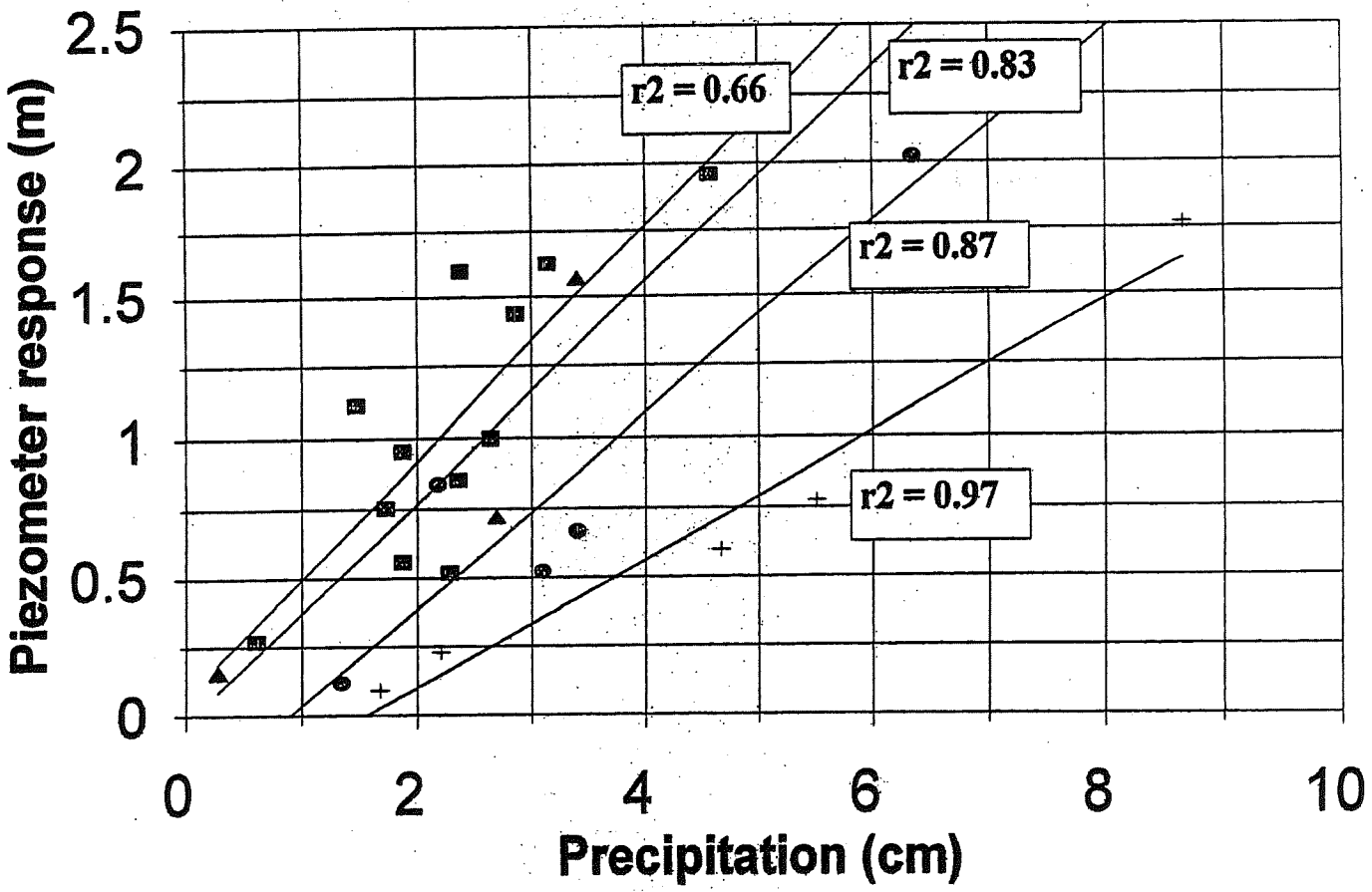

Figure 9. Response of water level in piezometer to precipitation events. The piezometer is located at Richfield on Figure 1. Events have been separated into 4 categories, each shown with its correlation coefficient and regression line. From the bottom they are: 1. rain events occurring after trees have leafed out; 2. rain events before leafing in the spring; 3. periods of melting snow on thawed ground; and 4. intense precipitation events (>0.3 cm/hr) which produce depression focused recharge at this site.

method. Then manual separation was done for each study year for the period when the ground was not frozen.

The first step was done to test the relative results of the manual and automated methods. The latter is designed to work best for a full year's record and is not readily adapted to seasonal differentiation. The two procedures produces very similar results, however, (Figure 10) so it was deemed appropriate to use the manual method exclusively for the remainder of the study

The second stage was manual baseflow separation with some imposed constraints. First, only precipitation events in excess of the minima defined above were considered to produce recharge. Secondly, it was assumed that no recharge would occur during the period when the ground was frozen (based on observations at Richfield). Snow melt or rainfall during the frozen ground period will produce surface runoff and a resultant increase in stream discharge, but it should not produce the infiltration necessary for recharge.

The baseflow separation curves are shown on the stream hydrographs (in both arithmetic and semi-log format) in Appendix III. The annual volumes of baseflow for each study watershed and their conversions to recharge and normalized recharge are provided in Table 4. There is considerable spatial variation in the normalized recharge across the study area. This variability, especially in light of the fact that most of the watersheds are geographically contiguous, suggests that recharge must be controlled by spatially variable factors.

Causes of Spatial Variability of Recharge

Attempts to correlate the observed normalized recharges with individual independent topographic, hydrogeologic or land use parameters failed. The cause of the spatial variability of recharge is more complex than a single watershed property. In view of this determination, a set of three dimensionless ratios of parameters was established which, when combined, would account for the spatial variability. Each of these parameters was generated as a ratio between factors which would enhance or reduce infiltration.

The first dimensionless parameter (called Term 1) is conceived as the ratio between the rate of infiltration and that of overland runoff and defined as:

$$\text{Infiltration/Runoff} = V_v/V_h = K_v/(S*[\%D^{0.3}]), \quad (3)$$

where;
K_v = effective vertical soil conductivity,
S = average hillslope in a watershed,
$\%D$ = percentage of the land in a watershed which is developed,
V_v = estimated infiltration velocity, and
V_h = estimated overland runoff velocity.

Infiltration rate equals the product of the vertical hydraulic conductivity of the soil cover and the vertical hydraulic gradient. In the unsaturated soil system at the ground surface, the former is represented by the effective soil conductivity (defined earlier) determined from percolation tests

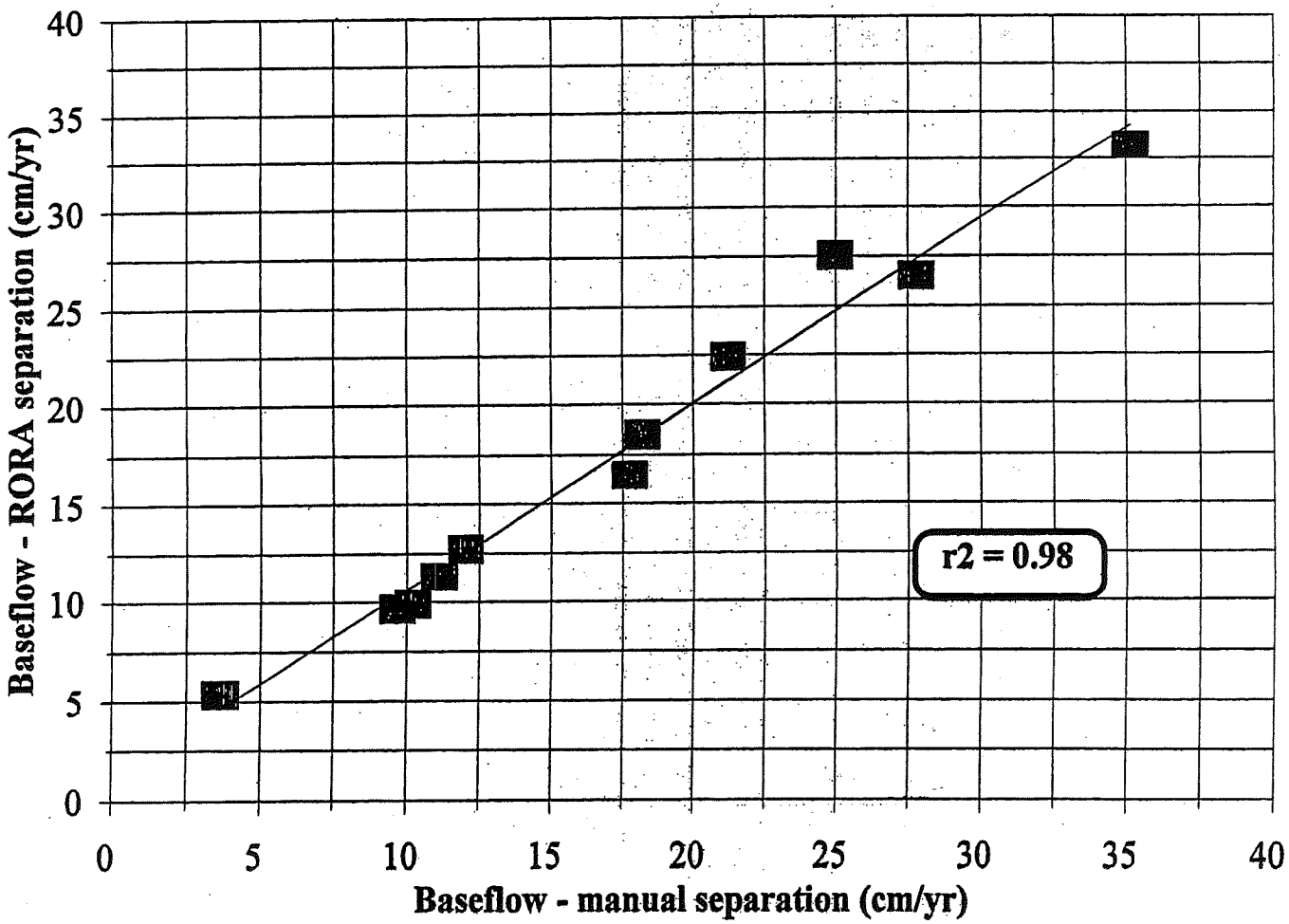

Figure 10. Comparison of recharge rates obtained by manual and RORA hydrograph separation. Values are for the study area for Year I. They include baseflow during frozen-ground months, so should not be compared to those cited in text.

Table 4. Observed baseflows and recharges in the study watersheds.

Watershed	Year I			Year II		
	Baseflow (m3/yr)	Recharge (cm/yr)	R/P (cm/cm)	Baseflow (m3/yr)	Recharge (cm/yr)	R/P (cm/cm)
Coney	2.29E+06	9.2	0.104	2.18E+06	8.7	0.097
Menomonee	6.84E+06	18.7	0.183	3.97E+06	10.9	0.114
W Branch 1	6.00E+05	11.8	0.118	1.10E+05	2.8	0.029
W Branch 2	6.79E+05	10.3	0.104	6.07E+05	9.2	0.096
W Branch 3	7.21E+05	24.9	0.257	5.73E+05	19.8	0.205
Willow 1	5.00E+05	10.9	0.109	5.40E+05	11.7	0.123
Willow 2	1.88E+06	20.9	0.207	1.19E+06	13.2	0.138
Cedar 1	1.56E+06	14.8	0.158	8.10E+05	7.4	0.077
Cedar 2	2.30E+05	6.0	0.064	9.00E+04	3.0	0.031
Cedar 3	1.13E+06	8.6	0.092	1.17E+06	8.9	0.091
Kinnickinnic	5.73E+06	11.8	0.120	5.24E+06	10.8	0.108

on the soil cover. The latter can be assumed to be unity, so infiltration rate is approximated by K_v.

A representation of overland runoff velocity has been generated using the Manning equation as an analogy. Hillslope (S) and the amount of developed land (%D) are analogous to the Manning channel slope and the inverse of the friction factor. The Manning relation also includes a channel's hydraulic radius. For overland flow, that quantity effectively becomes the runoff depth. Its value is extremely small and is being considered a constant here. The exponents in the denominator of equation 3 have been determined empirically; they are the values which provide the best fit with the observed normalized recharges. As presented, the relation indicates that as the land within a watershed is developed, the amount on recharge should decrease. This is particularly true in areas where storm sewers are constructed to carry storm water to the nearest open channel (as in the Kinnickinnic watershed). In most of the study area, however, storm drainage consists only of roadside ditches. Even these should reduce the amount of infiltration by enhancing runoff and evaporation.

When the normalized recharges for the first year of record are compared to the values of Term 1 (Figure 11), a weak direct correlation is observed. As the ratio increases (either K_v increases or K_h declines), R/P increases. This is intuitively reasonable; faster infiltration enhances recharge, while faster runoff diminishes it. The correlation coefficient shown on Figure 11 demonstrates that this parameter alone does not account for the total variability of R/P, however. In addition, the Willow 2 watershed is a clear outlier and has not been included in the calculation of r^2.

A second dimensionless parameter (Term 2) has been conceived as the ratio of the distances that water must travel in the vertical and horizontal directions. It's defined as:

$$\text{Vertical flow distance/horizontal flow distance} = L_v/L_h = D_W/(0.5*(A_d/L_c)) \quad (4)$$

where:
- D_W = average depth to the water table (m),
- A_d = watershed drainage area (m^2),
- L_C = length of the main channel in a watershed (m),
- L_v = average vertical distance water travels to become recharge, and
- L_h = average horizontal distance water travels to enter the main channel.

In order to recharge the ground water system, water must travel from the ground surface to the water table. As that distance increases, there is greater opportunity for evapotranspiration loss from the unsaturated zone, so there should be an inverse relation between recharge and the average depth of the water table in a watershed. Conversely, as the distance that surface runoff must travel to reach the main channel increases, the opportunity for infiltration increases; there should be a direct relation between recharge and overland flow distance. The depth to the water table has been measured (Table 2). The average overland runoff distance is calculated in equation 4 as one half the average width of the watershed (A_d/L_c). This is an approximation which considers each watershed to be rectangular in shape.

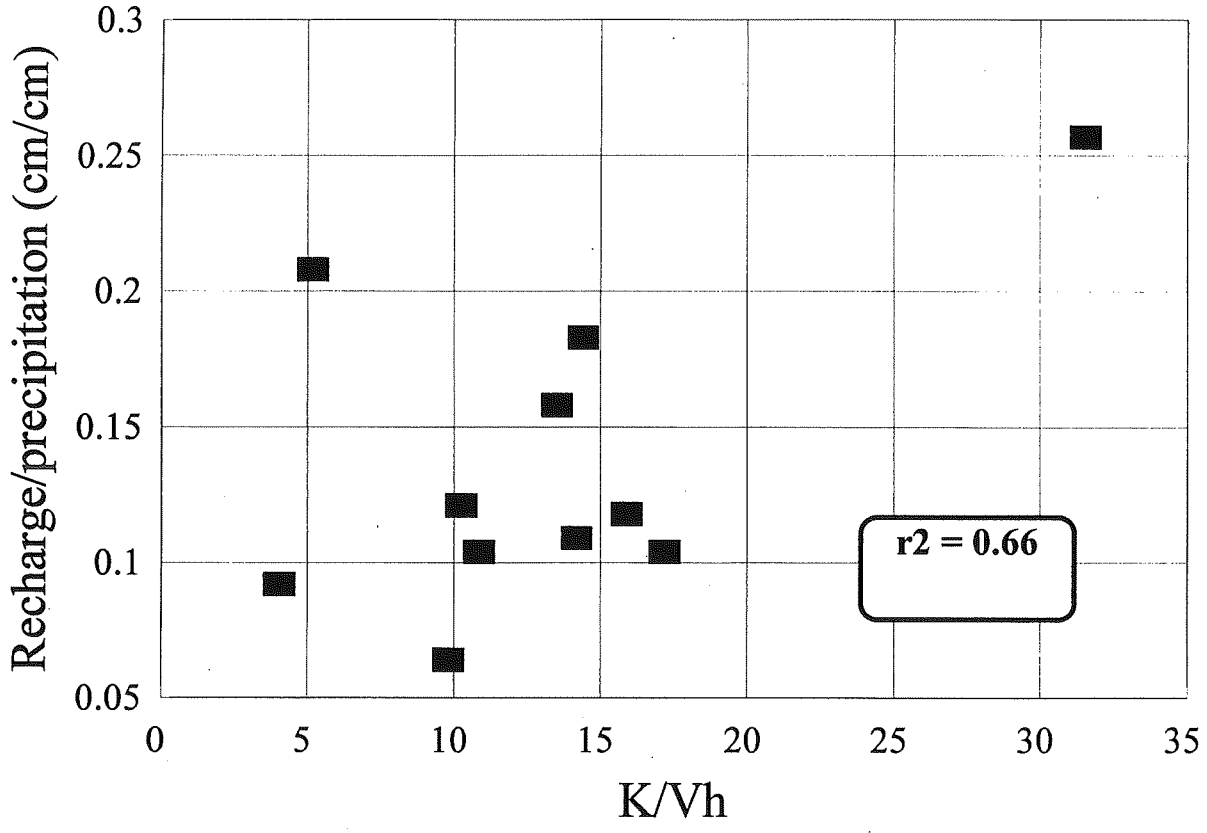

Figure 11. Relation of observed normalized recharge to the ratio of flow velocities. Points plotted are for the study watersheds in Year I. The ratio is defined in Equation 3. The outlier in the upper left has been omitted in the calculation of r^2.

When the normalized recharge values for the first year of record are compared to Term 2 (Figure 12), the expected inverse relation appears. There are three populations apparent in Figure 12, and correlation coefficients have been calculated for the two sets with more than one member. As in Figure 11, there is a single outlier, although it's not the same watershed. At this time, it's not known what distinguishes the populations on Figure 12.

The third dimensionless parameter used in this study is the percentage of the watershed which remains in natural land use (woodland, wetland, parks). Intuitively, natural land use should enhance infiltration, just as development tends to enhance runoff (and diminish infiltration). For the first year of record in this study, there is only a faint direct relation between normalized recharge and natural land use (Figure 13). Natural land use does not explain much of the spatial variability of recharge by itself.

Figures 11 through 13 indicate that there is some relation between the individual dimensionless parameters and normalized recharge, but that it's not strong. When the three are combined by multiple regression, however, they provide a relationship for the prediction of R/P. That relation is:

$$R/P = 0.0085(V_v/V_h) - 4.18(L_v/L_h) + 0.0025(\%N) + 0.022 \quad (5)$$

where: R/P = normalized annual recharge (recharge per unit precipitation),
%N = percentage of land in a watershed in natural state, and the remainder of the terms are explained in equation 3 and 4 above.

When equation 5 is used to calculate the normalized recharge in each watershed and that is compared to the observed values, an excellent correlation is obtained (Figure 14, Table 5). The one outlier on Figure 14 (again the Willow 2 watershed, as in Figure 11) has not been included in the calculation of the correlation coefficient. The Willow 2 watershed has a lot of relatively low conductivity soil, all located on low ground along the stream, a configuration which distinguishes it from the other study watersheds. It's possible this is the cause of the watershed's anomalous response, but this remains conjectural.

Testing of the Observed Relationship

Three levels of testing were conducted to determine the validity of equation 5. The first has already been presented as Figure 14, which shows that equation 5 can explain 91% of the spatial variability of normalized recharge for the study watersheds (except Willow 2). It can also predict the observed value to within $\pm$ 10% (Table 5).

To determine if equation 5 is valid outside the set of study watersheds, normalized recharges were collected from six nearby sites. Five are USGS gaging stations around the perimeter of the main study area. The relevant independent variables were measured as explained above, and normalized recharge for these sites was obtained by separating the baseflow manually from the hydrograph. All of these sites are independent from the study site. Even though two gaging stations are on the Menomonee River downstream from the study site, both

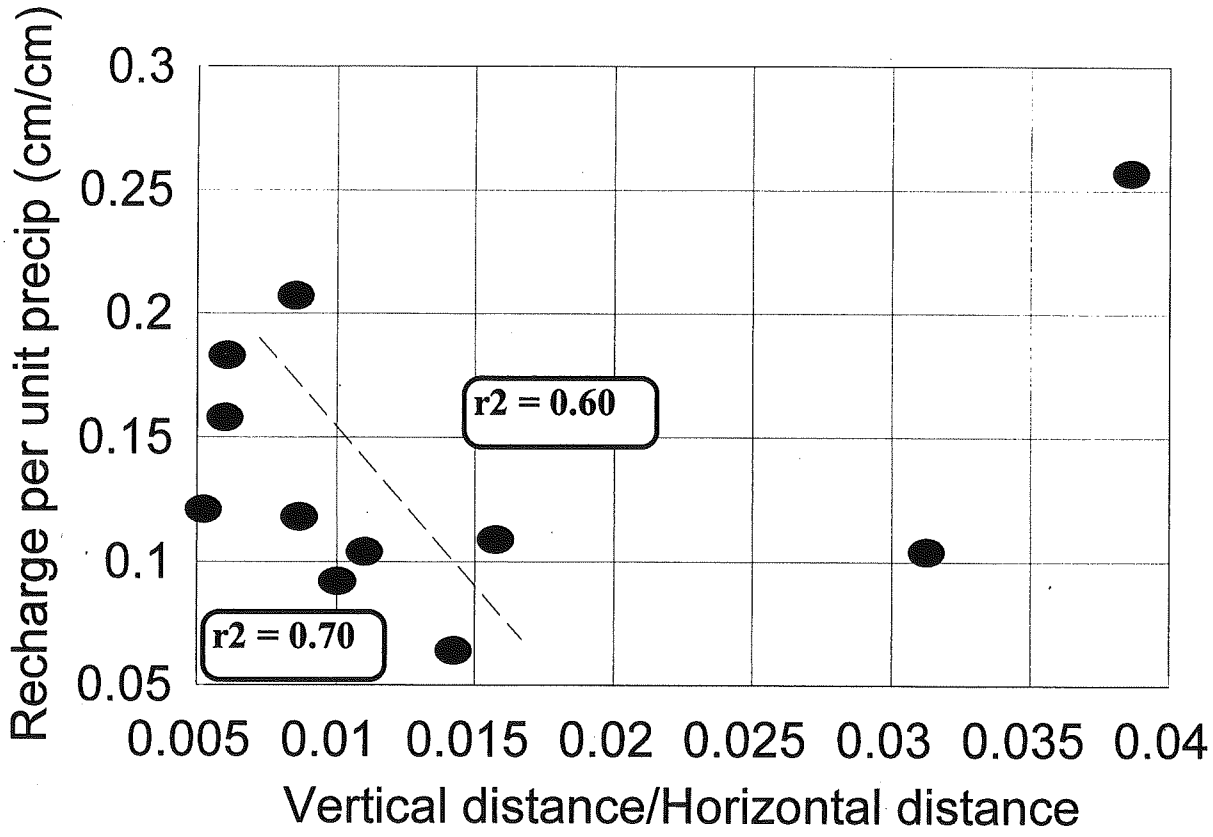

Figure 12. Relation of observed normalized recharges to the ratio of flow distances. Points plotted are for the study watersheds in Year I. The ratio is defined in Equation 4. The $r^2 = 0.70$ is for point below the dashed line; 0.60 for the 3 closest ones above it. Outlier in upper right not included in calculations.

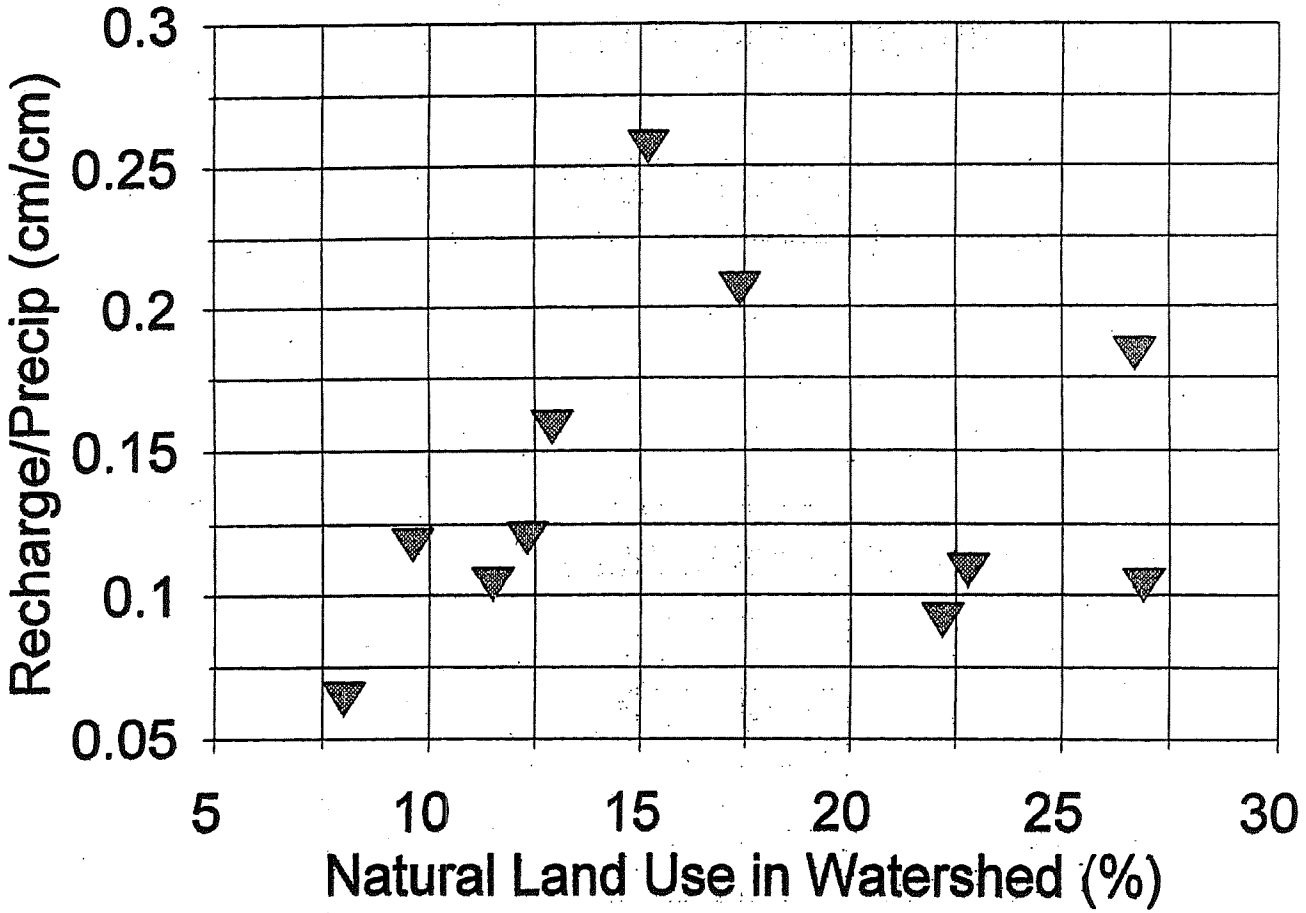

Figure 13. Relation of observed normalized recharge to natural land use. Points plotted are for the study watersheds in Year I.

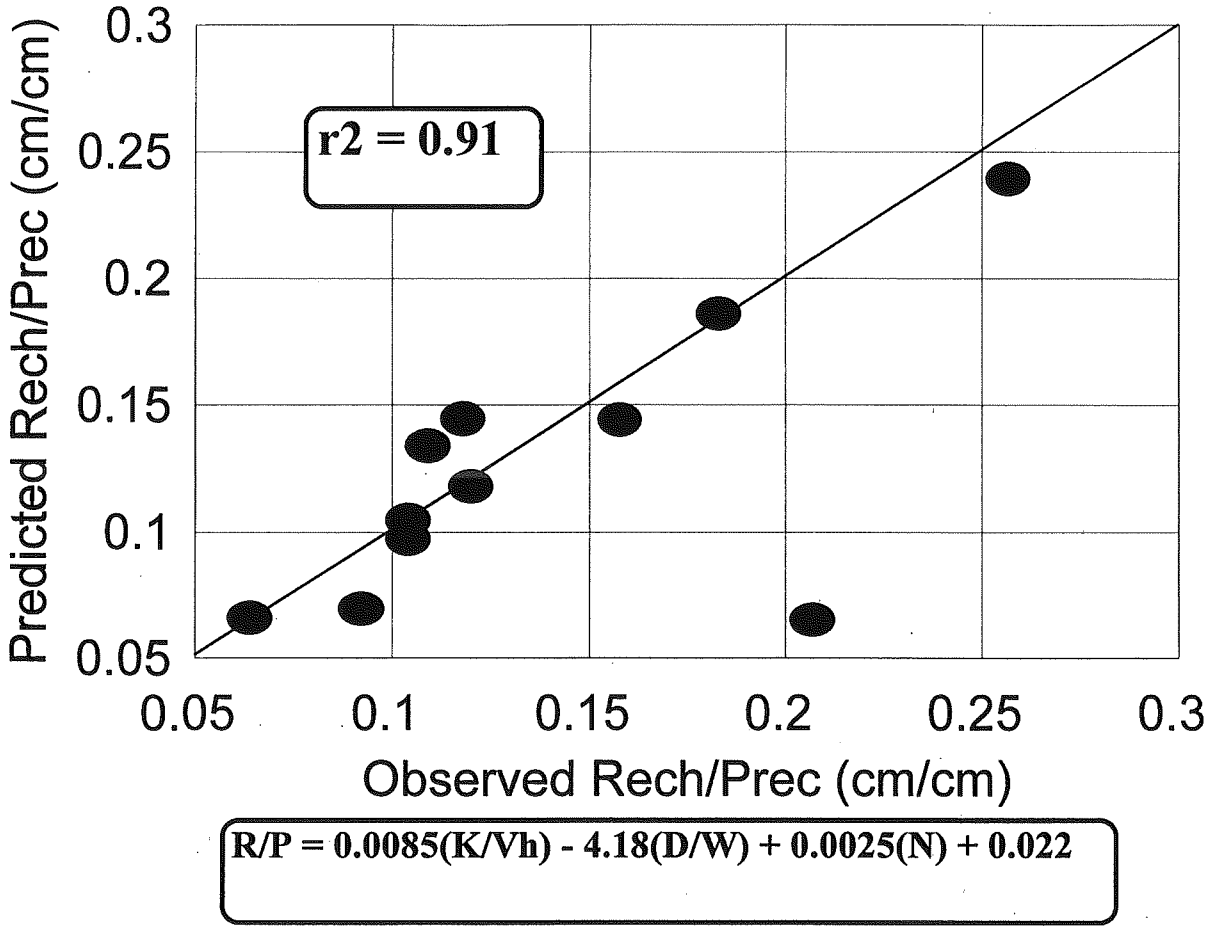

Figure 14. Comparison of observed and predicted normalized recharges - Year I - study area. Predicted values are calculated from Equation 5 (expression at bottom of figure). Correlation coefficient calculated without outlier at lower right. Values and prediction errors are in Table 5.

Table 5. Observed and calculated R/P for study watersheds in Year 1.

Watershed	R/P Observed (cm/cm)	From Equation 5			R/P Calc'd (from Eq 5)	Difference (Obs-Calc) (%)
		Kv/Vh (Term 1)	Lv/Lh (Term 2)	% Nat (Term 3)		
Coney	0.104	0.146	-0.131	0.067	0.105	0.8
Menomonee	0.183	0.123	-0.025	0.067	0.186	1.5
W Branch 1	0.118	0.135	-0.036	0.024	0.145	22.7
W Branch 2	0.104	0.093	-0.046	0.029	0.097	-6.5
W Branch 3	0.257	0.268	-0.089	0.038	0.239	-6.9
Willow 1	0.109	0.121	-0.066	0.057	0.134	23.2
Willow 2	0.207	0.053	-0.053	0.044	0.065	-68.4
Cedar 1	0.158	0.115	-0.025	0.032	0.144	-8.8
Cedar 2	0.064	0.084	-0.060	0.020	0.066	3.0
Cedar 3	0.092	0.034	-0.042	0.056	0.070	-23.8
Kinnickinnic	0.121	0.087	-0.022	0.031	0.118	-2.1
Mean Absolute Error without Anomalous Willow 2						9.9

the recharge and the independent variable were measured for the drainage areas between gaging sites. Hence, the data for the Menomonee at Menomonee Falls, which contains the study's Menomonee site, are only for the incremental drainage area between the study and the USGS sites. The same is true for the Cedar Creek gaging station. The two sites on the Fox River are entirely outside the study area.

The sixth site is southeastern Mequon, where recharge was calculated in 1978 using a water budget (Cherkauer and Bacon, 1978). Independent variables for site conditions in 1978 were used for this site (Table 6), although only land use, precipitation and depth to the water table change over time. The fact that this site's recharge has been calculated with a procedure other than baseflow separation allows assessment of whether equation 5 is method dependent. In addition, all six of these test sites are considerably larger than the study watersheds, allowing determination of whether equation 5 is restricted to small sites.

Normalized recharge for each independent site was calculated using equation 5 and compared to the observed value (Year I points on Figure 15 and Table 7). The comparison is excellent. Recharge at an individual site was predicted to within an average of $\pm$19%. The prediction errors are relatively small errors up to a drainage area of 225 km^2 and then increase dramatically for larger watersheds (Year I points on Figure 16). This indicates that the relation expressed in equation 5 is valid up to drainage areas of 225 km^2 and then becomes less reliable for larger watersheds. Equation 5 also accurately reproduces the recharge at the Mequon site (Figure 15), meaning that it's validity is independent of the method used to obtain recharge.

The Menomonee Falls site, listed in Table 6, is not included in Table 7 or Figures 15 and 16. Two community supply wells open in the shallow aquifer are located very close to the river where they could effect flow at the USGS gaging site. They pump as much as 1 mgd and apparently induce considerable water to flow from the river to the aquifer (perhaps as much as 10^6 m^3/yr). This controverts the assumptions for site validity for the baseflow separation method and requires elimination of this site as a test locale. Observed ground-water discharge at the station is only 10% of what would be expected from equation 5. The Falls site remains useful, however, for calculation of the gain in baseflow between it and the Wauwatosa site downstream.

Finally it's necessary to test whether the relationship is valid for any time other than the first year of the study. Equation 5 will always predict the same R/P value for a given watershed, because it is not configured to recognize the variation of precipitation through time. For use in years other than Year I of the study period, it was necessary to account for temporal changes as follows:

$$R/P_{Year\ X} = R/P_{Base\ Year} * (\text{precipitation correction}) * (\text{event correction}), \quad (6)$$

where: $R/P_{Year\ X}$ = the recharge per unit precipitation for any year of interest,
$R/P_{Base\ Year}$ = the R/P predicted by equation 5 (for Year I of the study)

The "spring correction" and "event correction" terms in equation 6 have been defined as:

Table 6. Properties of the test areas.

Test Area	Drainage area (km2)	Hydrogeology		Land Use		Topography		
		Effective Soil K (m/day)	Depth to water table (m)	Natural (%)	Developed (%)	Drainage density (km/km2)	Channel length (km)	Average hillslope (m/m)
Menomonee @ Falls	52.1	1.00	20	19.3	21.4	7.4	7600	0.038
Menomonee @ Tosa	228.8	0.37	13	14.3	50.4	11.1	25100	0.020
Fox @ Plank Road	200.5	0.85	15	25.2	31.9	9.3	28000	0.028
Fox @ Waukesha	125.9	0.67	7.5	29.0	24.2	9.3	6550	0.034
Cedar @ Cedarburg	284.0	1.40	15	25.9	9.7	9.1	36700	0.046
Mequon	29.9	1.00	30	22.3	39.9	5.9	8000	0.037

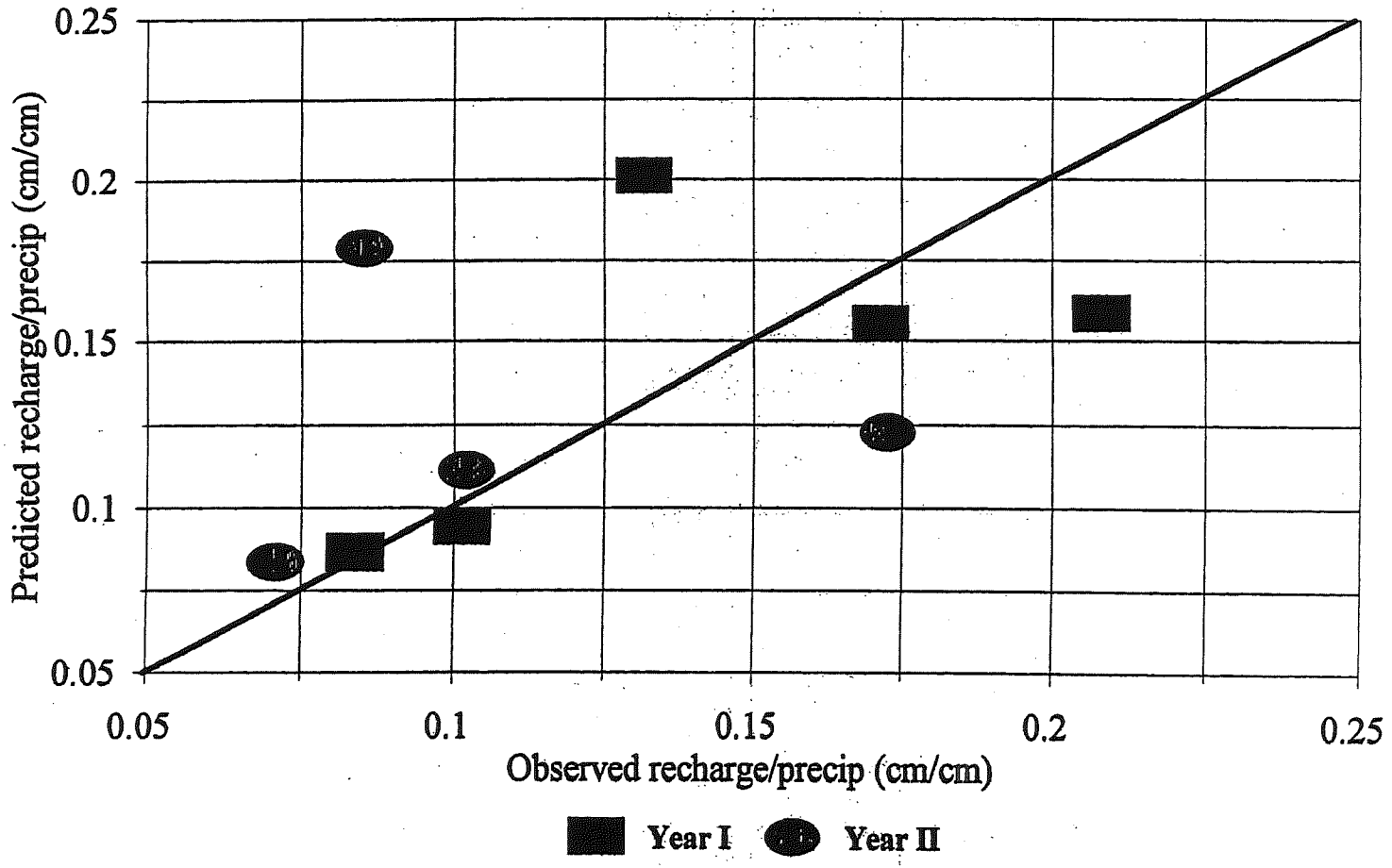

Figure 15. Comparison of observed and predicted normalized recharges - test areas for both years. Predicted values are calculated from Equation 6. Values and prediction errors are in Table 7.

Table 7. Observed and calculated R/P for the test areas.

Test Area	R/P Observed (cm/cm)	From Equation 6					R/P Calc'd (from Eq 6)	Difference (Obs-Calc) (%)
		Kv/Vh (Term 1)	Lv/Lh (Term 2)	% Nat (Term 3)	(Spring prec multiplier)	(Event multiplier)		
Year I								
Menomonee @ Tosa	0.101	0.049	-0.012	0.036	1.0	1.0	0.094	-7.0
Fox @ Plank Road	0.208	0.091	-0.018	0.063	1.0	1.0	0.159	-23.7
Fox @ Waukesha	0.171	0.064	-0.003	0.073	1.0	1.0	0.156	-9.2
Cedar @ Cedarburg	0.132	0.131	-0.016	0.065	1.0	1.0	0.201	53.0
Mequon	0.084	0.076	-0.067	0.056	1.0	1.0	0.087	3.4
						Mean Absolute Error =		19.2
Year II								
Menomonee @ Tosa	0.071	0.049	-0.012	0.036	0.971	1.0	0.084	18.0
Fox @ Plank Road	0.172	0.091	-0.018	0.063	0.878	1.0	0.123	-28.7
Fox @ Waukesha	0.102	0.064	-0.003	0.073	0.816	1.0	0.111	9.1
Cedar @ Cedarburg	0.085	0.131	-0.016	0.065	0.878	1.0	0.179	109.8
						Mean Absolute Error =		41.4

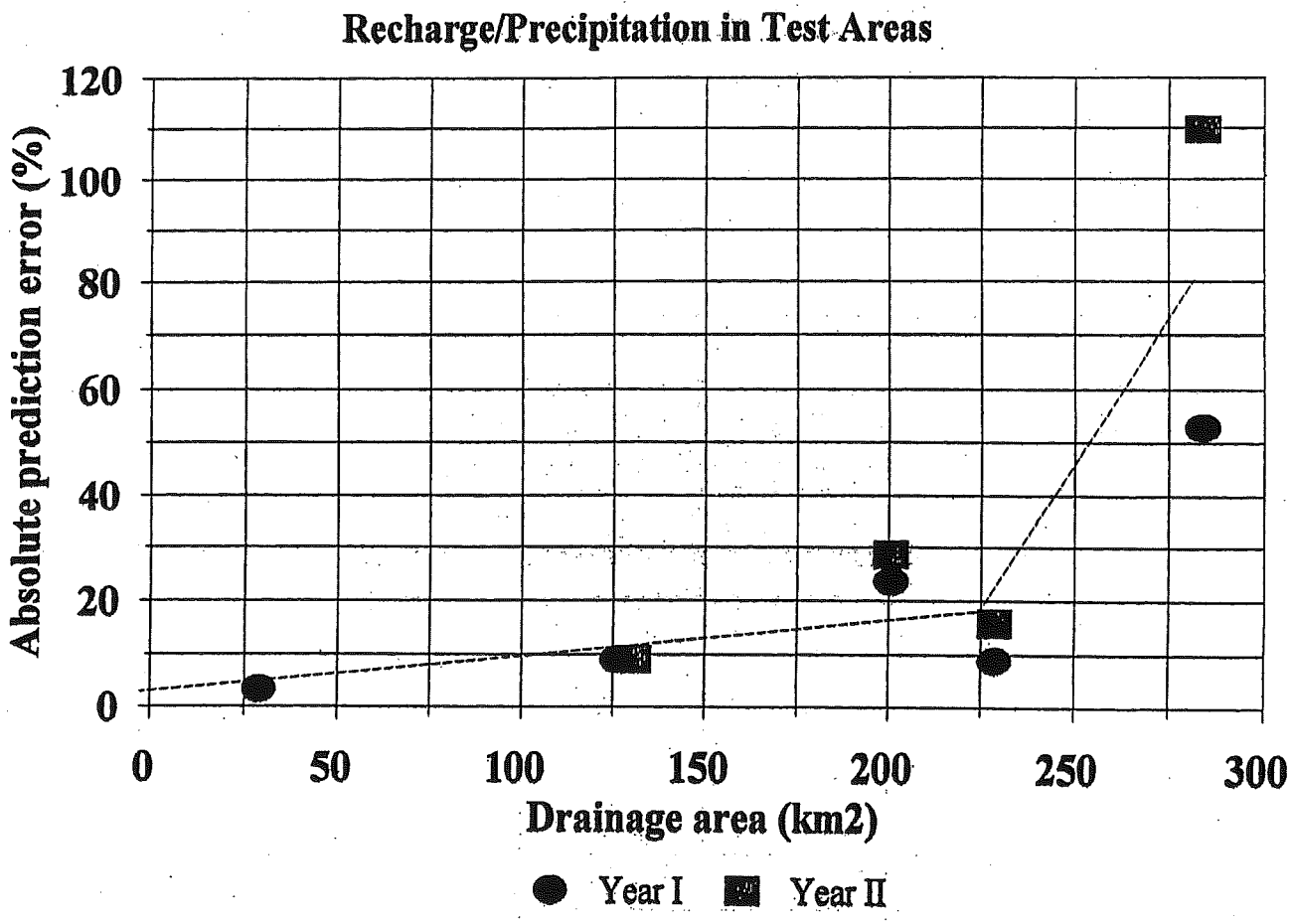

Figure 16. Relation of accuracy of normalized recharge predictions to size of test area. Dashed line is an eyeball fit which shows errors are < 20% when areas are < 225 km^2.

$(SP_{Year\ X}/SP_{Base\ Year})$ and $(EF_{Year\ X}/EF_{Base\ Year})$

where: SP = spring precipitation, the total amount occurring in March through June,
EF = event frequency, the total number of recharge events (precipitation > 1 cm) occurring during the non-frozen months at a site.

Recharge in this study occurs primarily in response to precipitation in excess of 1 cm and only in the months when the ground is not frozen. Thus two years with the same total precipitation will have different recharges if the frequency of these events differ, and the "event correction" logically accounts for that difference.

Intuitively there should also be more recharge in years when there is more total precipitation. In this study, it was learned that the observed recharges are more sensitive to the precipitation in the spring months (March through June) than to the that for the whole year. Consequently, the other temporal correction applied to the recharge prediction relation uses just the spring precipitation.

When above relations are used to predict the normalized recharge of the study watersheds in Year II of the study, the results are quite good (Table 8, Figure 17). The relation accounts for 71% of the spatial variation of the observed normalized recharge (Figure 17). The predicted values are within about ±30% of the observed values (Table 8). Both the Willow 2 and West Branch 1 watersheds have been excluded from the calculations of these percentages, because of anomalous behavior. Willow 2 was anomalous in both years of the study. West Branch 1, on the other hand, was anomalous only in the second year, when observed discharges at the site were lower than those of the next upstream site (WB2) close to 75% of the time. It's believed that WB1 and WB2 are spaced so close together that in years with relatively low recharge (Year II), the differences in their baseflows approach the accuracy of the baseflow separation method.

Equation 6 was also applied to the test watersheds (Table 7, Figure 15 and 16). Once again, the results were very reasonable. The average prediction error for the four test sites is ± 41% (Table 7), although that is highly skewed by the single largest watershed (Cedar Creek). Figure 16 shows that for test areas smaller than 225 km^2, the prediction is good to within ± 20% for both years. Recharge for the Mequon site was only measured once in the past, so it has only been included once in Table 7 and Figures 15 and 17.

Range of Observed Recharge

One underlying purpose for this study was to refine the very broad range of recharge rates that has been estimated for southeastern Wisconsin. Prior studies have listed values in the range of 1 to 25 cm/yr, but are in disagreement on what a general rate might be. This study indicates that there is tremendous spatial variation. Figure 18 shows the frequency of the observed rates for Year I and for both years of the study. The observed range is from 4 to 26 cm/yr, very similar to that previously cited. However, over half of the observed values fall in the range from 10 to 14 cm/yr (Figure 18). If one is unable to apply equation 5 or 6 to an area, then this study shows it would be prudent to use a value in the 10 to 14 cm/yr range as an initial estimate.

Table 8. Observed and calculated R/P for study watersheds in Year II.

Watershed	R/P Observed (cm/cm)	From Equation 5			For Equation 6		R/P Calc'd (from Eq 6)	Difference (Obs-Calc) (%)
		Kv/Vh (Term 1)	Lv/Lh (Term 2)	% Nat (Term 3)	(Spring prec multiplier)	(Event multiplier)		
Coney	0.097	0.146	-0.131	0.067	0.88	0.85	0.080	-18.1
Menomonee	0.114	0.123	-0.025	0.067	0.93	0.85	0.138	20.9
W Branch 1	0.029	0.135	-0.036	0.024	0.95	0.85	0.112	280.8
W Branch 2	0.096	0.093	-0.046	0.029	0.96	0.85	0.077	-19.6
W Branch 3	0.205	0.268	-0.089	0.038	0.98	0.85	0.198	-3.2
Willow 1	0.123	0.121	-0.066	0.057	0.95	0.85	0.104	-15.4
Willow 2	0.138	0.053	-0.053	0.044	0.94	0.85	0.049	-64.3
Cedar 1	0.085	0.115	-0.025	0.032	1.00	0.85	0.127	49.5
Cedar 2	0.031	0.084	-0.060	0.020	1.00	0.85	0.058	88.8
Cedar 3	0.091	0.034	-0.042	0.056	1.00	0.85	0.062	-32.6
Kinnickinnic	0.108	0.087	-0.022	0.031	0.89	0.92	0.098	-8.8
		Mean Absolute Error without Anomalous Willow 2 & W. Branch 1 =						28.5

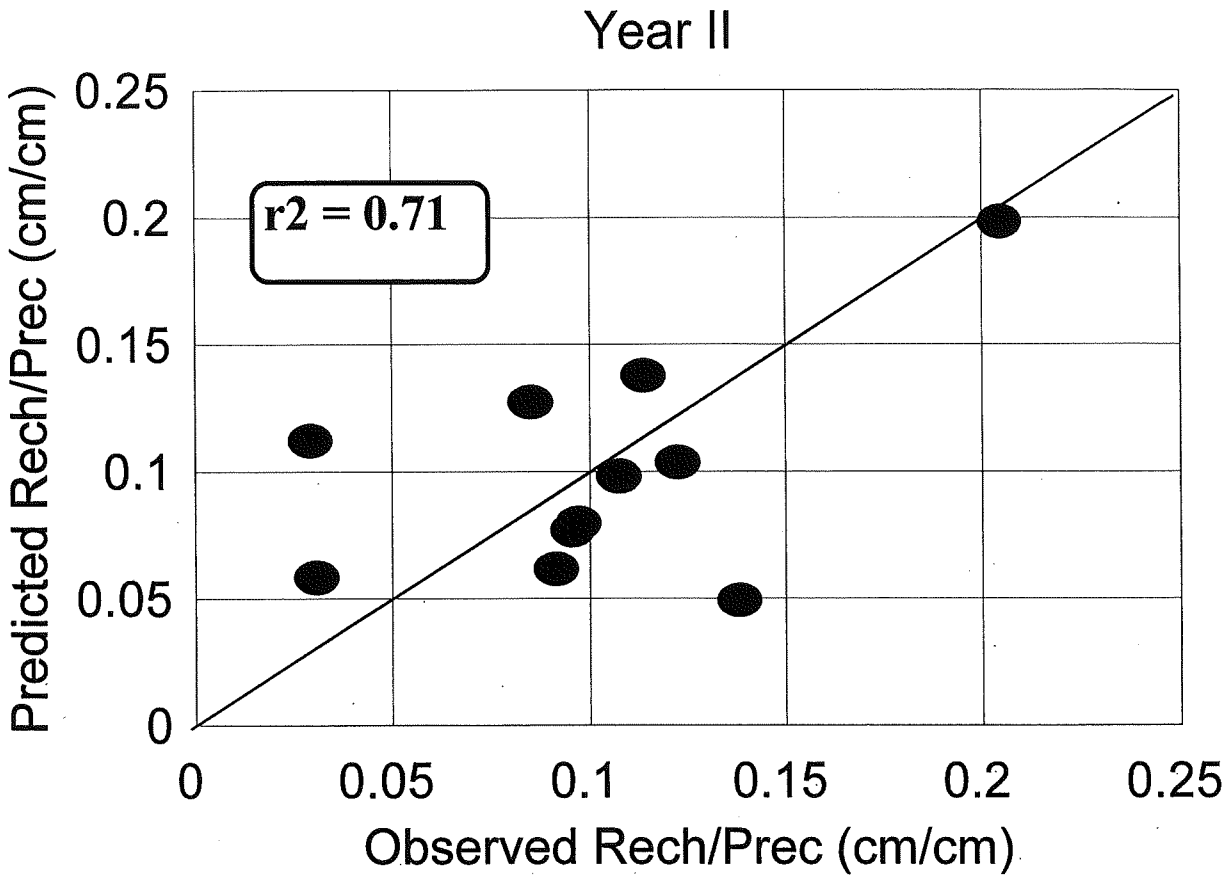

Figure 17. Comparison of observed and predicted normalized recharges - Year II - study area. Predicted values are calculated from Equation 6. Correlation coefficient calculated without the 2 points farthest from the line. Point in lower right is same outlier as in Figure 14. Point in upper left is site which lost water in Year II. Values and prediction errors are in Table 8.

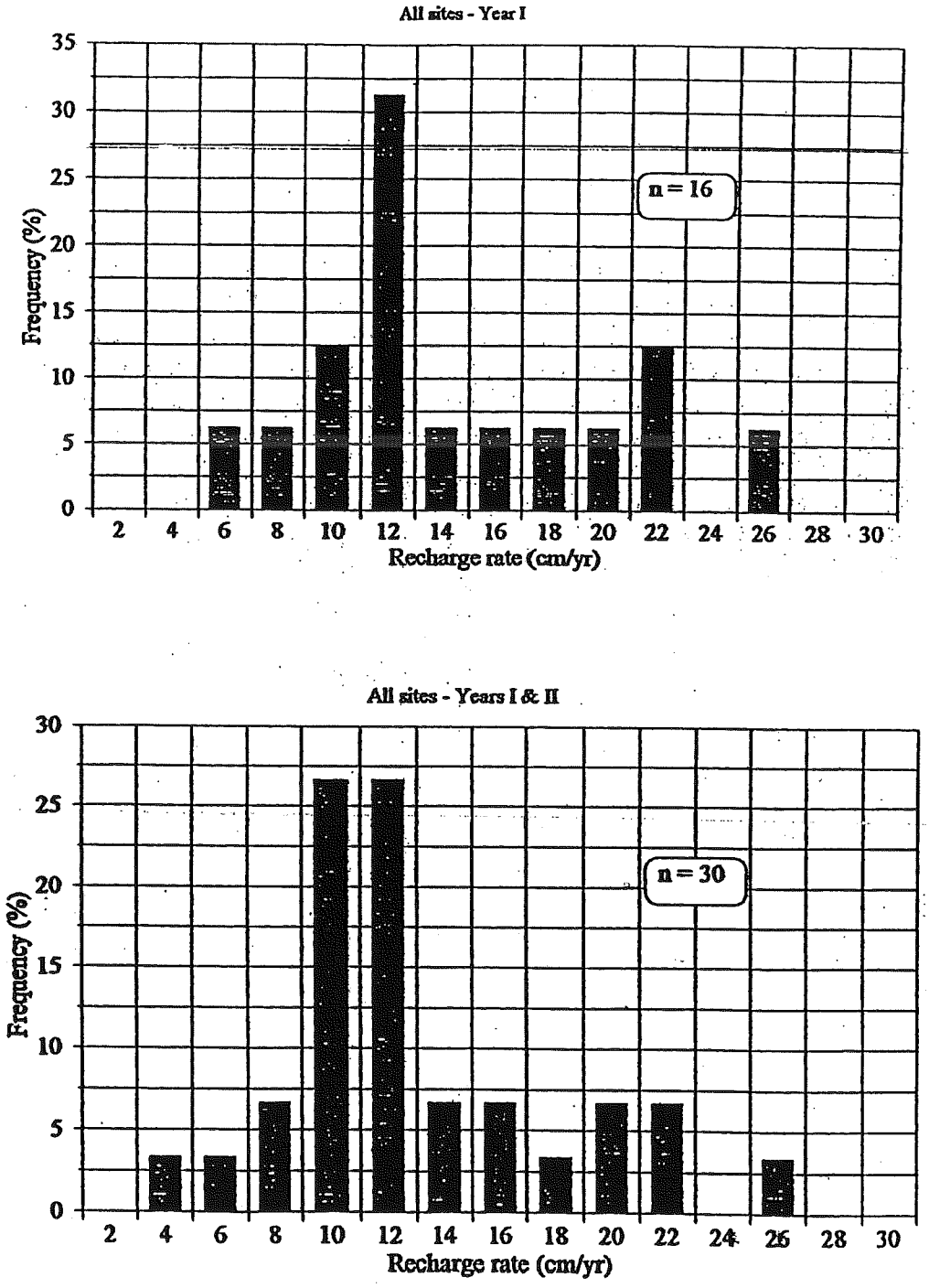

Figure 18. Frequency distribution of recharge rates observed in this study. Upper plot is for Year I; lower is composite for both years of study. Shown are the recharge rates observed at both study watersheds and test areas.

CONCLUSIONS

Streamflow in eleven small watersheds has been monitored for two years. The watersheds were specifically selected for possessing the properties that baseflow is the only significant ground-water discharge and recharge is the only significant ground-water inflow in them. Baseflow separation from the stream hydrograph was then used to determine stream baseflow which has then been equated to recharge. During the process, it was assumed that no recharge occurs during the months when the ground surface is frozen, so separation has been limited to the non-frozen months.

The recharges were then calculated for each of the study watersheds, and they range from 3 to 25 cm/yr. Because the precipitation in any year is spatially varied, part of the variation of recharge rates is due to rainfall variation. To eliminate this source of variation, recharges (R) have been normalized to total annual precipitation (P) and expressed as R/P. For the study watersheds, these range from 0.03 to 0.26 cm/cm, meaning that between 3% and 26% of the total annual precipitation ultimately becomes ground-water recharge.

The spatial distribution of normalized recharge has been linked to independent topographic, hydrogeologic and land use factors. For a given year, the observed R/P in the study area varies directly with the effective vertical permeability of the soil, the average length of overland flow and the percentage of land cover which remains in natural state (wetlands, woodlands and parks). Conversely it varies inversely with the average land surface slope, the depth to the water table (thickness of the unsaturated zone) and the percentage of the land surface which has been developed for residential, commercial or industrial purposes. Equation 5 provides an empirical relation between R/P and some dimensionless ratios of the independent variables which prediction of normalized recharge for conditions in Year I of the study. Extrapolation to other years requires using Equation 6, which adjusts the predicted R/P to account for changes from the base year of precipitation and the number of individual events that produce recharge (precipitation > 1 cm).

Testing of the relationships has taken three forms. First, use of equation 5 to calculate the normalized recharge for Year I of the study accounted for 91% of the spatial variation in the study watersheds. The average prediction error was less than 10%. Second, when the relation was used to predict normalized precipitations for areas outside the study watersheds for Year I, it was accurate to within $\pm$ 19%. Finally, normalized recharges were predicted for both the study and test watersheds for a second year's observations. In the study watersheds, the procedure developed was able to account for 71% of the spatial variation and was accurate to within $\pm$ 30%. For the outside test watersheds, prediction errors were less than $\pm$ 40%. All the testing has been done within southeastern Wisconsin, so it's not known how well the relations could be extrapolated to other geographic locations.

The method was developed using observations from watersheds ranging between 3 and 50 km^2. It has been shown to be accurate for areas up to 225 km^2, with most of the error at the outside test sites above occurring in the largest watershed. The predictive accuracy also

diminishes toward the lower end of the observed spectrum, so the method presented to calculate normalized recharge should be limited in use to areas between 3 and 225 km^2. The method was also less accurate when used to predict recharges for the second year of the study, the one for which the empirical relations were not developed. It's believed that this reduction of accuracy indicates that the correction factors in Equation 6 need further refinement, but that is beyond the scope of the current project.

Finally the study showed that the previously published range of estimated recharge rates in southeastern Wisconsin, 1 to 25 cm/yr, is actually reasonable. The observed rates in the study and test watersheds over a two year period ranged between 3 and 25 cm/yr. However, this study showed that the majority of the observed rates fell within the range of 10 to 14 cm/yr. If insufficient information exists at a site to allow application of Equation 6, then a value within that range would be a reasonable approximation.

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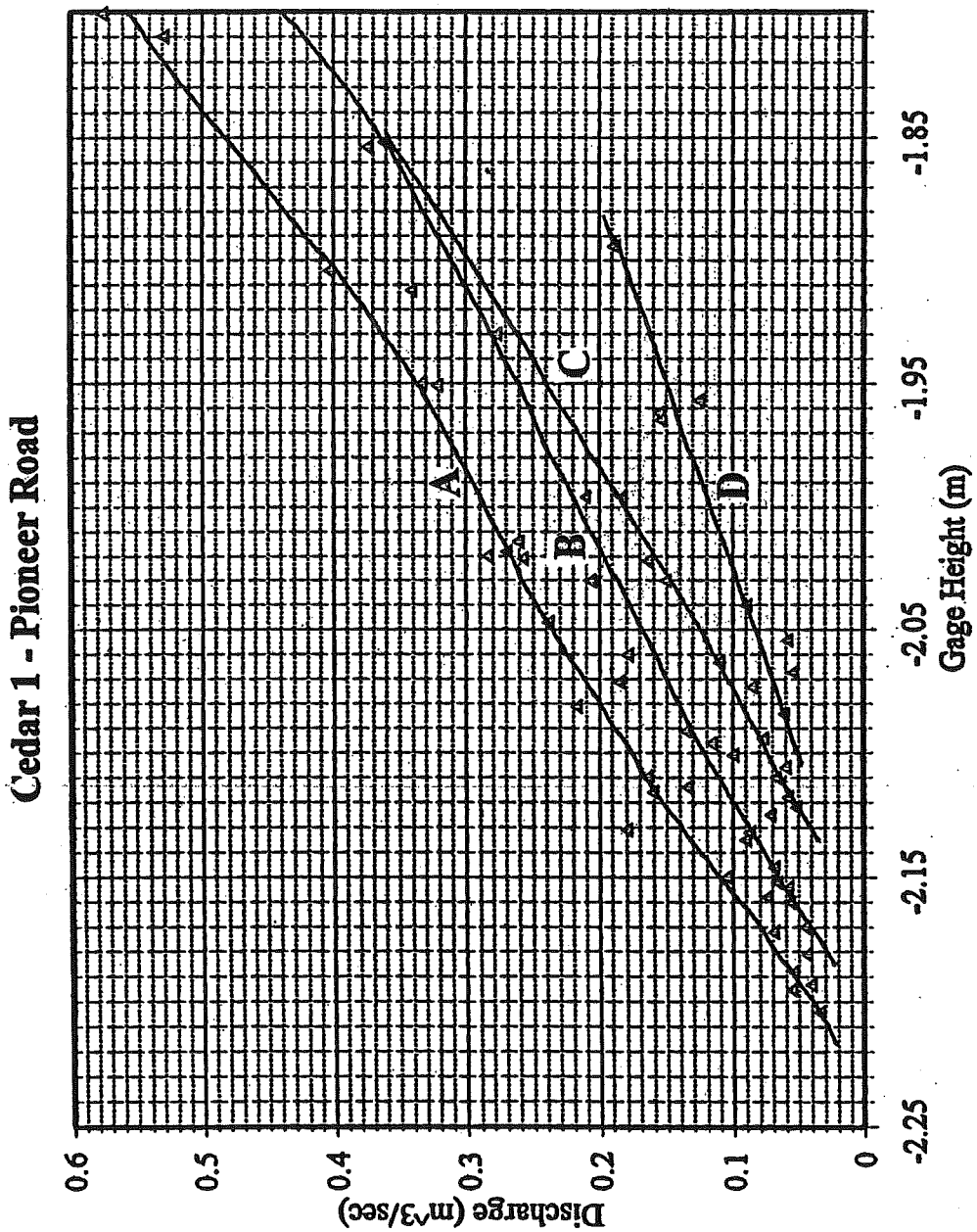
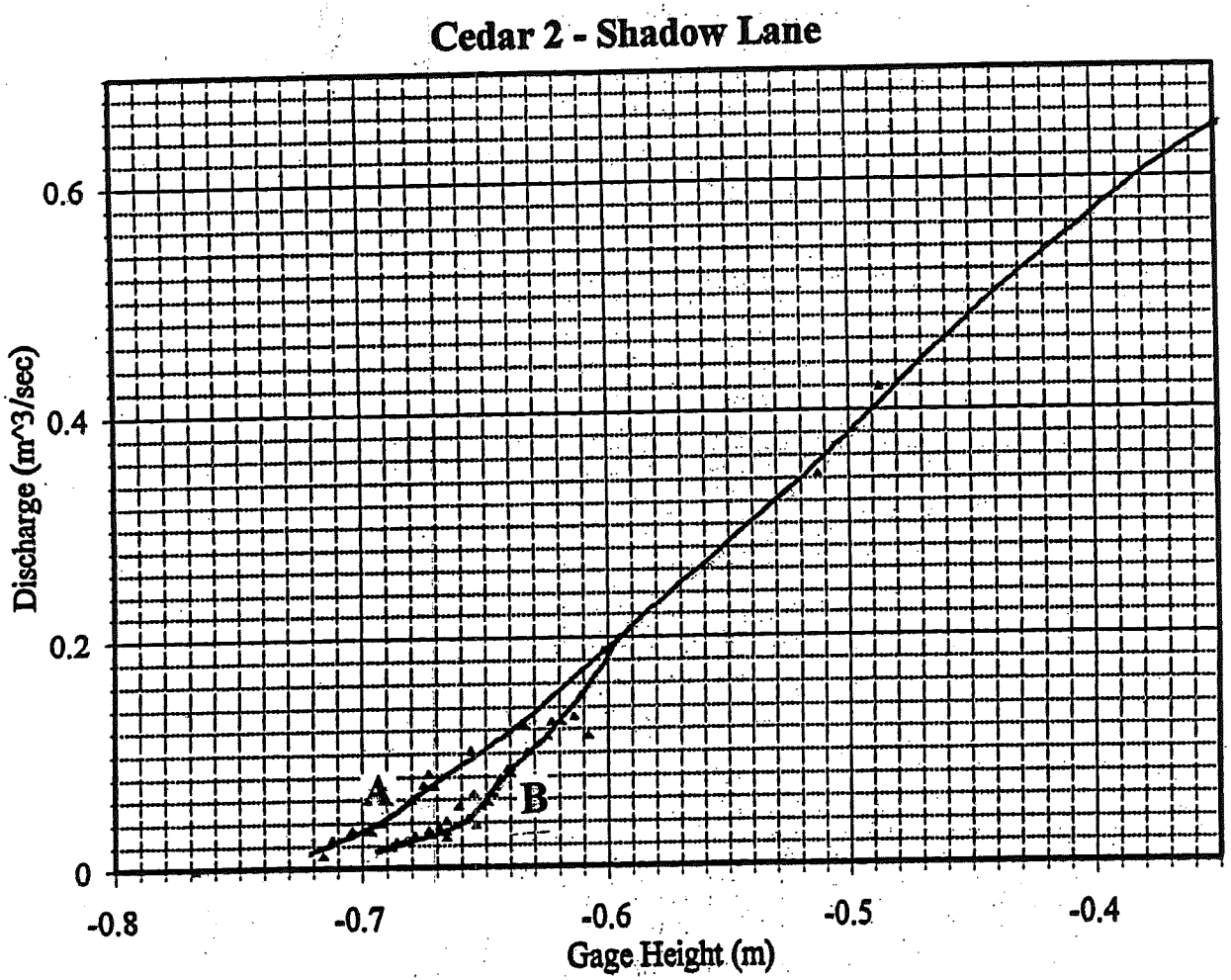
APPENDIX I. Rating Curves for the Study Gaging Sites

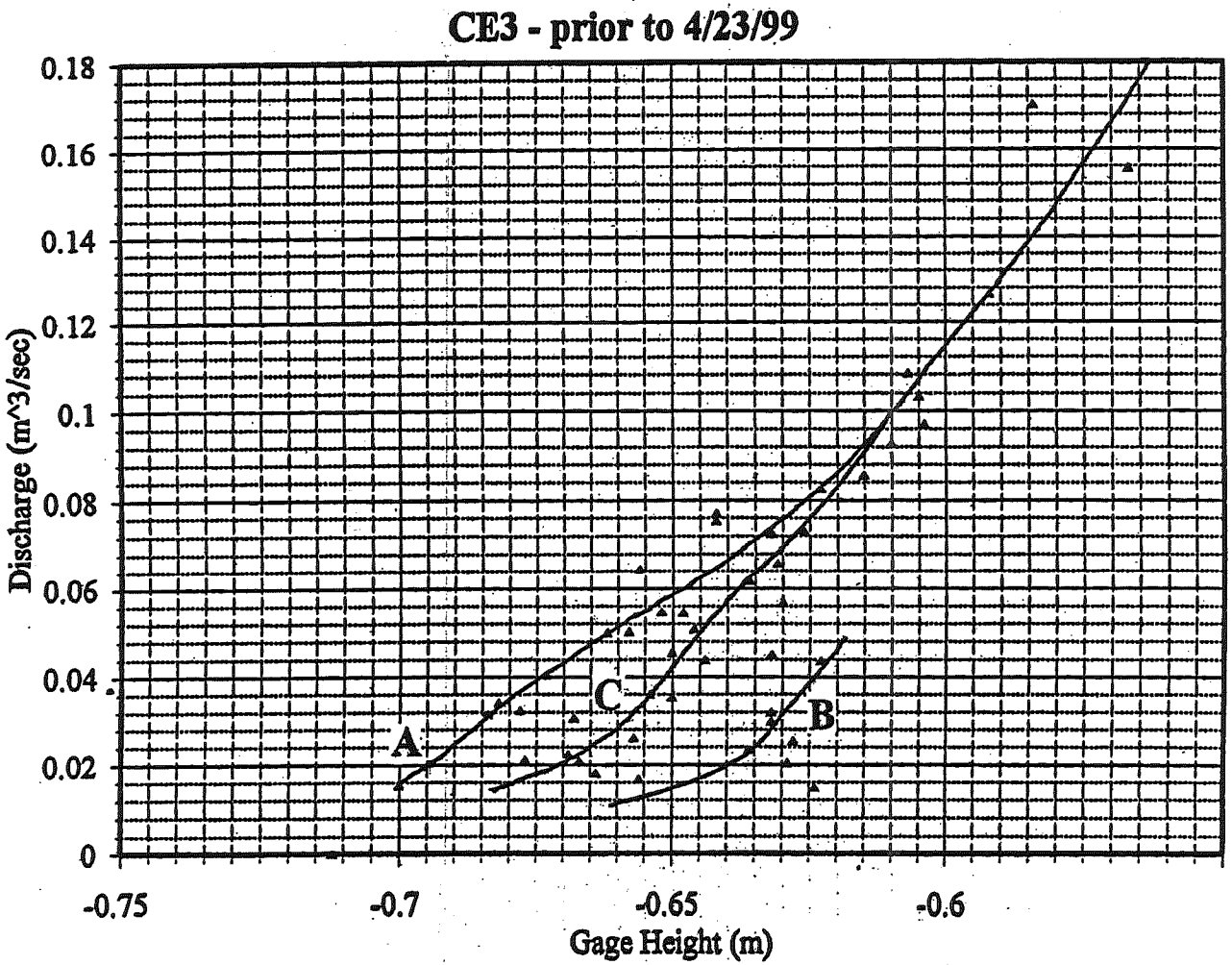
A graph for each site displays the relation of discharge to gage height. The different lines are for different seasons or time periods. The raw data for each rating curve and the dates for each line's validity are in Appendix II. The sites, whose locations are on Figure 1, are arranged alphabetically:

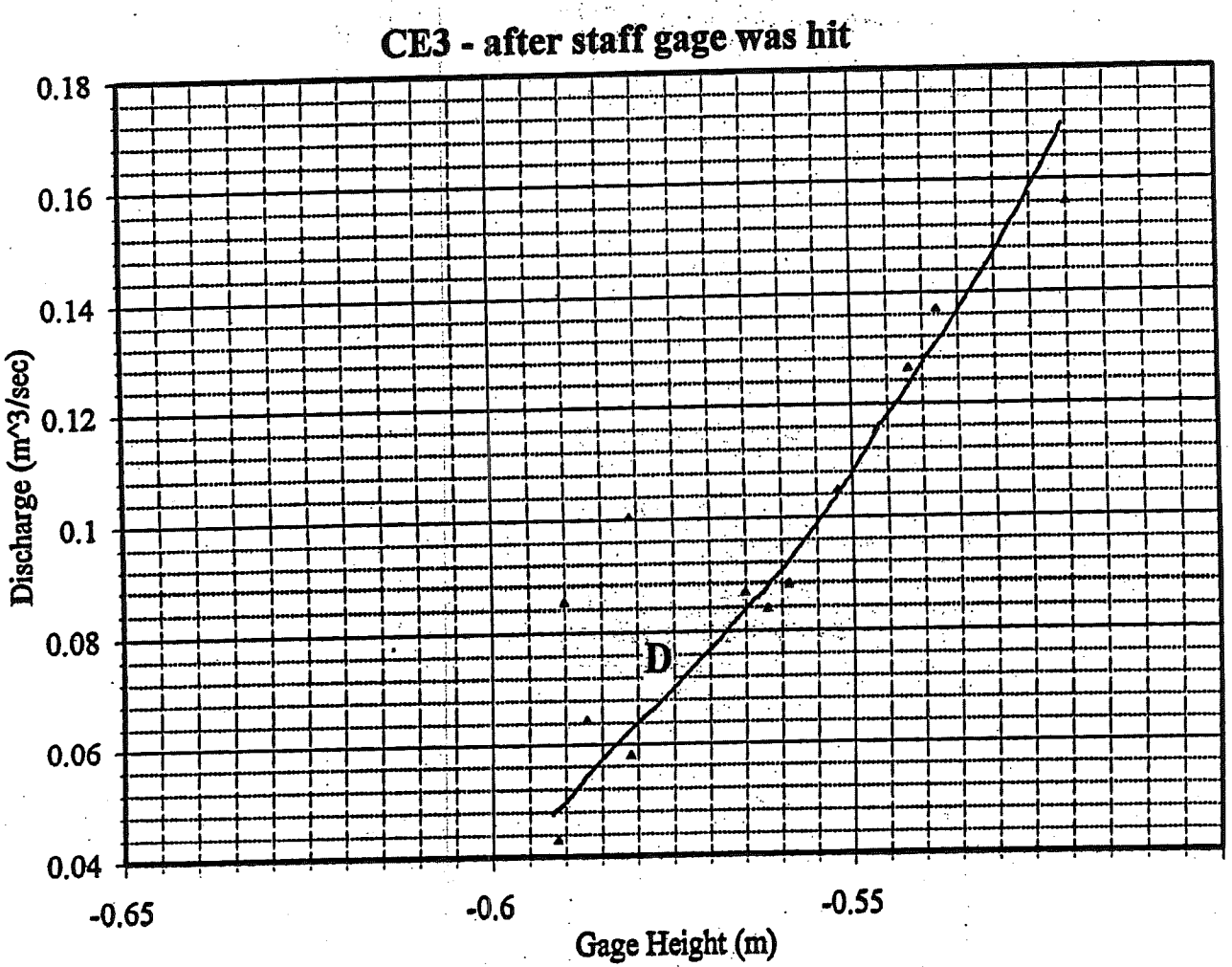
Cedar 1 (CE1)
Cedar 2 (CE2)
Cedar 3 * (CE3)
Coney (CO) (CO)
Menomonee (M1)
West Branch 1 (WB1)
West Branch 2 (WB2)
West Branch 3 (WB3)
Willow 1 (W1)
Willow 2 (W2)

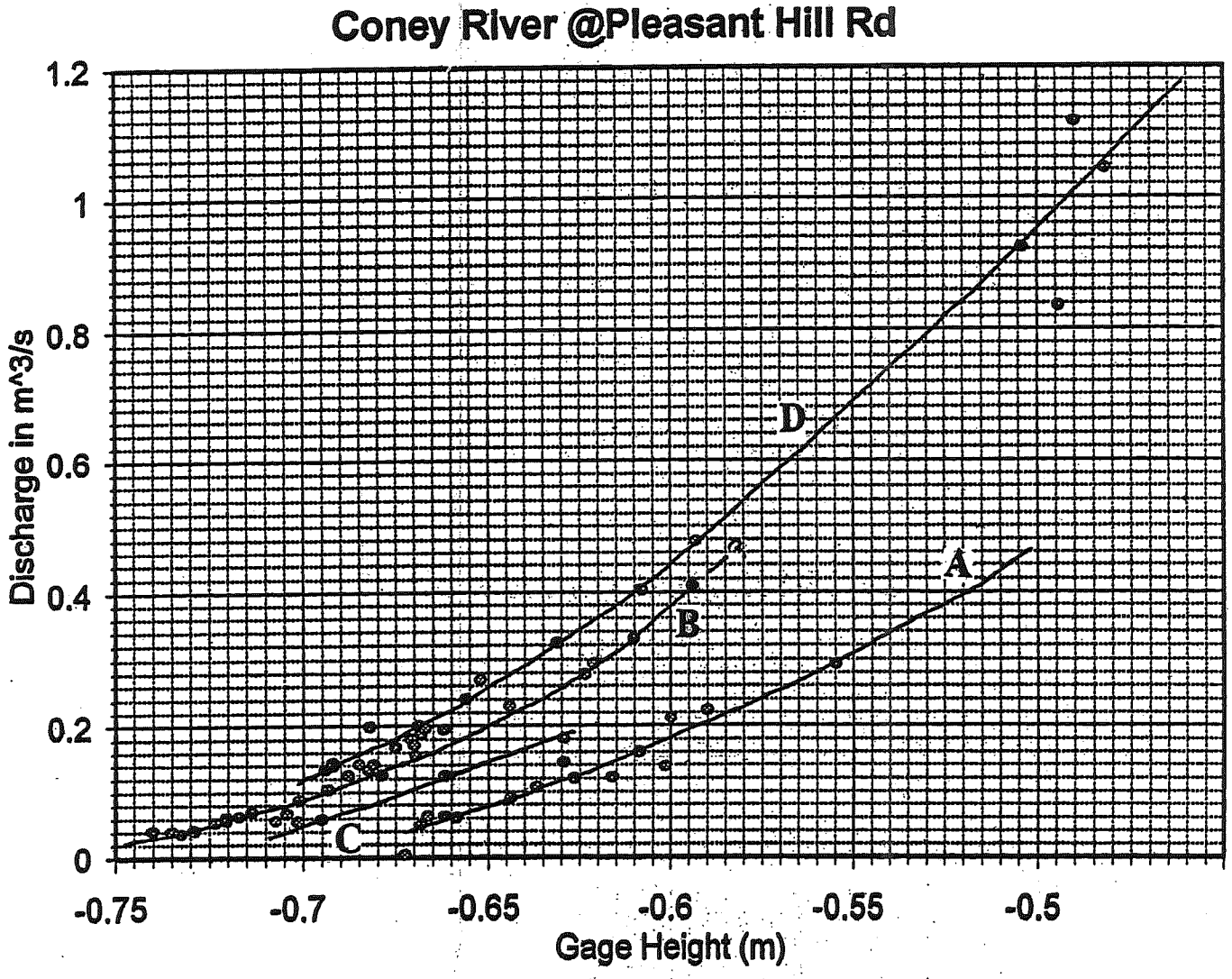
* The Cedar 3 staff gage was hit be floating debris on April 23, 1999. Separate rating curve plots are presented for the periods before and after that event.

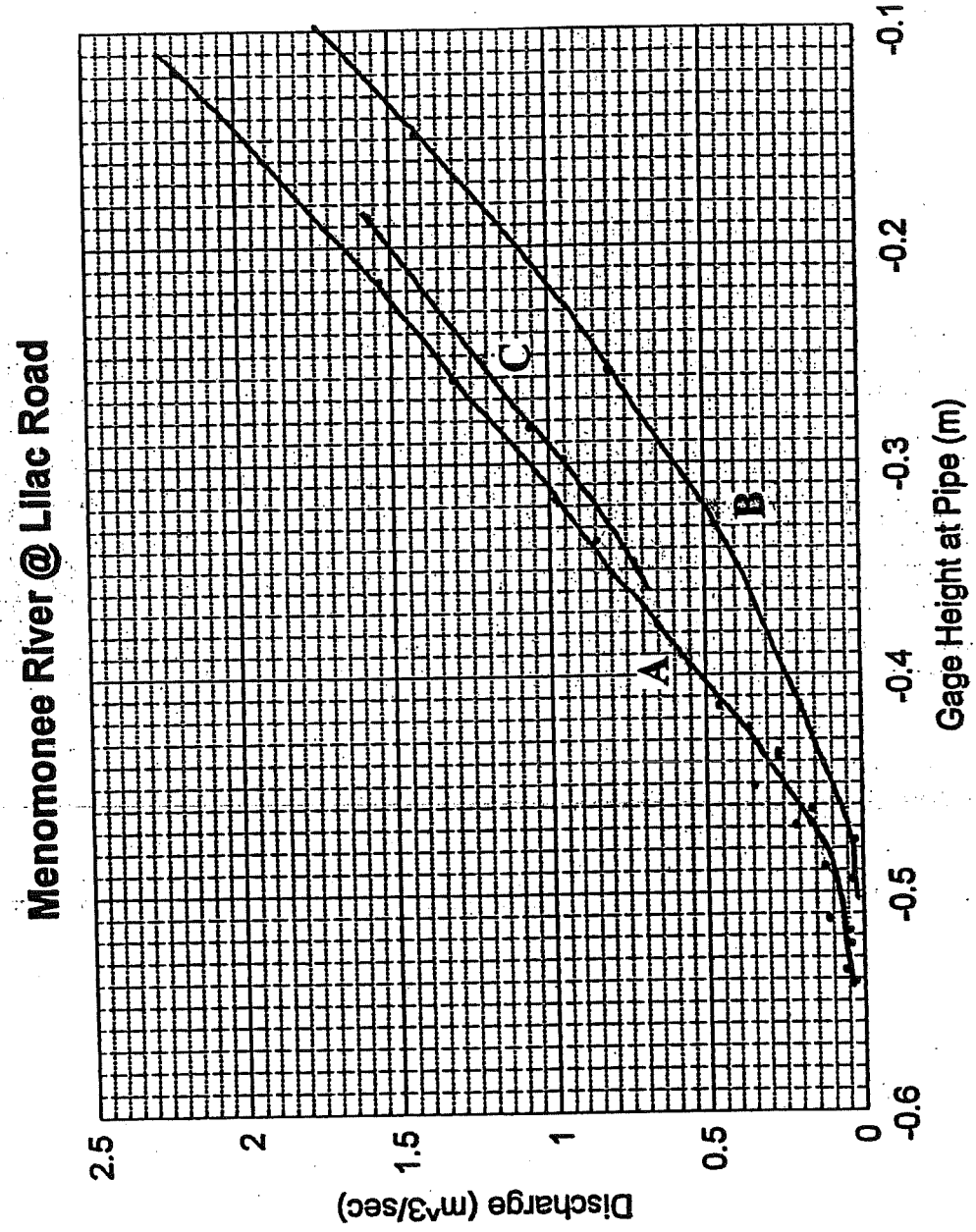

Cedar 1 - Pioneer Road
Discharge (m^3/sec)
0.6
0.5
0.4
0.3
0.2
0.1
0
A
B
C
D
-2.25
-2.15
-2.05
-1.95
-1.85
Gage Height (m)

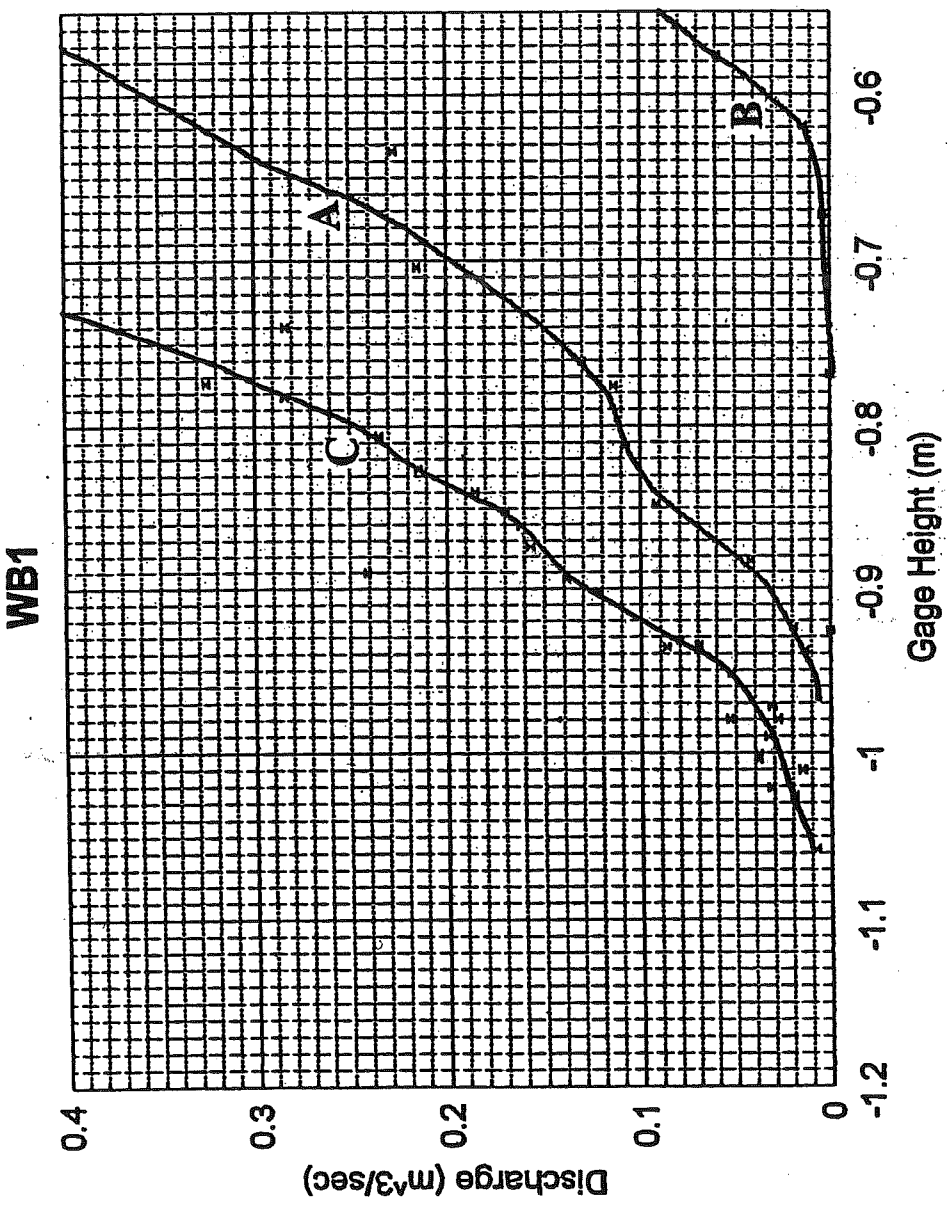

Cedar 2 - Shadow Lane
Discharge (m^3/sec)
0.6
0.4
0.2
0
-0.8
-0.7
-0.6
-0.5
-0.4
Gage Height (m)
A
B

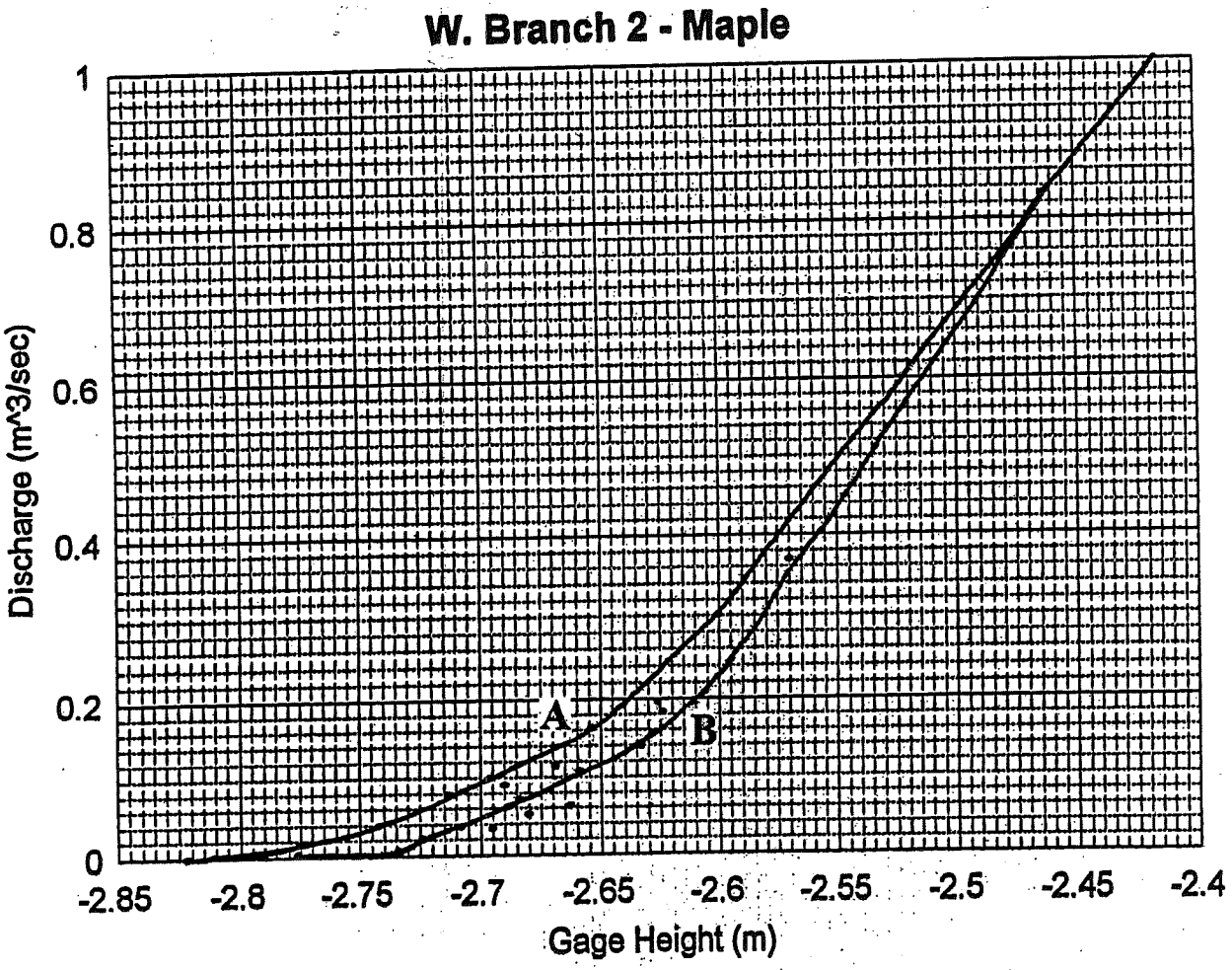

CE3 - prior to 4/23/99
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Discharge (m^3/sec)
-0.75
-0.7
-0.65
-0.6
Gage Height (m)
A
B
C

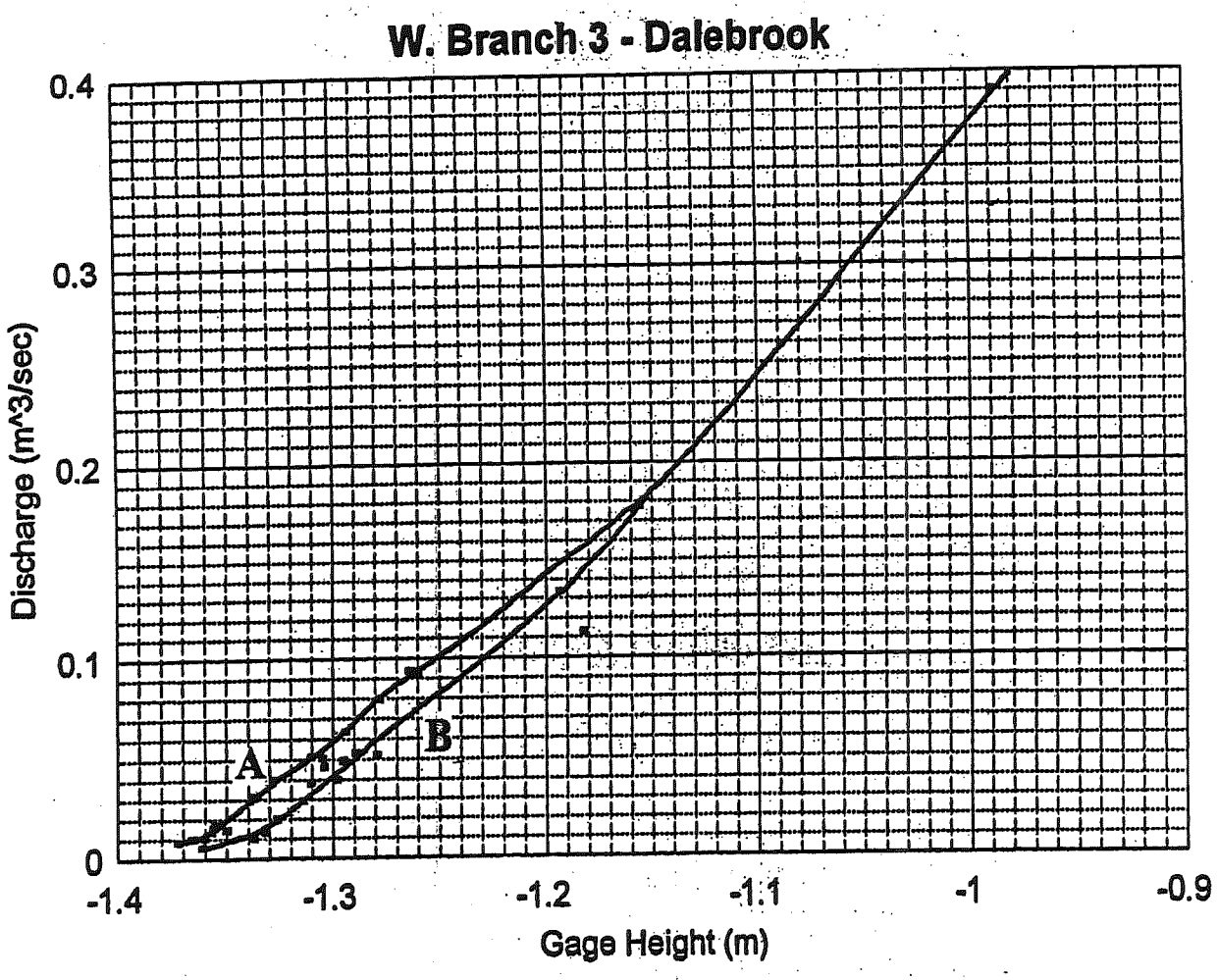

CE3 - after staff gage was hit
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
Discharge (m^3/sec)
D
-0.65
-0.6
-0.55
Gage Height (m)

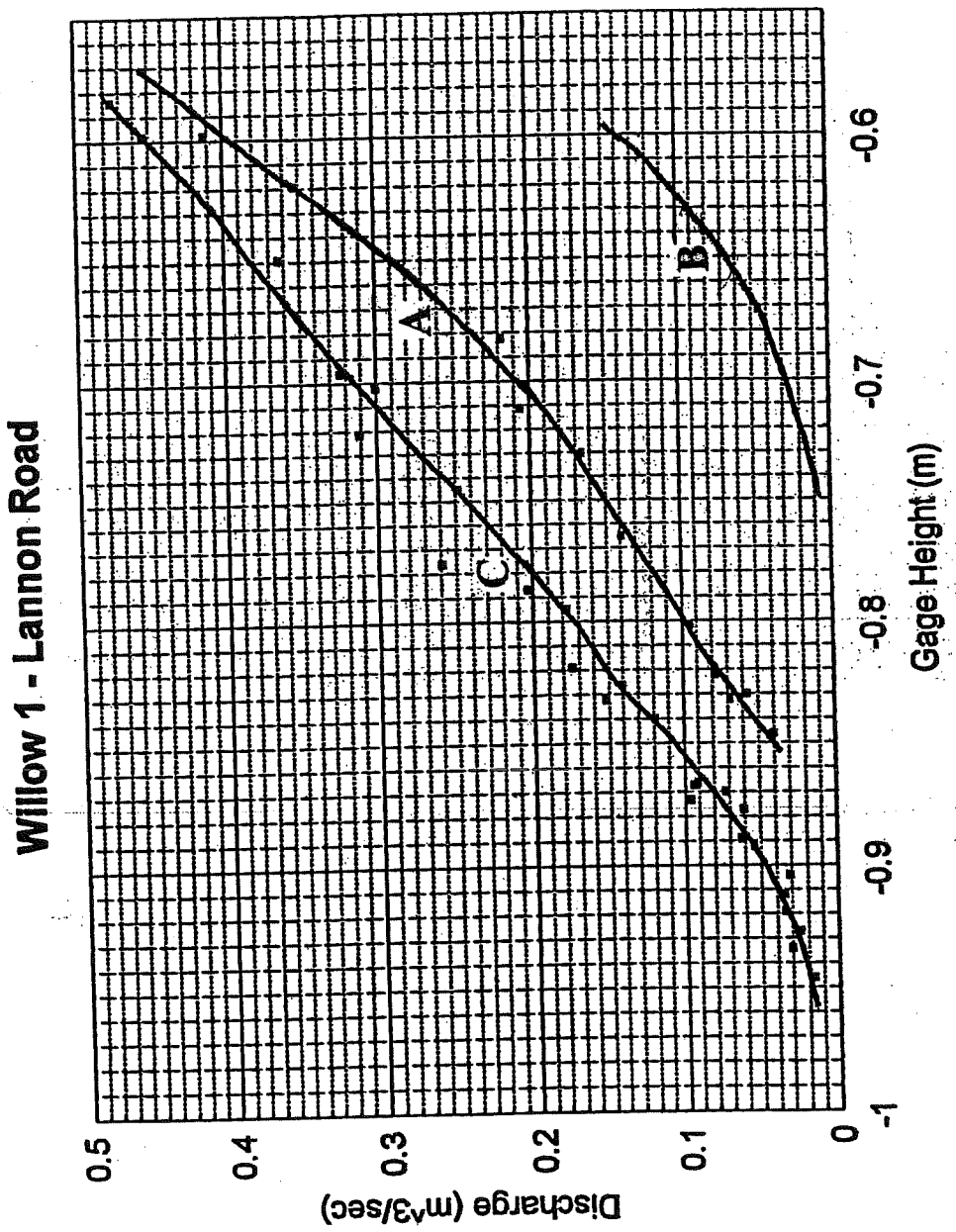

Coney River @Pleasant Hill Rd
Discharge in m^3/s
1.2
1
0.8
0.6
0.4
0.2
0
-0.75
-0.7
-0.65
-0.6
-0.55
-0.5
Gage Height (m)
A
B
C
D

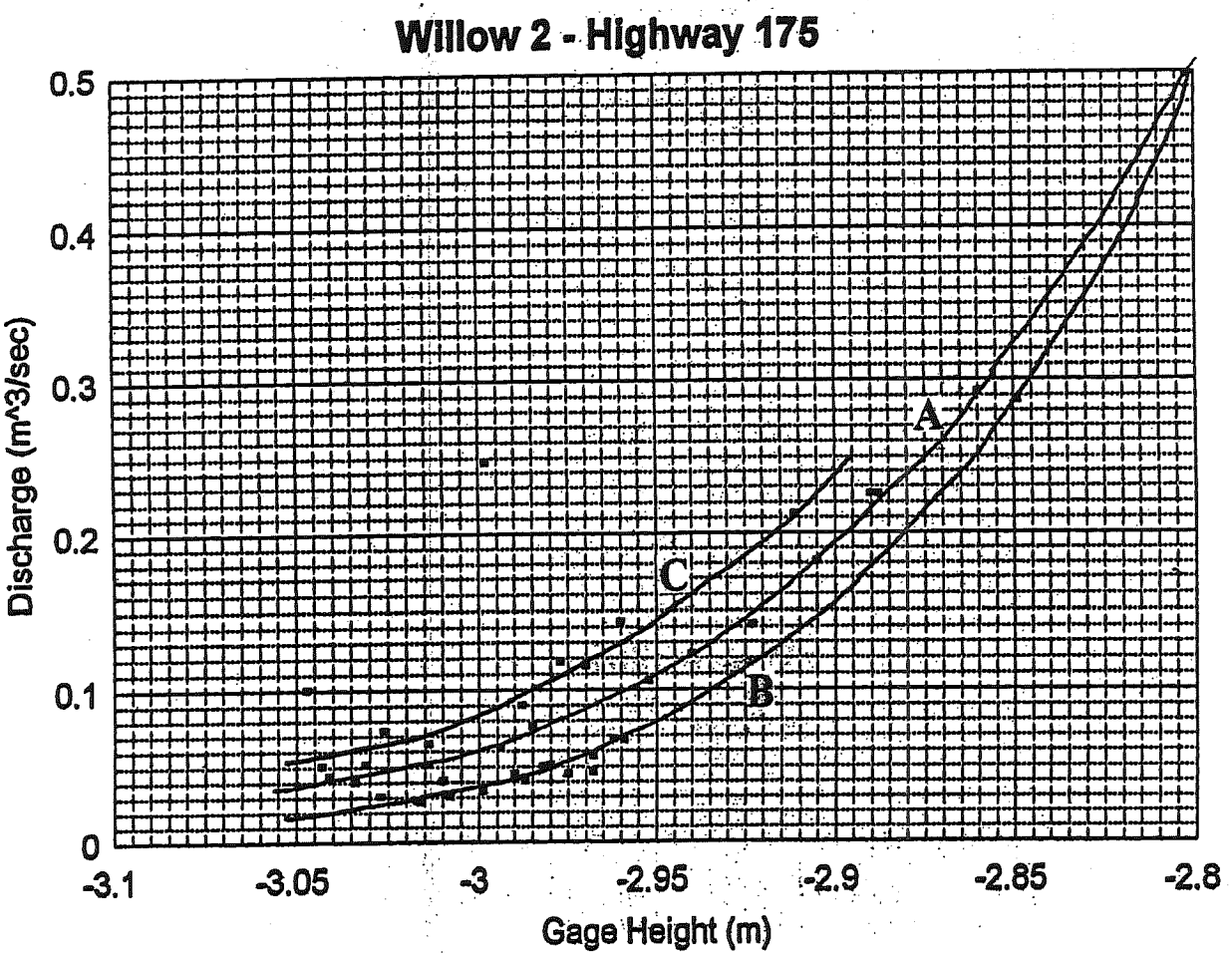

Menomonee River @ Lilac Road
Discharge (m^3/sec)
2.5
2
1.5
1
0.5
0
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
Gage Height at Pipe (m)
A
B
C


WB1
A
B
C
Discharge (m^3/sec)
0.4
0.3
0.2
0.1
0
-1.2
-1.1
-1
-0.9
-0.8
-0.7
-0.6
Gage Height (m)


W. Branch 2 - Maple
Discharge (m^3/sec)
1
0.8
0.6
0.4
0.2
0
A
B
-2.85
-2.8
-2.75
-2.7
-2.65
-2.6
-2.55
-2.5
-2.45
-2.4
Gage Height (m)


W. Branch 3 - Dalebrook
Discharge (m^3/sec)
0.4
0.3
0.2
0.1
0
A
B
-1.4
-1.3
-1.2
-1.1
-1
-0.9
Gage Height (m)


Willow 1 - Lannon Road
Discharge (m^3/sec)
0.5
0.4
0.3
0.2
0.1
0
-1
-0.9
-0.8
-0.7
-0.6
Gage Height (m)
A
B
C


Willow 2 - Highway 175
Discharge (m^3/sec)
0.5
0.4
0.3
0.2
0.1
0
-3.1
-3.05
-3
-2.95
-2.9
-2.85
-2.8
Gage Height (m)
A
B
C

APPENDIX II. Stream Gaging Data for each of the Study Gaging Sites

A two page table lists all the field data at each site's gaging station. The first page shows Year I data, the second page shows Year II. Each table is arranged in 7 columns, with the following information:

Column 1	Calendar date of reading
Column 2	Number of days elapsed since the start of the project
Column 3	Gage height (m)
Column 4	Stream Discharge (m^3/sec)
Column 5	G indicates a direct measurement of discharge was done that day, S means only a gage height reading was made.
Column 6	Comments about field conditions
Column 7	Indicates which rating curve the date lies on (Appendix I).

The sites, whose locations are on Figure 1, are arranged alphabetically:

Cedar 1 (CE1)
Cedar 2 (CE2)
Cedar 3 (CE3)
Coney (CO)
Menomonee (M1)
West Branch 1 (WB1)
West Branch 2 (WB2)
West Branch 3 (WB3)
Willow 1 (W1)
Willow 2 (W2)

Date	Consec. Days	CE1 - Pioneer Rd				Curve Type
		G Hgt (m)	Q (m3/sec)	G or S	Comments	
24-Jun-97	1					A
01-Jul-97	8					A
03-Jul-97	10					A
07-Jul-97	14					A
09-Jul-97	16					A
11-Jul-97	18					A
14-Jul-97	21					A
16-Jul-97	23					A
18-Jul-97	25					A
21-Jul-97	28					A
23-Jul-97	30	-2.022	0.164775	G	Rating Curve Before Aug'97	A
25-Jul-97	32	-2.044	0.131	S		A
28-Jul-97	35	-2.035	0.1415	S		A
30-Jul-97	37	-2.073	0.086374	G		A
01-Aug-97	39	-2.084	0.061832	G		A
04-Aug-97	42	-2.073	0.0915	S	Partly Sunny 80F	A
06-Aug-97	44	-2.106	0.060878	G	Partly Cloudy 60F	A
08-Aug-97	46	-2.122	0.052391	G		A
11-Aug-97	49	-2.11	0.068217	G		A
13-Aug-97	51	-1.996	0.184058	G		A
18-Aug-97	56	-2.042	0.133	S		A
20-Aug-97	58	-2.03	0.151366	G	Cloudy/drizzling	A
22-Aug-97	60					A
25-Aug-97	63	-2.022	0.157	S	Cloudy 65F	A
29-Aug-97	67	-2.12	0.0485	S	Partly Cloudy	A
01-Sep-97	70	-2.135	0.091069	G	Part Sunny 80, Curve after Aug	C
06-Sep-97	75	-2.158	0.074717	G	Sunny 85F	C
09-Sep-97	78	-2.16	0.696	S	Cloudy/Drizzly 65F	B
12-Sep-97	81	-2.172	0.070045	G	Partly Cloudy	B
17-Sep-97	86	-2.032	0.252	S	Rained last night	B
19-Sep-97	88	-2.167	0.0865	S	Rainy/humid	B
23-Sep-97	92	-2.157	0.0995	S	Rained Yesterday	B
26-Sep-97	95	-2.173	0.0775	S	Sunny 70F	B
30-Sep-97	99	-2.195	0.056227	G	Partly Sunny 70F	B
03-Oct-97	102	-2.188	0.054453	G	Sunny 70F	B
07-Oct-97	106	-2.199	0.04	S	Sunny 75F	B
10-Oct-97	109	-2.192	0.05	S	Sunny 60F	B
14-Oct-97	113	-2.168	0.084	S	Sunny 60F	B
17-Oct-97	116	-2.165	0.089	S	Sunny 54F	B
21-Oct-97	120	-2.18	0.0675	S	Sunny 45F	B
24-Oct-97	123	-2.165	0.089	S	Overcast 45F	B
28-Oct-97	127	-2.162	0.0935	S	Sunny 45F	B
31-Oct-97	130	-2.17	0.082	S	Sunny 55F	B
07-Nov-97	137	-2.151	0.109	S	Cloudy, upper 40s	B
11-Nov-97	141	-2.173	0.0775	S	Sunny 35F	B
14-Nov-97	144	-2.171	0.081	S	Cloudy 35F	B
18-Nov-97	148	-2.163	0.089	S	Sunny 40F	B
21-Nov-97	151	-2.172	0.079	S	Sunny 40F	B
25-Nov-97	155	-2.158	0.098	S	Sunny 48F	B

Date	Consec. Days	CE1 - Pioneer Rd				Curve Type
		G Hgt (m)	Q (m3/sec)	G or S	Comments	
29-Nov-97	159	-2.161	0.094	S	Foggy, 40F	B
05-Dec-97	165	-2.128	0.148	S	Snowy/P. Cloudy	B
12-Dec-97	172	-2.102	0.1815	S	Cold/Sunny 30F	B
19-Dec-97	179	-2.127	0.147	S	Partly Cloudy 42F	B
27-Dec-97	187	-2.12	0.156	S	Sunny/Cold	B
03-Jan-98	194	-2.057	0.231	S	Overcast 50s	B
16-Jan-98	207	-1.958	0.328	S	Cloudy, 28F	B
23-Jan-98	214	-1.926	0.383	S	Thick Ice 5-6"	B
30-Jan-98	221	-2.118	0.159	S	Cloudy 33F	B
07-Feb-98	229	-2.081	0.218535	G	Sunny, 40s	B
13-Feb-98	235	-1.93	0.368	S	Cloudy, 33F	B
21-Feb-98	243	-1.95	0.334044	G	Partly Cloudy, 30s	B
27-Feb-98	249	-1.475	0.944	S	Too Deep	B
03-Mar-98	253	-1.998	0.284	S	Upper 30's, Cloudy	B
07-Mar-98	257	-2.047	0.239584	G	Upper 30's, Partly Sunny	B
10-Mar-98	260	-1.904	0.402	S	15F, Thru' Ice, Windchill -10	B
13-Mar-98	263	-2.01	0.275	S	Cloudy, 24F, Thawing	B
17-Mar-98	267	-2.139	0.128	S	Cloudy, 30's, Truck Stuck	B
20-Mar-98	270	-1.81	0.529742	G	Cloudy, Windy, 32F	B
24-Mar-98	274	-2.006	0.278	S	Sunny, 40s	B
27-Mar-98	277	-2.04	0.247	S	Cloudy, 65F, Gusty Wind	B
31-Mar-98	281	-0.489	1.88	S	Cloudy And Rainy	B
02-Apr-98	283	-1.534	0.839	S	45F, Cloudy	B
07-Apr-98	288	-2.014	0.26148	G	Partly sunny, 60s	B
09-Apr-98	290	-1.444	0.978	S	Rainy, 40-45F	B
14-Apr-98	295	-1.904	0.403587	G	Cloudy, 60s	B
17-Apr-98	298	-1.532	0.887	S	Sunny, 52F	B
21-Apr-98	302	-1.915	0.3865	S	Cloudy 40's	B
24-Apr-98	305	-2.02	0.284914	G	Sunny 65F	B
28-Apr-98	309	-2.043	0.244	S	Sunny 50s	B
01-May-98	312	-1.548	0.871	S	Rainy 55F	B
05-May-98	316	-2.018	0.270546	G	Cloudy 60s	B
08-May-98	319	-1.801	0.576029	G	Sunny 60's	B
12-May-98	323	-2.07	0.22	S	Partly Cloudy 60s	B
14-May-98	325	-2.02	0.284417	G	Sunny 80F	B
18-May-98	329	-2.131	0.180556	G	Sunny 90s	B
21-May-98	332	-2.11	0.165444	G	Sunny 65F	B
25-May-98	336	-2.108	0.1725	S	Sunny upper 60s	B
28-May-98	339	-2.105	0.177	S	Rainy Morning, Sunny Afternoon	B
01-Jun-98	343	-2.116	0.160721	G	Storm @530AM, Sunny 75F	B
03-Jun-98	345	-2.141	0.125	S	Cloudy 50s	B
05-Jun-98	347	-2.15	0.105918	G	Cloudy upper 50s	B
08-Jun-98	350	-2.157	0.0995	S	Sunny Upper 60s	B
11-Jun-98	353	-2.091	0.13588	G	Cloudy/Rainy 65F	C
12-Jun-98	354	-1.991	0.225	S	Storm Last Night, Sunny 70s	C
15-Jun-98	357	-2.111	0.108	S	Sunny 70s	C
18-Jun-98	360	-2.132	0.087897	G	Sunny 78F (Rained Overnight)	C
19-Jun-98	361	-1.993	0.2225	S	Sunny 80F (Rained Overnight)	C
22-Jun-98	364	-2.101	0.100661	G	Sunny 85F	C

Date	Consec. Days	CE1 - Pioneer Rd				Curve Type
		G Hgt (m)	Q (m3/sec)	G or S	Comments	
25-Jun-98	367	-2.094	0.077815	G	Partly Cloudy, 90's	C
29-Jun-98	371	-1.852	0.362468	G	Storm in Weekend, Hot 90F	C
02-Jul-98	374	-2.032	0.092	S	Sunny 80F	D
04-Jul-98	376	-2.02	0.101	S	Cloudy 70S	D
06-Jul-98	378	-2.04	0.090751	G	80's Overcast/Partly Cloudy	D
09-Jul-98	381	-2.054	0.058735	G	Partly Sunny 80's	D
13-Jul-98	385	-2.06	0.076	S	Sunny Upper 80's	D
16-Jul-98	388	-2.06	0.076	S	Sunny 85F, Rained Last Night	D
20-Jul-98	392	-2.067	0.054788	G	90's, Sunny and Humid	D
21-Jul-98	393	-1.894	0.189824	G	1.5" rain Last Night, Cloudy 85	D
23-Jul-98	395	-2.031	0.145	S	Sunny 80's	A
27-Jul-98	399	-2.069	0.096	S	LATE SUMMER CURVE	A
30-Jul-98	402	-2.102	0.115	S	Between Lowest and Early Aug	A
03-Aug-98	406	-2.118	0.058424	G	Cloudy, 80's Humid	A
05-Aug-98	408	-2.072	0.0925	S	Early August Curve	A
06-Aug-98	409	-1.76	0.47	S	Cloudy and rainy	A
07-Aug-98	410	-1.934	0.26	S	Cloudy, 70's	A
10-Aug-98	413	-2.063	0.111074	G	Sunny 80's	A
13-Aug-98	416	-2.118	0.051	S	Clear, mid 70's	A
17-Aug-98	420	-2.125	0.072124	G	Cloudy 80F	A
20-Aug-98	423	-2.154	0.038559	G	Clear 80's	C
25-Aug-98	428	-2.146	0.069195	G	Sunny 80	C
28-Aug-98	431	-2.16	0.056959	G	Rainy, 70's	C
01-Sep-98	435	-2.17	0.045766	G	Sunny, 80's	C
04-Sep-98	438	-2.181	0.043973	G	Sunny 80's	C
08-Sep-98	442	-2.17	0.0535	S	Late August and Sept Curve	B
11-Sep-98	445	-2.204	0.034807	G	Sunny, 80's	B
15-Sep-98	449	-2.112	0.1065	S	Overcast and drizzle	B
18-Sep-98	452	-2.193	0.041661	G	Sunny, upper 70's	B
22-Sep-98	456	-2.194	0.042	S	Cloudy, 50 to 60 F	B
25-Sep-98	459	-2.189	0.043	S	Sunny, upper 70's	B
29-Sep-98	463	-2.172	0.0525	S	Cloudy, 60s	B
02-Oct-98	466	-2.164	0.0575	S	Cloudy, upper 60s	B
06-Oct-98	470	-1.93	0.278016	G	Cloudy, mid 60s and rainy	B
09-Oct-98	473	-2.09	0.126	S	Partly Sunny, 70's	B
13-Oct-98	477	-2.148	0.07	S	50's, Windy	B
16-Oct-98	480	-2.165	0.057	S	Partly Cloudy, 60 -70s	B
20-Oct-98	484	-2.122	0.1	S	50s, clear	B
23-Oct-98	487	-2.158	0.062	S	Sunny, 60's	B
27-Oct-98	491	-2.153	0.066	S	Cloudy and rainy	B
30-Oct-98	494	-2.152	0.066835	G	Cloudy and Drizzly, upper 50s	B
06-Nov-98	501	-2.165	0.057	S	Sunny, 40's	B
10-Nov-98	505	-1.474	0.82	S	Rainy, 45-50F, CE1 too deep	B
13-Nov-98	508	-2.091	0.126	S	Sunny, 50s	B
17-Nov-98	512	-2.137	0.0825	S	Sunny, upper 50s	B
20-Nov-98	515	-2.149	0.069	S	Cloudy, 35F	B
24-Nov-98	519	-2.154	0.065	S	Sunny, 40s-50s	B
27-Nov-98	522	-2.154	0.065	S	Sunny, 50s	B

Date	Consec. Days	CE1 - Pioneer Rd				Curve Type
		G Hgt (m)	Q (m3/sec)	G or S	Comments	
01-Dec-98	526	-2.142	0.077	S	Sunny, upper 40s-50s	B
04-Dec-98	529	-2.155	0.064	S	Cloudy, 50s	B
08-Dec-98	533	-2.096	0.116897	G	Sunny, 30s	B
11-Dec-98	536	-2.136	0.083	S	Sunny, upper 50s	B
15-Dec-98	540	-2.144	0.074	S	Sunny, 40s	B
23-Dec-98	548	-2.107	0.1115	S	Sunny, 10-20F. Frozen	B
29-Dec-98	554	-2.008	0.2085	S	Snowy 30s. Frozen	B
12-Jan-99	568	-1.825	0.048	S	Snowy 10s, TOP OF ICE	B
19-Jan-99	575	-1.825	0.048	S	Extrapolated TOP OF ICE, Frozen,	B
29-Jan-99	585	-1.943	1	S	Sunny 40's. Mostly Frozen	B
05-Feb-99	592	-1.854	0.374429	G	Partly Cloudy, 20's.	B
12-Feb-99	599	-1.379	0.95	S	Partly Sunny, upper 20's	B
19-Feb-99	606	-2.06	0.179756	G	Snow Flurries, 20's	B
26-Feb-99	613	-2.114	0.134924	G	Sunny 40's.	B
05-Mar-99	620	-2.1	0.121	S	Snow Flurries, low 30's	B
12-Mar-99	627	-2.08	0.14	S	Sunny 40's.	B
16-Mar-99	631	-2.034	0.185	S	Sunny 45-50F	B
19-Mar-99	634	-1.912	0.341897	G	Sunny 40-50F	B
23-Mar-99	638	-2.042	0.18	S	Sunny 50s	B
27-Mar-99	642	-2.089	0.13	S	Sunny 50-55F	B
30-Mar-99	645	-2.1	0.121	S	Sunny 60's	B
02-Apr-99	648	-2.103	0.118	S	Sunny to Partly Cloudy 50-60F	B
06-Apr-99	652	-2.055	0.165	S	Overcast and drizzle, 53F, 40mph	B
9-Apr-99	655	-1.2	1.18	S*	Rainy, 40's	B
13-Apr-99	659	-1.899	0.315	S*	Partly Cloudy 55F	B
16-Apr-99	662	-2.021	0.258339	G	Sunny, 50's	B
20-Apr-99	666	-2.071	0.166193	G	Partly Cloudy 50's	B
23-Apr-99	669	-0.472	2.57	S	Partly Cloudy 40's, prev rains	B
27-Apr-99	673	-1.951	0.322119	G	Sunny 60's	B
30-Apr-99	676	-2.03	0.207484	G	Sunny 60's	B
4-May-99	680	-2.089	0.132	S	Sunny 60's	B
7-May-99	683	-1.936	0.277	S	Overcast, 60's	B
12-May-99	688	-1.275	1.29	S	Cloudy, 50s	B
15-May-99	691	-1.996	0.210904	S	Sunny 60's	B
19-May-99	695	-1.294	1.26	S	Sunny-cloudy, 70's	B
21-May-99	697	-1.92	0.292	S	Partly cloudy, 60's	B
25-May-99	701	-1.88	0.335	S	Partly cloudy, 55-60s	B
28-May-99	704	-2.03	0.188	S	Sunny, 80's	B
1-Jun-99	708	-2.073	0.149	S	Overcast, 60's	B
4-Jun-99	711	-1.991	0.192	S	65-70, showers	B
8-Jun-99	715	-1.982	0.234	S	Sunny, 80's	B
11-Jun-99	718	-1.702	0.68	S	Sunny, 80's	B
13-Jun-99	720	-0.462	2.55	S	Rain/estimate	B
15-Jun-99	722	-1.662	0.33	S	Sunny, 60's	D
18-Jun-99	725	-1.904	0.18	S	Sunny, 70's	D
22-Jun-99	729	-1.962	0.155951	G	Partly cloudy, 75-80	D
25-Jun-99	732	-1.965	0.154559	G	Sunny, 80's	D
29-Jun-99	736	-1.957	0.12597	G	Partly cloudy, 75	D

Date	Consec. Days	CE2 - 2351 Shadow Lane (Harold Schowalter)				Curve Type
		G Hgt (m)	Q (m3/sec)	G or S	Comments	
24-Jun-97	1	-0.64	0.126	S	Curve	A
01-Jul-97	8	-0.682	0.057	S	Before	A
03-Jul-97	10	-0.673	0.08349	G	Oct'15	A
07-Jul-97	14	-0.683	0.0555	S		A
09-Jul-97	16	-0.656	0.1027	G		A
11-Jul-97	18	-0.692	0.043	S		A
14-Jul-97	21	-0.671	0.07317	G		A
16-Jul-97	23	-0.699	0.0345	S		A
18-Jul-97	25	-0.68	0.06	G		A
21-Jul-97	28	-0.644	0.1205	S		A
23-Jul-97	30	-0.673	0.07404	G		A
25-Jul-97	32	-0.686	0.0502	S		A
28-Jul-97	35	-0.695	0.04	S		A
30-Jul-97	37	-0.705	0.031257	G		A
01-Aug-97	39	-0.704	0.034107	G		A
04-Aug-97	42	-0.692	0.043	S		A
06-Aug-97	44	-0.712	0.026167	G		A
08-Aug-97	46	-0.716	0.012283	G		A
11-Aug-97	49	-0.696	0.032612	G		A
13-Aug-97	51	-0.671	0.0775	S		A
18-Aug-97	56	-0.671	0.0775	S		A
20-Aug-97	58	-0.674	0.0725	S		A
22-Aug-97	60	-0.692	0.040277	G		A
25-Aug-97	63	-0.662	0.093	S		A
29-Aug-97	67	-0.692	0.043	S		A
01-Sep-97	70	-0.695	0.04	S		A
06-Sep-97	75	-0.702	0.032	S		A
09-Sep-97	78	-0.698	0.032912	G		A
12-Sep-97	81	-0.703	0.031	S		A
17-Sep-97	86	-0.665	0.088	S		A
19-Sep-97	88	-0.695	0.04	S		A
23-Sep-97	92	-0.697	0.037	S		A
26-Sep-97	95	-0.697	0.037	S		A
30-Sep-97	99	-0.697	0.037	S		A
03-Oct-97	102	-0.69	0.0465	S		A
07-Oct-97	106	-0.688	0.0485	S		A
10-Oct-97	109	-0.679	0.0625	S		A
14-Oct-97	113	-0.672	0.076	S		A
17-Oct-97	116	-0.674	0.026	S	Curve	B
21-Oct-97	120	-0.677	0.021	S	After Oct'15	B
24-Oct-97	123	-0.659	0.052	S		B
28-Oct-97	127	-0.669	0.0345	S		B
31-Oct-97	130	-0.667	0.0375	S		B
07-Nov-97	137	-0.661	0.055077	G		B
11-Nov-97	141	-0.674	0.026	S		B
14-Nov-97	144	-0.672	0.029	S		B
18-Nov-97	148	-0.676	0.0225	S		B
21-Nov-97	151	-0.675	0.024	S		B
25-Nov-97	155	-0.675	0.024	S		B

Date	Consec. Days	CE2 - 2351 Shadow Lane (Harold Schowalter)				Curve Type
		G Hgt (m)	Q (m3/sec)	G or S	Comments	
29-Nov-97	159	-0.668	0.0365	S		B
05-Dec-97	165	-0.666	0.04183	G		B
12-Dec-97	172	-0.66	0.05	S		B
19-Dec-97	179	-0.66	0.05	S		B
27-Dec-97	187	-0.656	0.0575	S		B
03-Jan-98	194	-0.64	0.08424	G		B
16-Jan-98	207	-0.622	0.1345	S		B
23-Jan-98	214	-0.648	0.073	S	25F	B
30-Jan-98	221	-0.647	0.0755	S		B
07-Feb-98	229	-0.641	0.089	S		B
13-Feb-98	235	-0.602	0.1865	S		B
21-Feb-98	243	-0.593	0.201	S		B
27-Feb-98	249	-0.35	0.64663	G		B
03-Mar-98	253	-0.616	0.148	S		B
07-Mar-98	257	-0.627	0.1225	S		B
10-Mar-98	260	-0.595	0.196	S	Free	B
13-Mar-98	263	-0.646	0.078	S	Free	B
17-Mar-98	267	-0.66	0.05	S		B
20-Mar-98	270	-0.559	0.27	S		B
24-Mar-98	274	-0.619	0.1279	G		B
27-Mar-98	277	-0.622	0.1345	S		B
31-Mar-98	281	0.104	1.385	S		B
02-Apr-98	283	-0.487	0.41983	G		B
07-Apr-98	288	-0.634	0.12377	G		B
09-Apr-98	290	-0.362	0.627	S		B
14-Apr-98	295	-0.602	0.18859	G		B
17-Apr-98	298	-0.506	0.3825	S		B
21-Apr-98	302	-0.598	0.1975	S		B
24-Apr-98	305	-0.622	0.1345	S		B
28-Apr-98	309	-0.633	0.108	S		B
01-May-9	312	-0.446	0.509	S		B
05-May-9	316	-0.625	0.1275	S		B
08-May-9	319	-0.563	0.26	S		B
12-May-9	323	-0.639	0.0935	S		B
14-May-9	325	-0.623	0.12792	G		B
18-May-9	329	-0.658	0.053	S		B
21-May-9	332	-0.644	0.07965	G		B
25-May-9	336	-0.641	0.08717	G		B
28-May-9	339	-0.642	0.087	S		B
01-Jun-98	343	-0.647	0.0657	G		B
03-Jun-98	345	-0.648	0.073	S		B
05-Jun-98	347	-0.661	0.048	S		B
08-Jun-98	350	-0.665	0.0415	S		B
11-Jun-98	353	-0.642	0.087	S		B
12-Jun-98	354	-0.617	0.1465	S		B
15-Jun-98	357	-0.659	0.06569	G		B
18-Jun-98	360	-0.669	0.03665	G		B
19-Jun-98	361	-0.633	0.1125	S		B
22-Jun-98	364	-0.659	0.052	S		B

Date	Consec. Days	CE2 - 2351 Shadow Lane (Harold Schowalter)				Curve Type
		G Hgt (m)	Q (m3/sec)	G or S	Comments	
25-Jun-98	367	-0.672	0.029832	G		B
29-Jun-98	371	-0.611	0.15059	G		B
02-Jul-98	374	-0.654	0.0615	S		B
04-Jul-98	376	-0.657	0.0575	S		B
06-Jul-98	378	-0.672	0.0325	S		B
09-Jul-98	381	-0.672	0.0325	S		B
13-Jul-98	385	-0.679	0.029036	G		B
16-Jul-98	388	-0.678	0.0275	S		B
20-Jul-98	392	-0.679	0.029	S		B
21-Jul-98	393	-0.634	0.1	S		B
23-Jul-98	395	-0.664	0.045	S		B
27-Jul-98	399	-0.671	0.034	S		B
30-Jul-98	402	-0.679	0.02904	S		B
03-Aug-98	406	-0.678	0.0297	S		B
05-Aug-98	408	-0.628	0.1198	S		B
06-Aug-98	409	-0.62	0.1372	S		B
07-Aug-98	410	-0.613	0.155	S		B
10-Aug-98	413	-0.655	0.063	S		B
13-Aug-98	416	-0.673	0.033674	G		B
17-Aug-98	420	-0.669	0.0408	S		B
20-Aug-98	423	-0.686	0.023636	G		B
25-Aug-98	428	-0.679	0.02904	S		B
28-Aug-98	431	-0.668	0.0422	S		B
01-Sep-98	435	-0.67	0.0395	S		B
04-Sep-98	438	-0.688	0.019514	G		B
08-Sep-98	442	-0.67	0.0395	S		B
11-Sep-98	445	-0.693	0.018	S		B
15-Sep-98	449	-0.663	0.0498	S		B
18-Sep-98	452	-0.682	0.0225	S		B
22-Sep-98	456	-0.68	0.024	S		B
25-Sep-98	459	-0.675	0.028	S		B
29-Sep-98	463	-0.662	0.043	S		B
02-Oct-98	466	-0.657	0.044442	G		B
06-Oct-98	470	-0.594	0.32	S		B
09-Oct-98	473	-0.637	0.093	S		B
13-Oct-98	477	-0.662	0.043	S		B
16-Oct-98	480	-0.654	0.0575	S		B
20-Oct-98	484	-0.654	0.038576	G		B
23-Oct-98	487	-0.667	0.036	S		B
27-Oct-98	491	-0.664	0.039	S		B
30-Oct-98	494	-0.666	0.027683	G		B
06-Nov-98	501	-0.662	0.043	S		B
10-Nov-98	505	-0.478	0.427	S		B
13-Nov-98	508	-0.645	0.075	S		B
17-Nov-98	512	-0.663	0.0415	S		B
20-Nov-98	515	-0.663	0.0415	S		B
24-Nov-98	519	-0.666	0.032868	G		B
27-Nov-98	522	-0.664	0.039	S		B

Date	Consec. Days	CE2 - 2351 Shadow Lane (Harold Schowalter)				Curve Type
		G Hgt (m)	Q (m3/sec)	G or S	Comments	
01-Dec-98	526	-0.661	0.044	S		B
04-Dec-98	529	-0.667	0.036	S		B
08-Dec-98	533	-0.652	0.05488	G		B
11-Dec-98	536	-0.662	0.043	S		B
15-Dec-98	540	-0.662	0.043	S		B
23-Dec-98	548	-0.67	0.0325	S	Frozen	B
29-Dec-98	554	-0.669	0.034	S	Partly Froz.	B
12-Jan-99	568	-0.617	0.138	S	Frozen	B
19-Jan-99	575	-0.492	0.4	S	Frozen	B
29-Jan-99	585	-0.568	0.26	S	Partly Froze	B
05-Feb-99	592	-0.578	0.24	S		B
12-Feb-99	599	-0.513	0.3449	G		B
19-Feb-99	606	-0.635	0.098	S		B
26-Feb-99	613	-0.652	0.061	S		B
05-Mar-99	620	-0.649	0.05882	G		B
12-Mar-99	627	-0.638	0.091	S		B
16-Mar-99	631	-0.587	0.22	S		B
19-Mar-99	634	-0.592	0.21	S		B
23-Mar-99	638	-0.625	0.11525	G		B
27-Mar-99	642	-0.64	0.086	S		B
30-Mar-99	645	-0.645	0.075	S		B
02-Apr-99	648	-0.647	0.07	S		B
06-Apr-99	652	-0.633	0.10134	G		B
9-Apr-99	655	-0.07	1.055	S		B
13-Apr-99	659	-0.602	0.178	S		B
16-Apr-99	662	-0.637	0.091	S		B
20-Apr-99	666	-0.644	0.078	S		B
23-Apr-99	669	0.05	1.23	S	(above gage	B
27-Apr-99	673	-0.617	0.135	S		B
30-Apr-99	676	-0.634	0.098	S		B
4-May-99	680	-0.649	0.065	S		B
7-May-99	683	-0.608	0.11559	G		B
########	688	-0.463	0.456	S		B
########	691	-0.626	0.118	S		B
########	695	-0.489	0.41	S		B
########	697	-0.614	0.145	S		B
########	701	-0.594	0.22	S		B
########	704	-0.627	0.113	S		B
1-Jun-99	708	-0.644	0.078	S		B
4-Jun-99	711	-0.616	0.14	S		B
8-Jun-99	715	-0.627	0.113	S		B
11-Jun-99	718	-0.562	0.268	S		B
13-Jun-99	720	0.424	1.43	S		B
15-Jun-99	722	-0.564	0.265	S		B
18-Jun-99	725	-0.614	0.13205	G		B
22-Jun-99	729	-0.645	0.077	S		B
25-Jun-99	732	-0.646	0.0719	G		B
29-Jun-99	736	-0.654	0.05	S		B

Date	Consec. Days	CES - 2324 Mayfield R (Charles Schmitt) G Hgt (m)	Q (m3/sec)	G or S	Comments	Curve Type
24-Jun-97	1	-0.605	0.146	S		A
01-Jul-97	8	-0.664	0.047	S		A
03-Jul-97	10	-0.652	0.05471	G		A
07-Jul-97	14	-0.638	0.0505	S		A
09-Jul-97	16	-0.642	0.07721	G		A
11-Jul-97	18	-0.678	0.0358	S		A
14-Jul-97	21	-0.648	0.054613	G		A
16-Jul-97	23	-0.679	0.035	S		A
18-Jul-97	25	-0.658	0.05046	G		A
21-Jul-97	28	-0.636	0.086	S		A
23-Jul-97	30	-0.656	0.064555	G		A
25-Jul-97	32	-0.67	0.0418	S		A
28-Jul-97	35	-0.676	0.0374	S		A
30-Jul-97	37	-0.682	0.034344	G		A
01-Aug-97	39	-0.692	0.0245	S		A
04-Aug-97	42	-0.672	0.0403	S		A
06-Aug-97	44	-0.696	0.0212	G		A
08-Aug-97	46	-0.7	0.015535	G		A
11-Aug-97	49	-0.684	0.03162	G		A
13-Aug-97	51	-0.656	0.05235	S		A
18-Aug-97	56	-0.652	0.0572	S		A
20-Aug-97	58	-0.654	0.0544	S		A
22-Aug-97	60	-0.673	0.040526	G		A
25-Aug-97	63	-0.641	0.0778	S		A
29-Aug-97	67	-0.669	0.0425	S		A
01-Sep-97	70	-0.675	0.0381	S		A
06-Sep-97	75	-0.679	0.035	S		A
09-Sep-97	78	-0.678	0.032453	G		A
12-Sep-97	81	-0.679	0.035	S		A
17-Sep-97	86	-0.642	0.075543	G		A
19-Sep-97	88	-0.671	0.041	S		A
23-Sep-97	92	-0.668	0.030706	G		A
26-Sep-97	95	-0.667	0.0445	S		A
30-Sep-97	99	-0.668	0.0438	S		A
03-Oct-97	102	-0.667	0.046	S	Curve of	A
07-Oct-97	106	-0.656	0.016876	G	Oct and	B
10-Oct-97	109	-0.647	0.017	S	Dec'12	B
14-Oct-97	113	-0.624	0.014929	G		B
17-Oct-97	116	-0.629	0.020493	G		B
21-Oct-97	120	-0.639	0.022	S		B
24-Oct-97	123	-0.628	0.025441	G		B
28-Oct-97	127	-0.633	0.0263	S		B
31-Oct-97	130	-0.632	0.031977	G		B
07-Nov-97	137	-0.623	0.043658	G		B
11-Nov-97	141	-0.635	0.0248	S		B
14-Nov-97	144	-0.636	0.023393	G		B
18-Nov-97	148	-0.639	0.022	S		B
21-Nov-97	151	-0.632	0.030038	G		B
25-Nov-97	155	-0.641	0.0205	S		B

Date	Consec. Days	CES - 2324 Mayfield R (Charles Schmitt) G Hgt (m)	Q (m3/sec)	G or S	Comments	Curve Type
29-Nov-97	159	-0.636	0.024	S		B
05-Dec-97	165	-0.628	0.0325	S		B
12-Dec-97	172	-0.631	0.029	S		B
19-Dec-97	179	-0.638	0.0633	S		C
27-Dec-97	187	-0.65	0.045683	G		C
03-Jan-98	194	-0.625	0.0775	S		C
16-Jan-98	207	-0.638	0.0639	S		C
23-Jan-98	214	-0.631	0.0732	S		C
30-Jan-98	221	-0.63	0.056769	G		C
07-Feb-98	229	-0.63	0.074	S		C
13-Feb-98	235	-0.604	0.106	S		C
21-Feb-98	243	-0.591	0.146	S		C
27-Feb-98	249	-0.46	0.492	S		C
03-Mar-98	253	-0.607	0.108398	G		C
07-Mar-98	257	-0.617	0.0856	S		C
10-Mar-98	260	-0.594	0.134	S	Free	C
13-Mar-98	263	-0.631	0.0732	S	Partly Thawed	C
17-Mar-98	267	-0.638	0.0633	S		C
20-Mar-98	270	-0.558	0.225	S		C
24-Mar-98	274	-0.605	0.10346	G		C
27-Mar-98	277	-0.604	0.09715	G		C
31-Mar-98	281	0.133	1.659417	G		C
02-Apr-98	283	-0.486	0.415	S		C
07-Apr-98	288	-0.61	0.092708	G		C
09-Apr-98	290	-0.456	0.509304	G		C
14-Apr-98	295	-0.584	0.170322	G		C
17-Apr-98	298	-0.512	0.332516	G		C
21-Apr-98	302	-0.584	0.1663	S		C
24-Apr-98	305	-0.604	0.106	S		C
28-Apr-98	309	-0.616	0.087	S		C
01-May-98	312	-0.507	0.349	S		C
05-May-98	316	-0.607	0.1013	S		C
08-May-98	319	-0.555	0.233	S		C
12-May-98	323	-0.623	0.082667	G		C
14-May-98	325	-0.606	0.103	S		C
18-May-98	329	-0.662	0.050079	G		C
21-May-98	332	-0.631	0.0732	S		C
25-May-98	336	-0.623	0.07925	S		C
28-May-98	339	-0.637	0.068	S		C
01-Jun-98	343	-0.614	0.0897	S		C
03-Jun-98	345	-0.644	0.0622	S		C
05-Jun-98	347	-0.645	0.0615	S		C
08-Jun-98	350	-0.653	0.0555	S		C
11-Jun-98	353	-0.626	0.073024	G		C
12-Jun-98	354	-0.601	0.114	S		C
15-Jun-98	357	-0.636	0.061858	G		C
18-Jun-98	360	-0.655	0.0539	S		C
19-Jun-98	361	-0.621	0.081	S		C
22-Jun-98	364	-0.642	0.0643	S		C

Date	Census Days	CE3 - 2324 Mayfield R (Charles Schmidt)				Curve Type
		G Hgt (m)	Q (m3/sec)	G or S	Comments	
25-Jun-98	367	-0.656	0.053	S		C
29-Jun-98	371	-0.592	0.1267	G		C
02-Jul-98	374	-0.646	0.051024	S		C
04-Jul-98	376	-0.645	0.0615	S		C
06-Jul-98	378	-0.65	0.058	S		C
09-Jul-98	381	-0.662	0.0501	S		C
13-Jul-98	385	-0.66	0.05	S		C
16-Jul-98	388	-0.656	0.053	S		C
20-Jul-98	392	-0.657	0.0522	S		C
21-Jul-98	393	-0.616	0.087	S		C
23-Jul-98	395	-0.646	0.051	S		C
27-Jul-98	399	-0.652	0.0563	S		C
30-Jul-98	402	-0.654	0.0372	S	August 98 Curve	C
03-Aug-98	406	-0.658	0.033	S		C
05-Aug-98	408	-0.646	0.049	S		C
06-Aug-98	409	-0.615	0.0882	S		C
07-Aug-98	410	-0.595	0.1305	S		C
10-Aug-98	413	-0.632	0.872671	G		C
13-Aug-98	416	-0.656	0.0356	S		C
17-Aug-98	420	-0.649	0.044	S		C
20-Aug-98	423	-0.669	0.022409	G		C
25-Aug-98	428	-0.658	0.033	S		C
28-Aug-98	431	-0.654	0.036119	G		C
01-Sep-98	435	-0.667	0.02102	G		C
04-Sep-98	438	-0.669	0.0224	S		C
08-Sep-98	442	-0.657	0.026236	G		C
11-Sep-98	445	-0.677	0.021166	G		C
15-Sep-98	449	-0.654	0.0372	S		C
18-Sep-98	452	-0.67	0.0205	S		C
22-Sep-98	456	-0.664	0.018181	G		C
25-Sep-98	459	-0.661	0.0275	S		C
29-Sep-98	463	-0.65	0.043	S		C
02-Oct-98	466	-0.644	0.043881	G		C
06-Oct-98	470	-0.567	0.155685	G		C
09-Oct-98	473	-0.617	0.09	S		C
13-Oct-98	477	-0.586	0.135	S		C
16-Oct-98	480	-0.648	0.0455	S		C
20-Oct-98	484	-0.632	0.04508	G		C
23-Oct-98	487	-0.646	0.049	S		C
27-Oct-98	491	-0.646	0.049	S		C
30-Oct-98	494	-0.645	0.05	S		C
06-Nov-98	501	-0.635	0.064	S		C
10-Nov-98	505	-0.543	0.213922	G		C
13-Nov-98	508	-0.625	0.078	S		C
17-Nov-98	512	-0.643	0.053	S		C
20-Nov-98	515	-0.647	0.0475	S		C
24-Nov-98	519	-0.65	0.035501	G		C
27-Nov-98	522	-0.648	0.0455	S		C

Date	Census Days	CE3 - 2324 Mayfield R (Charles Schmidt)				Curve Type
		G Hgt (m)	Q (m3/sec)	G or S	Comments	
01-Dec-98	526	-0.645	0.05	S		C
04-Dec-98	529	-0.648	0.0455	S		C
08-Dec-98	533	-0.634	0.0655	S		C
11-Dec-98	536	-0.645	0.05	S		C
15-Dec-98	540	-0.646	0.049	S		C
23-Dec-98	548	-0.647	0.0475	S	Frozen	C
29-Dec-98	554	-0.664	0.024	S	Partly Froz.	C
12-Jan-99	568	-0.662	0.026	S	Partly Froz.	C
19-Jan-99	575	-0.648	0.0455	S	Frozen	C
29-Jan-99	585	-0.567	0.172	S	Partly Froz.	C
05-Feb-99	592	-0.584	0.142	S		C
12-Feb-99	599	-0.497	0.34	S		C
19-Feb-99	606	-0.623	0.08	S		C
26-Feb-99	613	-0.634	0.064	S		C
05-Mar-99	620	-0.632	0.068	S		C
12-Mar-99	627	-0.621	0.083	S		C
16-Mar-99	631	-0.604	0.18	S		C
19-Mar-99	634	-0.582	0.146	S		C
23-Mar-99	638	-0.605	0.1065	S		C
27-Mar-99	642	-0.62	0.084	S		C
30-Mar-99	645	-0.631	0.065951	G		C
02-Apr-99	648	-0.628	0.072	S		C
06-Apr-99	652	-0.615	0.08564	G		C
9-Apr-99	655	-0.31	0.88	S		C
13-Apr-99	659	-0.587	0.14	S		C
16-Apr-99	662	-0.614	0.092	S		C
20-Apr-99	666	-0.62	0.084	S		C
23-Apr-99	669	-0.162	0.94	S	(did staff gage get hit?)	D
27-Apr-99	673	-0.544	0.122	S		D
30-Apr-99	676	-0.559	0.088158	G		D
4-May-99	680	-0.587	0.064618	G		D
7-May-99	683	-0.551	0.17	S		D
12-May-99	688	-0.463	0.359428	G		D
15-May-99	691	-0.59	0.085372	G		D
19-May-99	695	-0.443	0.337901	G		D
21-May-99	697	-0.542	0.126405	G		D
25-May-99	701	-0.538	0.13713	G		D
28-May-99	704	-0.562	0.083902	G		D
1-Jun-99	708	-0.581	0.100508	G		D
4-Jun-99	711	-0.552	0.104948	G		D
8-Jun-99	715	-0.565	0.086812	G		D
11-Jun-99	718	-0.52	0.156181	G		D
13-Jun-99	720	0.092	1.542	S		D
15-Jun-99	722	-0.508	0.208872	G		D
18-Jun-99	725	-0.544	0.129	S		D
22-Jun-99	729	-0.579	0.069	S		D
25-Jun-99	732	-0.581	0.058239	G		D
29-Jun-99	736	-0.591	0.043221	G		D

Date	Consec. Days	CO1 - 4394 Pleasant Hill Rd (Debra Kennedy)				Curve Type
		G Hgt (m)	Q (m3/sec)	G or S	Comments	
24-Jun-97	1	-0.492	0.495	S		A
01-Jul-97	8	-0.648	0.085	S		A
03-Jul-97	10	-0.590	0.222995	G		A
07-Jul-97	14	-0.636	0.105	S		A
09-Jul-97	16	-0.600	0.21155	G		A
11-Jul-97	18	-0.641	0.096	S		A
14-Jul-97	21	-0.629	0.1447	G		A
16-Jul-97	23	-0.648	0.0845	S		A
18-Jul-97	25	-0.601	0.138523	G		A
21-Jul-97	28	-0.532	0.28	S		A
23-Jul-97	30	-0.608	0.160228	G		A
25-Jul-97	32	-0.630	0.114	S		A
28-Jul-97	35	-0.633	0.1105	S		A
30-Jul-97	37	-0.644	0.090078	G		A
08-Aug-97	46	-0.666	0.063605	G		A
13-Aug-97	51	-0.616	0.122008	G		A
22-Aug-97	60	-0.626	0.12036	G		A
29-Aug-97	67	-0.637	0.10671	G		A
01-Sep-97	70	-0.642	0.093	S		A
06-Sep-97	75	-0.664	0.058	S		A
09-Sep-97	78	-0.663	0.062	S		A
12-Sep-97	81	-0.665	0.057	S		A
17-Sep-97	86	-0.648	0.085	S		A
19-Sep-97	88	-0.661	0.0635	S		A
23-Sep-97	92	-0.664	0.058	S		A
26-Sep-97	95	-0.671	0.03	S		A
30-Sep-97	99	-0.673	0.025	G		A
03-Oct-97	102	-0.672	0.027	S		A
07-Oct-97	106	-0.668	0.049788	G		A
10-Oct-97	109	-0.663	0.0605	S		A
14-Oct-97	113	-0.664	0.058	S		A
17-Oct-97	116	-0.662	0.0625	S		A
21-Oct-97	120	-0.667	0.052	S		A
28-Oct-97	127	-0.659	0.060495	G		A
31-Oct-97	130	-0.658	0.0685	S		A
07-Nov-97	137	-0.660	0.066	S		A
11-Nov-97	141	-0.662	0.062419	G		A
14-Nov-97	144	-0.662	0.0625	S		A
18-Nov-97	148	-0.665	0.057	S		A
21-Nov-97	151	-0.664	0.058	S		A
25-Nov-97	155	-0.667	0.053	S		A
29-Nov-97	159	-0.663	0.062	S		A
05-Dec-97	165	-0.659	0.0675	S		A
13-Dec-97	173	-0.663	0.062	S		A
19-Dec-97	179	-0.660	0.065	S		A

Date	Consec. Days	CO1 - 4394 Pleasant Hill Rd (Debra Kennedy)				Curve Type
		G Hgt (m)	Q (m3/sec)	G or S	Comments	
27-Dec-97	187	-0.667	0.051	S		A
03-Jan-98	194	-0.638	0.1	S		A
16-Jan-98	207	-0.666	0.051	S		A
23-Jan-98	214	-0.666	0.051	S		A
30-Jan-98	221	-0.667	0.049	S		A
07-Feb-98	229	-0.652	0.076	S		A
13-Feb-98	235	-0.610	0.163	S		A
21-Feb-98	243	-0.555	0.292782	G		A
27-Feb-98	249	-0.546	0.373	S		A
03-Mar-98	253	-0.592	0.205	S		A
07-Mar-98	257	-0.615	0.152	S		A
10-Mar-98	260	-0.648	0.084	S	Thro' Ice	A
13-Mar-98	263	-0.658	0.063	S	Free	A
17-Mar-98	267	-0.686	0.11	S	Truck stuck here	B
20-Mar-98	270	-0.565	0.57	S		B
24-Mar-98	274	-0.627	0.26	S		B
27-Mar-98	277	-0.638	0.23	S		B
31-Mar-98	281	-0.490	1.11577	G		B
02-Apr-98	283	-0.466	1.257	S	Curve after	B
07-Apr-98	288	-0.634	0.248	S	March 31st	B
09-Apr-98	290	-0.581	0.533	S		B
14-Apr-98	295	-0.628	0.263	S		B
17-Apr-98	298	-0.521	0.923	S		B
21-Apr-98	302	-0.673	0.277942	G		B
24-Apr-98	305	-0.651	0.201	S		B
28-Apr-98	309	-0.655	0.19	S		B
01-May-98	312	-0.612	0.343	S		B
05-May-98	316	-0.649	0.207	S		B
08-May-98	319	-0.608	0.368	S		B
12-May-98	323	-0.670	0.135057	G		B
14-May-98	325	-0.664	0.17	S		B
18-May-98	329	-0.688	0.124717	G		B
21-May-98	332	-0.682	0.133089	G		B
25-May-98	336	-0.685	0.13	S		B
28-May-98	339	-0.694	0.109	S		B
01-Jun-98	343	-0.686	0.128	S		B
03-Jun-98	345	-0.691	0.1175	S		B
05-Jun-98	347	-0.701	0.088195	G		B
08-Jun-98	350	-0.703	0.083	S		B
11-Jun-98	353	-0.686	0.124	S		B
12-Jun-98	354	-0.661	0.178	S		B
15-Jun-98	357	-0.692	0.112	S		B
18-Jun-98	360	-0.704	0.082	S		B
19-Jun-98	361	-0.644	0.221	S		B
22-Jun-98	364	-0.692	0.113	S		B

Date	Consec. Days	CO1 - 4394 Pleasant Hill Rd (Debra Kennedy) G Hgt (m)	Q (m3/sec)	G or S	Comments	Curve Type
25-Jun-98	367	-0.700	0.09	S		B
29-Jun-98	371	-0.613	0.238	S		B
02-Jul-98	374	-0.686	0.124	S		B
04-Jul-98	376	-0.691	0.113	S		B
06-Jul-98	378	-0.703	0.094	S		B
09-Jul-98	381	-0.704	0.067631	G	July 9 to Aug 17 Curve	C
13-Jul-98	385	-0.714	0.069709	G		C
16-Jul-98	388	-0.720	0.061762	G		C
20-Jul-98	392	-0.727	0.034019	G		C
21-Jul-98	393	-0.667	0.162	S		C
23-Jul-98	395	-0.696	0.1025	S		C
27-Jul-98	399	-0.707	0.036502	G		C
30-Jul-98	402	-0.712	0.04	S		C
03-Aug-98	406	-0.720	0.03	S		C
05-Aug-98	408	-0.700	0.0625	S		C
06-Aug-98	409	-0.634	0.206	S		C
07-Aug-98	410	-0.658	0.149	S		C
10-Aug-98	413	-0.685	0.094	S		C
13-Aug-98	416	-0.695	0.058381	G		C
17-Aug-98	420	-0.701	0.054845	G		C
20-Aug-98	423	-0.720	0.036065	G	Back to upper(first) curv	B
25-Aug-98	428	-0.717	0.062268	G		B
28-Aug-98	431	-0.720	0.061	S		B
01-Sep-98	435	-0.729	0.041538	G		B
04-Sep-98	438	-0.730	0.043	S		B
08-Sep-98	442	-0.733	0.036235	G		B
11-Sep-98	445	-0.740	0.041197	G		B
15-Sep-98	449	-0.727	0.0495	S		B
18-Sep-98	452	-0.731	0.04	S		B
22-Sep-98	456	-0.735	0.040066	G		B
25-Sep-98	459	-0.734	0.038	S		B
29-Sep-98	463	-0.732	0.0395	S		B
02-Oct-98	466	-0.732	0.0395	S		B
06-Oct-98	470	-0.679	0.125578	G		B
09-Oct-98	473	-0.719	0.0575	S		B
13-Oct-98	477	-0.753	0.025	S		B
16-Oct-98	480	-0.723	0.053018	G		B
20-Oct-98	484	-0.714	0.063	S		B
23-Oct-98	487	-0.718	0.058	S		B
27-Oct-98	491	-0.718	0.059	S		B
30-Oct-98	494	-0.714	0.0615	S		B
06-Nov-98	501	-0.718	0.058	S		B
10-Nov-98	505	-0.622	0.28	S		B
13-Nov-98	508	-0.692	0.101	S		B
17-Nov-98	512	-0.704	0.079	S		B
20-Nov-98	515	-0.708	0.072	S		B
24-Nov-98	519	-0.708	0.072	S		B
27-Nov-98	522	-0.712	0.066	S		B

Date	Consec. Days	CO1 - 4394 Pleasant Hill Rd (Debra Kennedy) G Hgt (m)	Q (m3/sec)	G or S	Comments	Curve Type
01-Dec-98	526	-0.715	0.062	S		B
04-Dec-98	529	-0.714	0.063	S		B
08-Dec-98	533	-0.710	0.069	S		B
11-Dec-98	536	-0.711	0.067	S		B
15-Dec-98	540	-0.711	0.067	S		B
23-Dec-98	548	-0.722	0.054	S	Frozen	B
29-Dec-98	554	-0.719	0.057	S	Partly Frozen	B
12-Jan-99	568	-0.728	0.044	S	Partly Frozen	B
19-Jan-99	575	-0.718	0.058		Partly Frozen	B
29-Jan-99	585	-0.650	0.22	S		B
05-Feb-99	592	-0.629	0.180956	G		B
12-Feb-99	599	-0.524	0.715	S		B
19-Feb-99	606	-0.662	0.12403	G		B
26-Feb-99	613	-0.693	0.104149	G		B
05-Mar-99	620	-0.700	0.094	S		B
12-Mar-99	627	-0.694	0.13367	G		D
16-Mar-99	631	-0.662	0.194828	G		D
19-Mar-99	634	-0.621	0.293875	G		D
23-Mar-99	638	-0.671	0.181112	G		D
27-Mar-99	642	-0.685	0.142112	G		D
30-Mar-99	645	-0.692	0.14447	G		D
02-Apr-99	648	-0.692	0.139012	G		D
06-Apr-99	652	-0.656	0.24063	G		D
9-Apr-99	655	-0.590	0.458	S	Rain, 40's	D
13-Apr-99	659	-0.608	0.40353	G	Partly cloudy, 55F	D
16-Apr-99	662	-0.668	0.21	S	Sunny, 50's	D
20-Apr-99	666	-0.688	0.147	S	Partly cloudy, 50's	D
23-Apr-99	669	-0.494	0.835689	G	Cloudy, 40's	D
27-Apr-99	673	-0.593	0.477153	G	Sunny, 60's	D
30-Apr-99	676	-0.661	0.244	S	Sunny, 60's	D
4-May-99	680	-0.682	0.199053	G	Sunny, 60's	D
7-May-99	683	-0.652	0.34607	G	Overcast, 60's	D
12-May-99	688	-0.602	0.42	S	Cloudy, 50's	D
15-May-99	691	-0.650	0.258	S	Sunny, 60's	D
19-May-99	695	-0.482	1.04388	G	Sunny-cloudy, 70's	D
21-May-99	697	-0.594	0.409746	G	Partly cloudy, 60's	D
25-May-99	701	-0.631	0.3235711	G	Partly cloudy, 55-6	D
28-May-99	704	-0.668	0.1876996	G	Sunny, 80's	D
1-Jun-99	708	-0.681	0.141354	G	Overcast, 60's	D
4-Jun-99	711	-0.669	0.2008632	G	65-70, showers	D
8-Jun-99	715	-0.667	0.19630001	G	Sunny, 80's	D
11-Jun-99	718	-0.610	0.3296873	G	Sunny, 80's	B
13-Jun-99	720	-0.204	3.55	S	Rain/estimate	B
15-Jun-99	722	-0.504	0.9235394	G	Sunny, 60's	B
18-Jun-99	725	-0.644	0.2304486	G	Sunny, 70's	B
22-Jun-99	729	-0.675	0.1681772	G	Partly cloudy, 75-8	B
25-Jun-99	732	-0.670	0.1717	G	Sunny, 80's	B
29-Jun-99	736	-0.674	0.14	S	Partly cloudy, 75	B

Date	Consec. Days	MI -Lilac Road (Village of Germantown)				Comments	Curve Type
		G Hgt (culvert) (m)	G Hgt (staff gage) (m)	Q (m3/sec)	G or S		
24-Jun-97	1	-1.6	0.669	6.94	S		A
01-Jul-97	8	-2.65	-0.381	0.635	S		A
03-Jul-97	10	-2.417	-0.148	1.4194	G		A
07-Jul-97	14	-2.674	-0.405	0.507	S		A
09-Jul-97	16	-2.53	-0.261	1.3079	G		A
11-Jul-97	18	-2.682	-0.413	0.465	S		A
14-Jul-97	21	-2.693	-0.424	0.3625	G		A
16-Jul-97	23	-2.728	-0.459	0.262	S		A
18-Jul-97	25	-2.72	-0.451	0.3453	G	f. meter stiff	A
21-Jul-97	28	-2.586	-0.317	1.046	S		A
23-Jul-97	30	-2.689	-0.402	0.525	S		A
25-Jul-97	32	-2.73	-0.452	0.293	S		A
28-Jul-97	35	-2.723	-0.469	0.211141	G		A
30-Jul-97	37	-2.777	-0.515	0.1	S		A
01-Aug-97	39	-2.784	-0.512	0.113873	G		A
06-Aug-97	44	-2.776	-0.514	0.103			A
08-Aug-97	46		-0.536	0.060472	G		A
11-Aug-97	49		-0.538	0.055	S		A
13-Aug-97	51		-0.414	0.459752	G		A
18-Aug-97	56	-2.712	-0.443	0.33	S		A
20-Aug-97	58		-0.409	0.485	S		A
25-Aug-97	63		-0.376	0.653552	G		A
29-Aug-97	67		-0.473	0.2	S		A
01-Sep-97	70		-0.487	0.16	S		A
06-Sep-97	75		-0.484	0.172	S		A
09-Sep-97	78		-0.499	0.135	S		A
12-Sep-97	81		-0.496	0.14	S		A
17-Sep-97	86		-0.352	0.826	S		A
19-Sep-97	88		-0.462	0.244	S		A
23-Sep-97	92		-0.463	0.242	S		A
26-Sep-97	95		-0.49	0.135	S		A
30-Sep-97	99		-0.5	0.13	S		A
03-Oct-97	102		-0.505	0.12	S		A
07-Oct-97	106		-0.509	0.115	S		A
10-Oct-97	109		-0.506	0.122	S		A
14-Oct-97	113		-0.486	0.167	S		A
17-Oct-97	116		-0.48	0.18	S		A
21-Oct-97	120		-0.484	0.172	S		A
24-Oct-97	123		-0.387	0.61	S		A
28-Oct-97	127		-0.463	0.242	S		A
31-Oct-97	130		-0.478	0.185	S		A
07-Nov-97	137		-0.479	0.182	S		A
11-Nov-97	141		-0.475	0.19	S		A
14-Nov-97	144		-0.478	0.185	S		A
18-Nov-97	148		-0.488	0.16	S		A
21-Nov-97	151		-0.455	0.26	S		A
25-Nov-97	155		-0.493	0.147	S		A
29-Nov-97	159		-0.493	0.147	S		A

Date	Consec. Days	MI -Lilac Road (Village of Germantown)				Comments	Curve Type
		G Hgt (culvert) (m)	G Hgt (staff gage) (m)	Q (m3/sec)	G or S		
05-Dec-97	165		-0.46	0.258	S		A
13-Dec-97	173		-0.468	0.215	S		A
19-Dec-97	179		-0.442	0.338	S		A
27-Dec-97	187		-0.466	0.23	S		A
03-Jan-98	194		-0.411	0.477	S		A
16-Jan-98	207		-0.401	0.535	S		A
23-Jan-98	214		-0.412	0.465	S		A
30-Jan-98	221		-0.406	0.495	S		A
07-Feb-98	229		-0.376	0.6536	S		A
12-Feb-98	235		-0.23	1.485	S		A
21-Feb-98	243		-0.194	1.725	S		A
27-Feb-98	249		-0.236	1.45	S		A
03-Mar-98	253		-0.298	1.075	S		A
07-Mar-98	257		-0.346	0.815	S		A
10-Mar-98	260		-0.286	1.16	S	Free	A
13-Mar-98	263		-0.4	0.525	S	Free	A
17-Mar-98	267		-0.422	0.415	S		A
20-Mar-98	270		-0.118	2.19724	G		A
24-Mar-98	274		-0.317	0.980589	G		A
27-Mar-98	277		-0.344	0.815	S		A
31-Mar-98	281		0.572	6.63	S		A
02-Apr-98	283		0.559	6.58	S		A
07-Apr-98	288		-0.307	1.03	S		A
09-Apr-98	290		-0.118	2.19724	S		A
14-Apr-98	295		-0.242	1.4	S		A
17-Apr-98	298		0.275	5.05	S		A
21-Apr-98	302		-0.266	1.215	S		A
24-Apr-98	305		-0.324	0.925	S		A
28-Apr-98	309		-0.323	0.93	S		A
01-May-98	312		-0.282	1.165	S		A
05-May-98	316		-0.298	0.9534	G		A
08-May-98	319		-0.216	1.537506	G		A
12-May-98	323		-0.352	0.775	S		A
14-May-98	325		-0.323	0.93	S		A
18-May-98	329		-0.422	0.42	S		A
21-May-98	332		-0.442	0.315	S		A
25-May-98	336		-0.454	0.265	S		A
28-May-98	339		-0.46	0.235	S		A
01-Jun-98	343		-0.446	0.3	S		A
03-Jun-98	345		-0.462	0.225	S		A
05-Jun-98	347		-0.48	0.17	S		A
08-Jun-98	350		-0.494	0.088374	G		A
11-Jun-98	353		-0.436	0.35	S		A
12-Jun-98	354		-0.373	0.67	S		A
15-Jun-98	357		-0.461	0.23	S		A
18-Jun-98	360		-0.484	0.155	S		A
19-Jun-98	361		-0.438	0.325	S		A
22-Jun-98	364		-0.5	0.12	S		A

Date	Consec. Days	M1 -Lilac Road (Village of Germantown)				Comments	Curve Type
		G Hgt (culvert) (m)	G Hgt (staff gage) (m)	Q (m3/sec)	G or S		
25-Jun-98	367		-0.471	0.2	S		A
29-Jun-98	371		-0.292	1.115	S		A
02-Jul-98	374		-0.449	0.28	S		A
04-Jul-98	376		-0.474	0.215	S		A
06-Jul-98	378		-0.488	0.123712	G		A
09-Jul-98	381		-0.498	0.14	S		A
13-Jul-98	385		-0.516	0.1	S		A
16-Jul-98	388		-0.514	0.105	S		A
20-Jul-98	392		-0.532	0.067	S		A
21-Jul-98	393		-0.369	0.685	S		A
23-Jul-98	395		-0.478	0.2	S		A
27-Jul-98	399		-0.533	0.065	S		A
30-Jul-98	402		-0.531	0.057	S		A
03-Aug-98	406		-0.541	0.029495	G		A
05-Aug-98	408		-0.498	0.13	S		A
06-Aug-98	409		-0.436	0.265266	G		A
07-Aug-98	410		-0.355	0.755	S		A
10-Aug-98	413		-0.462	0.222	S		A
13-Aug-98	416		-0.494	0.135	S		A
17-Aug-98	420		-0.507	0.105	S		A
20-Aug-98	423		-0.51	0.1	S		A
25-Aug-98	428		-0.514	0.09	S		A
28-Aug-98	431		-0.524	0.042695	G		A
01-Sep-98	435		-0.534	0.055	S		A
04-Sep-98	438		-0.534	0.055	S		A
08-Sep-98	442		-0.542	0.04	S		A
11-Sep-98	445		-0.548	0.025	S		A
15-Sep-98	449		-0.488	0.1475	S		A
18-Sep-98	452		-0.528	0.054	S		A
22-Sep-98	456		-0.532	0.047	S		A
25-Sep-98	459		-0.533	0.045	S		A
29-Sep-98	463		-0.534	0.042	S		A
02-Oct-98	466		-0.536	0.04	S		A
06-Oct-98	470		-0.41	0.45	S		A
09-Oct-98	473		-0.503	0.102	S		A
13-Oct-98	477		-0.516	0.077	S		A
16-Oct-98	480		-0.518	0.046193	G		A
20-Oct-98	484		-0.484	0.04	S		B
23-Oct-98	487		-0.508	0.02	S		B
27-Oct-98	491		-0.502	0.022	S		B
30-Oct-98	494		-0.476	0.024797	G		B
06-Nov-98	501		-0.494	0.036421	G		B
10-Nov-98	505		-0.257	0.803853	G		B
13-Nov-98	508		-0.468	0.163877	G		A
17-Nov-98	512		-0.491	0.125	S		A
20-Nov-98	515		-0.497	0.115	S		A
24-Nov-98	519		-0.503	0.102	S		A
27-Nov-98	522		-0.504	0.101	S		A

Date	Consec. Days	M1 -Lilac Road (Village of Germantown)				Comments	Curve Type
		G Hgt (culvert) (m)	G Hgt (staff gage) (m)	Q (m3/sec)	G or S		
01-Dec-98	526		-0.488	0.135	S		A
04-Dec-98	529		-0.492	0.122	S		A
08-Dec-98	533		-0.462	0.162306	G		A
11-Dec-98	536		-0.487	0.137	S		A
15-Dec-98	540		-0.493	0.12	S		A
23-Dec-98	548		-0.522	0.062	S	Frozen	A
29-Dec-98	554		-0.513	0.082	S	Partly Froze	A
12-Jan-99	568		-0.485	0.14	S	Partly Froze	A
19-Jan-99	575		-0.498	0.11	S	Partly Froze	A
29-Jan-99	585		-0.294	1.1	S		A
05-Feb-99	592		-0.27	1.25	S		A
12-Feb-99	599		-0.005	2.97	S		A
19-Feb-99	606		-0.355	0.78	S		A
26-Feb-99	613		-0.429	0.35	S		A
05-Mar-99	620		-0.416	0.43	S		A
12-Mar-99	627		-0.429	0.35	S		A
16-Mar-99	631		-0.411	0.46	S		A
19-Mar-99	634		-0.218	1.525	S		A
23-Mar-99	638		-0.355	0.78	S		A
27-Mar-99	642		-0.412	0.46	S		A
30-Mar-99	645		-0.429	0.35	S		A
02-Apr-99	648		-0.436	0.31	S		A
06-Apr-99	652		-0.422	0.4	S		A
9-Apr-99	655		0.03	3.25	S	40's, rain (o	A
13-Apr-99	659		-0.205	1.62	S	Partly cloud	A
16-Apr-99	662		-0.336	0.84756	G	Sunny, 50's	A
20-Apr-99	666		-0.4	0.54	S	Partly cloud	A
23-Apr-99	669	-1.758	0.511		S	Cloudy, 40's	A
27-Apr-99	673		-0.262	1.17	S	Sunny, 60's	C
30-Apr-99	676		-0.346	0.727389	G	Sunny, 60's	C
4-May-99	680		-0.401	0.505	S	Sunny, 60's	C
7-May-99	683		-0.235	1.33	S	Overcast, 6	C
12-May-99	688		-0.075	2.55	S	Cloudy, 50's	C
15-May-99	691		-0.274	1.1	S	Sunny, 60's	C
19-May-99	695		0.05	3.43	S	staff covere	C
21-May-99	697		-0.186	1.568623	G	Partly cloud	C
25-May-99	701		-0.283	1.0644073	G	Partly cloud	C
28-May-99	704		-0.378	0.6	S	Sunny, 80's	C
1-Jun-99	708		-0.416	0.425	S	Overcast, 6	C
4-Jun-99	711		-0.39	0.55	S	65-70, sho	C
8-Jun-99	715		-0.284	0.57	S	Sunny, 80's	C
11-Jun-99	718		-0.361	0.67	S	Sunny, 80's	C
13-Jun-99	720		-0.34	5.78	S	Rain/estimat	C
15-Jun-99	722		0.24	5	S	Sunny, 60's,	C
18-Jun-99	725		-0.33	0.8	S	Sunny, 70's	C
22-Jun-99	729		-0.422	0.38	S	Partly cloud	A
25-Jun-99	732		-0.438	0.2675763	G	Sunny, 80's	A
29-Jun-99	736		-0.471	0.15	S	Partly cloud	A

Date	Consec. Days	WB1 - W 17520 Freistadt Rd (Rog Cwfkls) G Hgt (m)	Q (m3/sec)	G or S	Comments	Curve Type
24-Jun-97	1	-0.7	0.206	S	Curve Until Oct 3	A
01-Jul-97	8	-0.74	0.2836	G		A
03-Jul-97	10	-0.631	0.309	S		A
07-Jul-97	14	-0.776	0.1141	G		A
09-Jul-97	16	-0.593	0.2685	S		A
11-Jul-97	18	-0.761	0.1301	G		A
14-Jul-97	21	-0.758	0.136	S		A
16-Jul-97	23	-0.812	0.10799	G		A
18-Jul-97	25	-0.86	0.0705	S		A
21-Jul-97	28	-0.53	0.46757	G	location?, btry,rek	A
23-Jul-97	30	-0.808	0.105	S		A
25-Jul-97	32	-0.883	0.0422	G		A
28-Jul-97	35	-0.906	0.0325	S		A
30-Jul-97	37	-0.936	0.02	S		A
01-Aug-97	39	-0.926	0.02	G	saw water move	A
04-Aug-97	42	-0.929	0.0175	S	Partly Sunny 80F	A
06-Aug-97	44	-0.938	0.01372	G	Partly Cloudy 60F	A
07-Aug-97	45					A
08-Aug-97	46	-0.944	0.01	S	Clear 80F	A
11-Aug-97	49	-0.936	0.0148	S	Cloudy 70F	A
13-Aug-97	51	-0.848	0.09217	G	Rained Yesterday	A
18-Aug-97	56	-0.877	0.0535	S	Partly Sunny 70F	A
20-Aug-97	58	-0.794	0.215	G	Rained Today	A
25-Aug-97	63	-0.812	0.1025	S	Cloudy 65F	A
29-Aug-97	67	-0.911	0.029	S	Partly Cloudy	A
01-Sep-97	70	-0.924	0.0196	G	Partly Sunny 75F	A
06-Sep-97	75	-0.853	0.0765	S	Sunny 85F	A
09-Sep-97	78	-0.92	0.023	S	Cloudy & Drizzly	A
12-Sep-97	81	-0.853	0.0765	S	Partly Cloudy	A
17-Sep-97	86	-0.634	0.22741	G	Rained last night	A
19-Sep-97	88	-0.771	0.124	S	Rainy	A
23-Sep-97	92	-0.78	0.117	S	Rained Yesterday	A
26-Sep-97	95	-0.814	0.102	S	Sunny 70F	A
30-Sep-97	99	-0.73	0.165	S	Partly Sunny 70F	A
03-Oct-97	102	-0.836	0.0915	S	Sunny 70F	A
07-Oct-97	106	-0.655	0.007	S	Sunny 75F,Curve Oct 7-Nov 7	B
10-Oct-97	109	-0.619	0.01428	G	Sunny 60F	B
14-Oct-97	113	-0.576	0.05945	G	Sunny 60F	B
17-Oct-97	116	-0.672	0.00395	G	Sunny 54F	B
21-Oct-97	120	-0.39	0.0403	S	Sunny 45F	B
24-Oct-97	123	-0.729	0.0022	S	Overcast 45F	B
28-Oct-97	127	-0.695	0.004	S	Sunny 45F	B
31-Oct-97	130	-0.769		G	Sunny 35F, Stream Dammed, no flo	B
07-Nov-97	137	-0.745	0.0015	S	Cloudy upper 40's	B
11-Nov-97	141	-0.872	0.1535	S	Sunny 35F,Curve After Nov 7	C
14-Nov-97	144	-0.946	0.0605	S	Cloudy 35F	C
18-Nov-97	148	-0.951	0.055	S	Sunny 40F	C
21-Nov-97	151	-0.91	0.1087	S	Sunny 40F	C
25-Nov-97	155	-0.956	0.05	S	Sunny 48F	C

Date	Consec. Days	WB1 - W 17520 Freistadt Rd (Rog Cwfkls) G Hgt (m)	Q (m3/sec)	G or S	Comments	Curve Type
29-Nov-97	159	-0.885	0.1405	S	Foggy 40F	C
05-Dec-97	165	-0.948	0.0585	S	Snowy/P.Cloudy	C
13-Dec-97	173	-0.915	0.1012	S	Cold/Sunny 30F	C
19-Dec-97	179	-0.895	0.129	S	Partly Cloudy 42F	C
27-Dec-97	187	-0.91	0.1087	S	Cold and Sunny	C
03-Jan-98	194	-0.877	0.1496	S	Overcast 50s	C
16-Jan-98	207	-0.832	0.198	S		C
23-Jan-98	214	-0.895	0.129	S		C
30-Jan-98	221	-0.892	0.133	S		C
07-Feb-98	229	-0.893	0.132	S		C
13-Feb-98	235	-0.806	0.235227	G		C
21-Feb-98	243	-0.809	0.2365	S		C
27-Feb-98	249	-0.64	0.7	S		C
03-Mar-98	253	-0.828	0.2035	S		C
07-Mar-98	257	-0.857	0.1665	S		C
10-Mar-98	260	-0.823	0.2125	S	Through Ice	C
13-Mar-98	263	-0.899	0.1225	S	Partly Thawed	C
17-Mar-98	267	-0.909	0.1095	S		C
20-Mar-98	270	-0.783	0.285	S		C
24-Mar-98	274	-0.851	0.172	S		C
27-Mar-98	277	-0.861	0.161709	G		C
31-Mar-98	281	-0.19	1.31	S		C
02-Apr-98	283	-0.713	0.485	S		C
07-Apr-98	288	-0.825	0.21	S		C
09-Apr-98	290	-0.59	0.82	S		C
14-Apr-98	295	-0.775	0.302	S		C
17-Apr-98	298	-0.696	0.53	S		C
21-Apr-98	302	-0.782	0.284166	G		C
24-Apr-98	305	-0.84	0.185503	G		C
28-Apr-98	309	-0.86	0.164	S		C
01-May-9	312	-0.689	0.55	S		C
05-May-9	316	-0.852	0.169879	G		C
08-May-9	319	-0.774	0.325368	G		C
12-May-9	323	-0.902	0.121917	G		C
14-May-9	325	-0.874	0.137225	G		C
18-May-9	329	-0.935	0.069932	G		C
21-May-9	332	-0.932	0.080147	G		C
25-May-9	336	-0.936	0.073	S		C
28-May-9	339	-0.909	0.1093	S		C
01-Jun-98	343	-0.931	0.0785	S		C
03-Jun-98	345	-0.942	0.066	S		C
05-Jun-98	347	-0.952	0.052458	G		C
08-Jun-98	350	-0.972	0.031179	G		C
11-Jun-98	353	-0.902	0.119	S		C
12-Jun-98	354	-0.89	0.135	S		C
15-Jun-98	357	-0.953	0.053	S		C
18-Jun-98	360	-0.969	0.0385	S		C
19-Jun-98	361	-0.901	0.12	S		C
22-Jun-98	364	-0.98	0.0533	G		C

Date	Consec. Days	WB1 - W 17520 Freistadt Rd (Rus Cwfkls) G Hgt (m)	Q (m3/sec)	G or S	Comments	Curve Type
25-Jun-98	367	-0.97	0.0375	S		C
29-Jun-98	371	-0.871	0.1645	S		C
02-Jul-98	374	-0.964	0.05	S		C
04-Jul-98	376	-0.972	0.044	S		C
06-Jul-98	378	-0.976	0.0425	S		C
09-Jul-98	381	-0.982	0.0385	S		C
13-Jul-98	385	-1.001	0.03798	G		C
16-Jul-98	388	-0.99	0.03299	G		C
20-Jul-98	392	-1.004	0.03831	G		C
21-Jul-98	393	-0.89	0.1385	S		C
23-Jul-98	395	-1.002	0.0305	S		C
27-Jul-98	399	-1.021	0.03156	G		C
30-Jul-98	402	-1.004	0.028	S		C
03-Aug-98	406	-1.029	0.0175	S		C
05-Aug-98	408	-0.966	0.051	S		C
06-Aug-98	409	-0.924	0.091	S		C
07-Aug-98	410	-0.93	0.0853	S		C
10-Aug-98	413	-0.981	0.0395	S		C
13-Aug-98	416	-0.992	0.0335	S		C
17-Aug-98	420	-1.001	0.0295	S		C
20-Aug-98	423	-0.998	0.0305	S		C
25-Aug-98	428	-0.996	0.032	S		C
28-Aug-98	431	-0.998	0.0305	S		C
01-Sep-98	435	-1.008	0.027	S		C
04-Sep-98	438	-1.012	0.025	S		C
08-Sep-98	442	-1.01	0.01527	G		C
11-Sep-98	445	-1.058	0.00817	G		C
15-Sep-98	449	-0.976	0.043	S		C
18-Sep-98	452	-1.003	0.027	S		C
22-Sep-98	456	-1	0.028	S		C
25-Sep-98	459	-1.002	0.0275	S		C
29-Sep-98	463	-0.99	0.032	S		C
02-Oct-98	466	-1.005	0.026	S		C
06-Oct-98	470	-0.916	0.1025	S		C
09-Oct-98	473	-0.986	0.035	S		C
13-Oct-98	477	-0.954	0.054	S		C
16-Oct-98	480	-0.94	0.068	S		C
20-Oct-98	484	-0.965	0.047	S		C
23-Oct-98	487	-1.018	0.021	S		C
27-Oct-98	491	-0.98	0.0375	S		C
30-Oct-98	494	-0.98	0.03797	G		C
06-Nov-98	501	-0.996	0.03	S		C
10-Nov-98	505	-0.64	0.49	S		C
13-Nov-98	508	-0.971	0.0425	S		C
17-Nov-98	512	-0.969	0.044	S		C
20-Nov-98	515	-0.982	0.0365	S		C
24-Nov-98	519	-1.026	0.01977	G		C
27-Nov-98	522	-0.987	0.033	S		C

Date	Consec. Days	WB1 - W 17520 Freistadt Rd (Rus Cwfkls) G Hgt (m)	Q (m3/sec)	G or S	Comments	Curve Type
01-Dec-98	526	-0.97	0.043	S		C
04-Dec-98	529	-0.974	0.0405	S		C
08-Dec-98	533	-0.967	0.046	S		C
11-Dec-98	536	-0.98	0.0375	S		C
15-Dec-98	540	-0.974	0.0405	S		C
23-Dec-98	548	-0.976	0.04	S	Frozen	C
29-Dec-98	554	-0.963	0.048	S	Mostly Frozen	C
12-Jan-99	568	-0.968	0.045	S	Mostly Frozen, Height at ri	C
19-Jan-99	575	-0.956	0.053	S	Mostly Frozen, Culvert	C
29-Jan-99	585	-0.833	0.23	S		C
05-Feb-99	592	-0.832	0.24	S		C
12-Feb-99	599	-0.702	0.495	S		C
19-Feb-99	606	-0.891	0.134	S		C
26-Feb-99	613	-0.925	0.085	S		C
05-Mar-99	620	-0.928	0.082	S		C
12-Mar-99	627	-0.935	0.07	S		C
16-Mar-99	631	-0.894	0.138806	G		C
19-Mar-99	634	-0.834	0.23	S		C
23-Mar-99	638	-0.916	0.1	S		C
27-Mar-99	642	-0.933	0.072	S		C
30-Mar-99	645	-0.95	0.054	S		C
02-Apr-99	648	-0.952	0.053	S		C
06-Apr-99	652	-0.935	0.07	S		C
9-Apr-99	655	-0.476	1.05	S	Rain, 40's	C
13-Apr-99	659	-0.826	0.214467	G		C
16-Apr-99	662	-0.905	0.117	S		C
20-Apr-99	666	-0.92	0.094	S	Partly Cloudy 50's	C
23-Apr-99	669	-0.202	1.29	S	Cloudy, 40's	C
27-Apr-99	673	-0.819	0.219	S	Sunny 60's	C
30-Apr-99	676	-0.852	0.172	S	Sunny 60's	C
4-May-99	680	-0.893	0.133	S	Sunny 60's	C
7-May-99	683	-0.791	0.27	S	Overcast, 60's	C
########	688	-0.592	0.795	S	Cloudy, 50's	C
########	691	-0.846	0.182	S	Sunny 60's	C
########	695	-0.684	0.563242	G	Sunny-cloudy, 70's	C
########	697	-0.814	0.226	S	Partly Cloudy 60's	C
########	701	-0.816	0.224	S	Partly Cloudy 55-60s	C
########	704	-0.862	0.161	S	Sunny, 80's	C
1-Jun-99	708	-0.876	0.14	S	Overcast, 60's	C
4-Jun-99	711	-0.873	0.142	S	65-70, showers	C
8-Jun-99	715	-0.874	0.142	S	Sunny, 80's	C
11-Jun-99	718	-0.802	0.25	S	Sunny, 80's	C
13-Jun-99	720	-0.64	0.69	S	Rain/estimate	C
15-Jun-99	722	-0.89	0.241245	G	Sunny, 60's	C
18-Jun-99	725	-0.88	0.145	S	Sunny, 70's	C
22-Jun-99	729	-0.925	0.092	S	Partly Cloudy 75-80	C
25-Jun-99	732	-0.936	0.086852	G	Sunny, 80's	C
29-Jun-99	736	-0.946	0.062	S	Partly Cloudy 75	C

Date	Consec. Days	WH2 - Maple Road (Robert Madelinski)				Curve Type
		G Hgt (m)	Q (m3/sec)	G or S	Comments	
24-Jun-97	1	-2.604	0.285	S	Curve Before	A
01-Jul-97	8	-2.69	0.0918	G	Sept 17	A
03-Jul-97	10	-2.61	0.269	S		A
07-Jul-97	14	-2.712	0.0789	G		A
09-Jul-97	16	-2.607	0.278	S		A
11-Jul-97	18	-2.696	0.1005	G		A
14-Jul-97	21	-2.66	0.151	S		A
16-Jul-97	23	-2.713	0.07998	G		A
18-Jul-97	25	-2.732	0.067	S		A
21-Jul-97	28	-2.6	0.301763	G	rained last night,bt	A
23-Jul-97	30	-2.707	0.085	S		A
25-Jul-97	32	-2.742	0.039643	G		A
28-Jul-97	35	-2.76	0.028	S		A
30-Jul-97	37	-2.774	0.016	S		A
01-Aug-97	39	-2.774	0.016922	G	saw water move	A
04-Aug-97	42	-2.774	0.016	S		A
06-Aug-97	44	-2.77	0.019	S		A
07-Aug-97	45					A
08-Aug-97	46	-2.756	0.032	S		A
11-Aug-97	49	-2.772	0.018	S		A
13-Aug-97	51	-2.716	0.075	S		A
18-Aug-97	56	-2.728	0.06	S		A
20-Aug-97	58	-2.654	0.162156	G	Cloudy & Drizzly	A
25-Aug-97	63	-2.698	0.094	S		A
29-Aug-97	67	-2.751	0.037	S		A
01-Sep-97	70	-2.761	0.027	S		A
06-Sep-97	75	-2.696	0.097	S		A
09-Sep-97	78	-2.755	0.0325	S	65F	A
12-Sep-97	81	-2.694	0.0985	S		A
17-Sep-97	86	-2.606	0.208551	G	Curve After	B
19-Sep-97	88	-2.659	0.108948	G	Sept 17	B
23-Sep-97	92	-2.682	0.081	S		B
26-Sep-97	95	-2.694	0.063	S		B
30-Sep-97	99	-2.658	0.115	S		B
03-Oct-97	102	-2.737	0.0225	S		B
07-Oct-97	106	-2.629	0.165	S		B
10-Oct-97	109	-2.652	0.123	S		B
14-Oct-97	113	-2.616	0.198	S		B
17-Oct-97	116	-2.718	0.054	S		B
21-Oct-97	120	-2.655	0.12	S		B
24-Oct-97	123	-2.778	0.013	S		B
28-Oct-97	127	-2.746	0.022	S		B
31-Oct-97	130	-2.754	0.02	S		B
07-Nov-97	137	-2.744	0.023	S		B
11-Nov-97	141	-2.676	0.09	S		B
14-Nov-97	144	-2.745	0.0224	S		B
18-Nov-97	148	-2.739	0.0235	S		B
21-Nov-97	151	-2.714	0.037	S		B
25-Nov-97	155	-2.73	0.026	S		B

Date	Consec. Days	WH2 - Maple Road (Robert Madelinski)				Curve Type
		G Hgt (m)	Q (m3/sec)	G or S	Comments	
29-Nov-97	159	-2.68	0.0825	S		B
05-Dec-97	165	-2.736	0.025	S		B
13-Dec-97	173	-2.696	0.061	S		B
19-Dec-97	179	-2.688	0.063776	G		B
27-Dec-97	187	-2.701	0.056	S		B
03-Jan-98	194	-2.683	0.079	S		B
16-Jan-98	207	-2.635	0.153	S		B
23-Jan-98	214	-2.683	0.079	S		B
30-Jan-98	221	-2.68	0.0825	S		B
07-Feb-98	229	-2.682	0.081	S		B
13-Feb-98	235	-2.628	0.168	S		B
21-Feb-98	243	-2.634	0.155	S		B
27-Feb-98	249	-2.509	0.626	S		B
03-Mar-98	253	-2.635	0.153	S		B
07-Mar-98	257	-2.654	0.121	S		B
10-Mar-98	260	-2.641	0.143	S	Free	B
13-Mar-98	263	-2.666	0.104	S	Partly Thaw	B
17-Mar-98	267	-2.681	0.082	S		B
20-Mar-98	270	-2.623	0.18	S		B
24-Mar-98	274	-2.651	0.125	S		B
27-Mar-98	277	-2.66	0.113	S		B
31-Mar-98	281	-2.15	2.34	S		B
02-Apr-98	283	-2.592	0.277	S		B
07-Apr-98	288	-2.658	0.115	S		B
09-Apr-98	290	-2.463	0.831098	G		B
14-Apr-98	295	-2.615	0.2	S		B
17-Apr-98	298	-2.57	0.370789	G		B
21-Apr-98	302	-2.615	0.2	S		B
24-Apr-98	305	-2.644	0.136	S		B
28-Apr-98	309	-2.66	0.113	S		B
01-May-9	312	-2.524	0.56	S		B
05-May-9	316	-2.647	0.132	S		B
08-May-9	319	-2.602	0.241	S		B
12-May-9	323	-2.661	0.112	S		B
14-May-9	325	-2.655	0.12	S		B
18-May-9	329	-2.685	0.076	S		B
21-May-9	332	-2.684	0.0775	S		B
25-May-9	336	-2.684	0.073179	G		B
28-May-9	339	-2.669	0.115216	G		B
01-Jun-98	343	-2.685	0.076	S		B
03-Jun-98	345	-2.689	0.07	S		B
05-Jun-98	347	-2.692	0.068	S		B
08-Jun-98	350	-2.698	0.059	S		B
11-Jun-98	353	-2.665	0.107	S		B
12-Jun-98	354	-2.66	0.113	S		B
15-Jun-98	357	-2.685	0.076	S		B
18-Jun-98	360	-2.698	0.059	S		B
19-Jun-98	361	-2.658	0.115	S		B
22-Jun-98	364	-2.697	0.06	S		B

Date	Consec. Days	WB2 - Maple Road (Robert Madaliski)				Curve Type
		G Hgt (m)	Q (m3/sec)	G or S	Comments	
25-Jun-98	367	-2.694	0.063	S		B
29-Jun-98	371	-2.633	0.139704	G		B
02-Jul-98	374	-2.686	0.076	S		B
04-Jul-98	376	-2.691	0.069	S		B
06-Jul-98	378	-2.694	0.063	S		B
09-Jul-98	381	-2.692	0.068	S		B
13-Jul-98	385	-2.701	0.056	S		B
16-Jul-98	388	-2.69	0.07	S		B
20-Jul-98	392	-2.708	0.0374	G		B
21-Jul-98	393	-2.636	0.1515	S		B
23-Jul-98	395	-2.71	0.042	S		B
27-Jul-98	399	-2.724	0.02279	G		B
30-Jul-98	402	-2.694	0.063	S		B
03-Aug-98	406	-2.726	0.029	S		B
05-Aug-98	408	-2.662	0.11	S		B
06-Aug-98	409	-2.65	0.126	S		B
07-Aug-98	410	-2.657	0.118	S		B
10-Aug-98	413	-2.68	0.099	S		B
13-Aug-98	416	-2.69	0.0815	S		B
17-Aug-98	420	-2.696	0.061	S		B
20-Aug-98	423	-2.694	0.063	S		B
25-Aug-98	428	-2.69	0.07	S		B
28-Aug-98	431	-2.692	0.068	S		B
01-Sep-98	435	-2.782	0.055	S		B
04-Sep-98	438	-2.712	0.041	S		B
08-Sep-98	442	-2.706	0.03	S		B
11-Sep-98	445	-2.776	0.004314	G		B
15-Sep-98	449	-2.678	0.084	S		B
18-Sep-98	452	-2.708	0.04	S		B
22-Sep-98	456	-2.698	0.052	S		B
25-Sep-98	459	-2.708	0.04	S		B
29-Sep-98	463	-2.696	0.055	S		B
02-Oct-98	466	-2.712	0.036	S		B
06-Oct-98	470	-2.646	0.1215	S		B
09-Oct-98	473	-2.698	0.052	S		B
13-Oct-98	477	-2.694	0.057	S		B
16-Oct-98	480	-2.695	0.0565	S		B
20-Oct-98	484	-2.686	0.067	S		B
23-Oct-98	487	-2.705	0.0425	S		B
27-Oct-98	491	-2.692	0.059	S		B
30-Oct-98	494	-2.687	0.066	S		B
06-Nov-98	501	-2.695	0.034844	G		B
10-Nov-98	505	-2.436	0.965	S		B
13-Nov-98	508	-2.693	0.058	S		B
17-Nov-98	512	-2.693	0.058	S		B
20-Nov-98	515	-2.695	0.0565	S		B
24-Nov-98	519	-2.734	0.006279	G		B
27-Nov-98	522	-2.7	0.049	S		B

Date	Consec. Days	WB2 - Maple Road (Robert Madaliski)				Curve Type
		G Hgt (m)	Q (m3/sec)	G or S	Comments	
01-Dec-98	526	-2.688	0.064	S		B
04-Dec-98	529	-2.687	0.066	S		B
08-Dec-98	533	-2.686	0.067	S		B
11-Dec-98	536	-2.694	0.057	S		B
15-Dec-98	540	-2.698	0.052	S		B
23-Dec-98	548	-2.628	0.16	S	Frozen	B
29-Dec-98	554	-2.62	0.18	S	Frozen	B
12-Jan-99	568	-2.69	0.061	S	Frozen	B
19-Jan-99	575	-2.668	0.09	S	Frozen	B
29-Jan-99	585	-2.619	0.18	S		B
05-Feb-99	592	-2.62	0.177	S		B
12-Feb-99	599	-2.557	0.41	S		B
19-Feb-99	606	-2.658	0.1	S		B
26-Feb-99	613	-2.679	0.079	S		B
05-Mar-99	620	-2.672	0.083	S		B
12-Mar-99	627	-2.679	0.079	S		B
16-Mar-99	631	-2.642	0.128	S		B
19-Mar-99	634	-2.624	0.183452	G		B
23-Mar-99	638	-2.666	0.092	S		B
27-Mar-99	642	-2.667	0.091	S		B
30-Mar-99	645	-2.675	0.08	S		B
02-Apr-99	648	-2.678	0.079	S		B
06-Apr-99	652	-2.671	0.083	S		B
9-Apr-99	655	-2.294	1.3	S		B
13-Apr-99	659	-2.617	0.19	S		B
16-Apr-99	662	-2.667	0.091	S		B
20-Apr-99	666	-2.67	0.085	S		B
23-Apr-99	669	-2.172	2.1	S		B
27-Apr-99	673	-2.642	0.129	S		B
30-Apr-99	676	-2.656	0.11	S		B
4-May-99	680	-2.67	0.085	S		B
7-May-99	683	-2.63	0.15	S		B
########	688	-2.504	0.68	S		B
########	691	-2.652	0.11	S		B
########	695	-2.558	0.409	S		B
########	697	-2.636	0.139	S		B
########	701	-2.642	0.13	S		B
########	704	-2.66	0.1	S		B
1-Jun-99	708	-2.663	0.063764	G		B
4-Jun-99	711	-2.663	0.064	S		B
8-Jun-99	715	-2.658	0.11	S		B
11-Jun-99	718	-2.634	0.14	S		B
13-Jun-99	720	-2.466	0.81	S		B
15-Jun-99	722	-2.626	0.195758	G		B
18-Jun-99	725	-2.664	0.095	S		B
22-Jun-99	729	-2.678	0.078	S		B
25-Jun-99	732	-2.68	0.052035	G		B
29-Jun-99	736	-2.694	0.057	S		B

Date	Consec. Days	WBS - Goldendale Rd				Curve Type
		G Hgt (m)	Q (m3/sec)	G or S	Comments	
24-Jun-97	1					
01-Jul-97	8					
03-Jul-97	10					
07-Jul-97	14					
09-Jul-97	16					
11-Jul-97	18					
14-Jul-97	21					
16-Jul-97	23					
18-Jul-97	25					
21-Jul-97	28					
23-Jul-97	30	-1.337	0.0315	S		A
25-Jul-97	32	-1.353	0.017515	G		A
28-Jul-97	35	-1.361	0.0135	S		A
30-Jul-97	37	-1.366	0.0115	S		A
01-Aug-97	39	-1.372	0.008	S		A
04-Aug-97	42	-1.364	0.0107	S		A
06-Aug-97	44					A
07-Aug-97	45	-1.36	0.010982	G	Partly Cloudy 85F	A
08-Aug-97	46	-1.372	0.008717	G		A
11-Aug-97	49	-1.366	0.01051	G		A
13-Aug-97	51	-1.356	0.016261	G	Mostly Cloudy	A
18-Aug-97	56	-1.303	0.051801	G		A
20-Aug-97	58	-1.31	0.051574	G		A
25-Aug-97	63	-1.337	0.031564	G		A
29-Aug-97	67	-1.35	0.015174	G		A
01-Sep-97	70	-1.357	0.013609	G		A
06-Sep-97	75	-1.264	0.094156	G	-Upstream Addit	A
09-Sep-97	78	-1.344	0.0265	S		A
12-Sep-97	81	-1.26	0.092183	G		A
17-Sep-97	86	-1.234	0.116	S		A
19-Sep-97	88	-1.256	0.095	S		A
23-Sep-97	92	-1.304	0.0544	S	Partly Sunny 65F	A
26-Sep-97	95	-1.294	0.063871	G		A
30-Sep-97	99	-1.276	0.0796	S		A
03-Oct-97	102	-1.34	0.0305	S		A
07-Oct-97	106	-1.274	0.0683	S		A
10-Oct-97	109	-1.295	0.049616	G		A
14-Oct-97	113	-1.258	0.082	S		A
17-Oct-97	116	-1.332	0.013769	G		A
21-Oct-97	120	-1.299	0.045	S		A
24-Oct-97	123	-1.338	0.00935	S		A
28-Oct-97	127	-1.337	0.010807	G		A
31-Oct-97	130	-1.337	0.0103	S		A
07-Nov-97	137	-1.333	0.0137	S		A
11-Nov-97	141	-1.258	0.082	S		A
14-Nov-97	144	-1.338	0.032	S		A
18-Nov-97	148	-1.295	0.049	S		A
21-Nov-97	151	-1.289	0.053172	G		A
25-Nov-97	155	-1.294	0.0497	S		A

Date	Consec. Days	WBS - Goldendale Rd				Curve Type
		G Hgt (m)	Q (m3/sec)	G or S	Comments	
29-Nov-97	159	-1.261	0.093787	G		A
05-Dec-97	165	-1.328	0.040165	G		A
13-Dec-97	173	-1.298	0.046	S		A
19-Dec-97	179	-1.28	0.0624	S		A
27-Dec-97	187	-1.293	0.0507	S		A
03-Jan-98	194	-1.298	0.046	S		A
16-Jan-98	207	-1.287	0.0692	S		A
23-Jan-98	214	-1.286	0.0702	S		A
30-Jan-98	221	-1.278	0.080124	G		A
07-Feb-98	229	-1.295	0.0622	S		A
13-Feb-98	235	-1.263	0.092	S		A
21-Feb-98	243	-1.272	0.0828	S		A
27-Feb-98	249	-1.156	0.177576	G		B
03-Mar-98	253	-1.259	0.081	S		B
07-Mar-98	257	-1.257	0.083	S		B
10-Mar-98	260	-1.265	0.075	S	Free	B
13-Mar-98	263	-1.3	0.0422	S	Free	B
17-Mar-98	267	-1.296	0.048	S		B
20-Mar-98	270	-1.269	0.071	S		B
24-Mar-98	274	-1.285	0.0565	S		B
27-Mar-98	277	-1.29	0.053	S		B
31-Mar-98	281	-0.988	0.390863	G		B
02-Apr-98	283	-1.243	0.095	S		B
07-Apr-98	288	-1.288	0.054	S		B
09-Apr-98	290	-1.126	0.213	S		B
14-Apr-98	295	-1.274	0.066	S		B
17-Apr-98	298	-1.243	0.095	S		B
21-Apr-98	302	-1.265	0.075	S		B
24-Apr-98	305	-1.274	0.066	S		B
28-Apr-98	309	-1.307	0.037	S		B
01-May-98	312	-1.19	0.145	S		B
05-May-98	316	-1.288	0.054	S		B
08-May-98	319	-1.264	0.076	S		B
12-May-98	323	-1.319	0.026	S		B
14-May-98	325	-1.293	0.05	S		B
18-May-98	329	-1.303	0.0405	S		B
21-May-98	332	-1.304	0.0395	S		B
25-May-98	336	-1.305	0.039	S		B
28-May-98	339	-1.293	0.05	S		B
01-Jun-98	343	-1.302	0.041	S		B
03-Jun-98	345	-1.302	0.041	S		B
05-Jun-98	347	-1.305	0.039	S		B
08-Jun-98	350	-1.307	0.037	S		B
11-Jun-98	353	-1.297	0.0465	S		B
12-Jun-98	354	-1.308	0.036	S		B
15-Jun-98	357	-1.304	0.0395	S		B
18-Jun-98	360	-1.306	0.038	S		B
19-Jun-98	361	-1.298	0.045	S		B
22-Jun-98	364	-1.31	0.034	S		B

Date	Consec. Days	WB3 - Goldendale Rd				Curve Type
		G Hgt (m)	Q (m3/sec)	G or S	Comments	
25-Jun-98	367	-1.308	0.036	S		B
29-Jun-98	371	-1.288	0.054	S		B
02-Jul-98	374	-1.298	0.045	S		B
04-Jul-98	376	-1.307	0.037	S		B
06-Jul-98	378	-1.304	0.046995	G		B
09-Jul-98	381	-1.304	0.0395	S		B
13-Jul-98	385	-1.31	0.034	S		B
16-Jul-98	388	-1.31	0.038405	G		B
20-Jul-98	392	-1.31	0.034	S		B
21-Jul-98	393	-1.295	0.048	S		B
23-Jul-98	395	-1.326	0.020334	G		B
27-Jul-98	399	-1.333	0.018	S		B
30-Jul-98	402	-1.308	0.036	S		B
03-Aug-98	406	-1.332	0.018	S		B
05-Aug-98	408	-1.268	0.072	S		B
06-Aug-98	409	-1.306	0.038	S		B
07-Aug-98	410	-1.295	0.048	S		B
10-Aug-98	413	-1.296	0.0465	S		B
13-Aug-98	416	-1.296	0.0465	S		B
17-Aug-98	420	-1.301	0.042	S		B
20-Aug-98	423	-1.301	0.042	S		B
25-Aug-98	428	-1.296	0.0465	S		B
28-Aug-98	431	-1.294	0.049	S		B
01-Sep-98	435	-1.304	0.0395	S		B
04-Sep-98	438	-1.312	0.032	S		B
08-Sep-98	442	-1.308	0.036	S		B
11-Sep-98	445	-1.361	0.806102	G		B
15-Sep-98	449	-1.296	0.0465	S		B
18-Sep-98	452	-1.318	0.018	S		B
22-Sep-98	456	-1.306	0.038	S		B
25-Sep-98	459	-1.329	0.0175	S		B
29-Sep-98	463	-1.303	0.041	S		B
02-Oct-98	466	-1.333	0.014	S		B
06-Oct-98	470	-1.288	0.053	S		B
09-Oct-98	473	-1.325	0.022	S		B
13-Oct-98	477	-1.308	0.0365	S		B
16-Oct-98	480	-1.313	0.0325	S		B
20-Oct-98	484	-1.307	0.0375	S		B
23-Oct-98	487	-1.318	0.0275	S		B
27-Oct-98	491	-1.307	0.0375	S		B
30-Oct-98	494	-1.309	0.036	S		B
06-Nov-98	501	-1.315	0.03	S		B
10-Nov-98	505	-1.182	0.113319	G		B
13-Nov-98	508	-1.298	0.040228	G		B
17-Nov-98	512	-1.291	0.046	S		B
20-Nov-98	515	-1.307	0.0375	S		B
24-Nov-98	519	-1.347	0.01	S		B
27-Nov-98	522	-1.299	0.045	S		B

Date	Consec. Days	WB3 - Goldendale Rd				Curve Type
		G Hgt (m)	Q (m3/sec)	G or S	Comments	
01-Dec-98	526	-1.292	0.0505	S		B
04-Dec-98	529	-1.291	0.0515	S		B
08-Dec-98	533	-1.288	0.053	S		B
11-Dec-98	536	-1.3	0.044	S		B
15-Dec-98	540	-1.304	0.0395	S		B
23-Dec-98	548	-1.268	0.0705	S	Frozen	B
29-Dec-98	554	-1.301	0.043	S	Frozen	B
12-Jan-99	568	-1.315	0.03	S	Frozen	B
19-Jan-99	575	-1.304	0.0395	S	Frozen	B
29-Jan-99	585	-1.3	0.041	S		B
05-Feb-99	592	-1.264	0.077	S		B
12-Feb-99	599	-1.262	0.079	S		B
19-Feb-99	606	-1.285	0.057	S		B
26-Feb-99	613	-1.319	0.028	S		B
05-Mar-99	620	-1.302	0.04	S		B
12-Mar-99	627	-1.321	0.026	S		B
16-Mar-99	631	-1.26	0.08	S		B
19-Mar-99	634	-1.271	0.071	S		B
23-Mar-99	638	-1.31	0.042	S		B
27-Mar-99	642	-1.302	0.04	S		B
30-Mar-99	645	-1.313	0.032	S		B
02-Apr-99	648	-1.305	0.039	S		B
06-Apr-99	652	-1.303	0.04	S		B
9-Apr-99	655	-0.978	0.4	S		B
13-Apr-99	659	-1.29	0.052	S		B
16-Apr-99	662	-1.324	0.024	S		B
20-Apr-99	666	-1.313	0.032	S		B
23-Apr-99	669	-0.972	0.041	S		B
27-Apr-99	673	-1.29	0.052	S		B
30-Apr-99	676	-1.288	0.053	S		B
4-May-99	680	-1.296	0.045	S		B
7-May-99	683	-1.281	0.061	S		B
12-May-99	688	-1.193	0.133421	G		B
15-May-99	691	-1.29	0.052	S		B
19-May-99	695	-1.226	0.122	S		B
21-May-99	697	-1.274	0.067	S		B
25-May-99	701	-1.301	0.041	S		B
28-May-99	704	-1.294	0.047	S		B
1-Jun-99	708	-1.294	0.047	S		B
4-Jun-99	711	-1.3	0.043	S		B
8-Jun-99	715	-1.302	0.04	S		B
11-Jun-99	718	-1.279	0.052287	G		B
13-Jun-99	720	-0.99	0.372	S		B
15-Jun-99	722	-1.28	0.062	S		B
18-Jun-99	725	-1.306	0.037	S		B
22-Jun-99	729	-1.316	0.03	S		B
25-Jun-99	732	-1.314	0.029672	G		B
29-Jun-99	736	-1.32	0.024	S		B

Date	Consec. Days	W1 - Lannon Road (WDOT) G Hgt (m)	Q (m3/sec)	G or S	Comments	Curve Type
24-Jun-97	1	0.16	1.745	S	Backwater	A
01-Jul-97	8	-0.682	0.2187	G	Curve Before	A
03-Jul-97	10	-0.46	0.72	S	Feb'98	A
07-Jul-97	14	-0.73	0.166	G		A
09-Jul-97	16	-0.522	0.586	S		A
11-Jul-97	18	-0.711	0.2065	G		A
14-Jul-97	21	-0.749	0.157	S		A
16-Jul-97	23	-0.802	0.0949	G		A
18-Jul-97	25	-0.767	0.136	S		A
21-Jul-97	28	-0.598	0.453601	G	rained/battery	A
23-Jul-97	30	-0.722	0.188	S		A
25-Jul-97	32	-0.79	0.108	S		A
28-Jul-97	35	-0.765	0.13953	G		A
30-Jul-97	37	-0.821	0.074	S		A
01-Aug-97	39	-0.83	0.057689	G	tag line/angle	A
04-Aug-97	42	-0.822	0.078449	G		A
06-Aug-97	44	-0.832	0.068931	G		A
07-Aug-97	45					A
08-Aug-97	46	-0.846	0.040673	G		A
11-Aug-97	49	-0.836	0.0575	S		A
13-Aug-97	51	-0.732	0.173	S		A
18-Aug-97	56	-0.765	0.13953	S		A
20-Aug-97	58	-0.663	0.3075	S	ran out of time	A
22-Aug-97	60					A
25-Aug-97	63	-0.649	0.364022	G		A
29-Aug-97	67	-0.786	0.114	S		A
01-Sep-97	70	-0.792	0.105	S		A
06-Sep-97	75	-0.822	0.073	S		A
09-Sep-97	78	-0.825	0.071	S		A
12-Sep-97	81	-0.843	0.0485	S		A
17-Sep-97	86	-0.706	0.2165	S	Rained 16th, 75F	A
19-Sep-97	88	-0.809	0.086	S		A
23-Sep-97	92	-0.789	0.109	S		A
26-Sep-97	95	-0.822	0.073	S		A
30-Sep-97	99	-0.821	0.074	S		A
03-Oct-97	102	-0.804	0.092	S		A
07-Oct-97	106	-0.744	0.162	S	Get Curve	B
10-Oct-97	109	-0.712	0.026	S		B
14-Oct-97	113	-0.69	0.0365	S		B
17-Oct-97	116	-0.7	0.032	S		B
21-Oct-97	120	-0.7	0.032	S		B
24-Oct-97	123	-0.671	0.045293	G	Overcast 45F	B
28-Oct-97	127	-0.668	0.053	S		B
31-Oct-97	130	-0.674	0.047	S		B
07-Nov-97	137	-0.658	0.065	S	Cleared Fall leaves	B
11-Nov-97	141	-0.852	0.037	S	Curve Before	A
14-Nov-97	144	-0.852	0.037	S	Feb'98	A
18-Nov-97	148	-0.855	0.0325	S	Partly frozen river	A
21-Nov-97	151	-0.851	0.0375	S		A
25-Nov-97	155	-0.853	0.0355	S		A

Date	Consec. Days	W1 - Lannon Road (WDOT) G Hgt (m)	Q (m3/sec)	G or S	Comments	Curve Type
29-Nov-97	159	-0.851	0.0375	S		A
05-Dec-97	165	-0.827	0.0685	S		A
13-Dec-97	173	-0.835	0.0585	S		A
19-Dec-97	179	-0.829	0.065	S		A
27-Dec-97	187	-0.815	0.08	S		A
03-Jan-98	194	-0.758	0.1465	S		A
16-Jan-98	207	-0.727	0.1822	S	Generally Frozen	A
23-Jan-98	214	-0.794	0.105	S	Partly Frozen	A
30-Jan-98	221	-0.786	0.114	S		A
07-Feb-98	229	-0.785	0.115	S		A
13-Feb-98	235	-0.598	0.412794	G		A
21-Feb-98	243	-0.655	0.325	S		A
22-Feb-98	244					A
27-Feb-98	249	-0.337	0.983	S	Curve after	C
03-Mar-98	253	-0.701	0.3165	S	Feb'98	C
07-Mar-98	257	-0.749	0.2485	S		C
10-Mar-98	260	-0.705	0.31	S	Thro' Ice	C
13-Mar-98	263	-0.76	0.233	S	Frozen	C
17-Mar-98	267	-0.819	0.147	S		C
20-Mar-98	270	-0.595	0.735	S		C
24-Mar-98	274	-0.723	0.2865	S		C
27-Mar-98	277	-0.738	0.2655	S		C
31-Mar-98	281	-0.144	1.723	S		C
02-Apr-98	283	-0.195	1.335	S		C
07-Apr-98	288	-0.72	0.2915	S		C
09-Apr-98	290	-0.185	1.259	S		C
14-Apr-98	295	-0.584	0.475589	G		C
17-Apr-98	298	-0.292	1.076	S		C
21-Apr-98	302	-0.601	0.447	S		C
24-Apr-98	305	-0.727	0.281	S		C
28-Apr-98	309	-0.746	0.2525	S		C
01-May-9	312	-0.47	0.6985	S		C
05-May-9	316	-0.745	0.248835	G		C
08-May-9	319	-0.615	0.431	S		C
12-May-9	323	-0.795	0.178227	G		C
14-May-9	325	-0.787	0.203683	G		C
18-May-9	329	-0.854	0.1015	S		C
21-May-9	332	-0.86	0.094	S		C
25-May-9	336	-0.867	0.094049	G		C
28-May-9	339	-0.826	0.141423	G		C
01-Jun-98	343	-0.86	0.094	S		C
03-Jun-98	345	-0.861	0.0925	S		C
05-Jun-98	347	-0.877	0.060681	G		C
08-Jun-98	350	-0.892	0.054388	G		C
11-Jun-98	353	-0.83	0.1333	S		C
12-Jun-98	354	-0.782	0.201	S		C
15-Jun-98	357	-0.873	0.0765	S		C
18-Jun-98	360	-0.872	0.0775	S		C
19-Jun-98	361	-0.8	0.176	S		C
22-Jun-98	364	-0.891	0.0515	S		C

Date	Consec. Days	W1 - Lannon Road (WDOT)				Curve Type
		G Hgt (m)	Q (m3/sec)	G or S	Comments	
25-Jun-98	367	-0.883	0.062	S		C
29-Jun-98	371	-0.753	0.243	S		C
02-Jul-98	374	-0.87	0.072466	G		C
04-Jul-98	376	-0.872	0.0765	S		C
06-Jul-98	378	-0.89	0.0533	S		C
09-Jul-98	381	-0.904	0.031547	G		C
13-Jul-98	385	-0.919	0.03478	G		C
16-Jul-98	388	-0.912	0.035342	G		C
20-Jul-98	392	-0.927	0.025499	G		C
21-Jul-98	393	-0.796	0.1803	S		C
23-Jul-98	395	-0.896	0.05	S		C
27-Jul-98	399	-0.917	0.0273	S		C
30-Jul-98	402	-0.926	0.026	S		C
03-Aug-98	406	-0.934	0.030472	G		C
05-Aug-98	408	-0.92	0.03	S		C
06-Aug-98	409	-0.844	0.112	S		C
07-Aug-98	410	-0.841	0.117	S		C
10-Aug-98	413	-0.892	0.048	S		C
13-Aug-98	416	-0.912	0.034	S		C
17-Aug-98	420	-0.925	0.0275	S		C
20-Aug-98	423	-0.924	0.028	S		C
25-Aug-98	428	-0.921	0.0295	S		C
28-Aug-98	431	-0.926	0.026	S		C
01-Sep-98	435	-0.946	0.016878	G		C
04-Sep-98	438	-0.943	0.021	S		C
08-Sep-98	442	-0.945	0.0205	S		C
11-Sep-98	445	-0.947	0.0195	S		C
15-Sep-98	449	-0.888	0.052	S		C
18-Sep-98	452	-0.935	0.024	S		C
22-Sep-98	456	-0.934	0.0245	S		C
25-Sep-98	459	-0.935	0.024	S		C
29-Sep-98	463	-0.938	0.0225	S		C
02-Oct-98	466	-0.939	0.022	S		C
06-Oct-98	470	-0.868	0.082	S		C
09-Oct-98	473	-0.918	0.032	S		C
13-Oct-98	477	-0.926	0.027	S		C
16-Oct-98	480	-0.921	0.029	S		C
20-Oct-98	484	-0.915	0.034	S		C
23-Oct-98	487	-0.923	0.0285	S		C
27-Oct-98	491	-0.915	0.034	S		C
30-Oct-98	494	-0.904	0.0405	S		C
06-Nov-98	501	-0.93	0.0265	S		C
10-Nov-98	505	-0.42	0.81	S		C
13-Nov-98	508	-0.846	0.115	S		C
17-Nov-98	512	-0.882	0.0605	S		C
20-Nov-98	515	-0.888	0.054	S		C
24-Nov-98	519	-0.886	0.057	S		C

Date	Consec. Days	W1 - Lannon Road (WDOT)				Curve Type
		G Hgt (m)	Q (m3/sec)	G or S	Comments	
01-Dec-98	526	-0.873	0.075	S		C
04-Dec-98	529	-0.889	0.062799	G		C
08-Dec-98	533	-0.834	0.133	S		C
11-Dec-98	536	-0.856	0.1005	S		C
15-Dec-98	540	-0.86	0.094	S		C
23-Dec-98	548	-0.877	0.069	S	Frozen	C
29-Dec-98	554	-0.812	0.162	S	Frozen	C
12-Jan-99	568	-0.734	0.264	S	Frozen	C
19-Jan-99	575	-0.425	0.8	S	Frozen	C
29-Jan-99	585	-0.493	0.635	S		C
05-Feb-99	592	-0.696	0.323523	G		C
12-Feb-99	599	-0.17	1.33	S		C
19-Feb-99	606	-0.785	0.206	S		C
26-Feb-99	613	-0.837	0.125	S		C
05-Mar-99	620	-0.826	0.14	S		C
12-Mar-99	627	-0.824	0.141	S		C
16-Mar-99	631	-0.721	0.31165	G		C
19-Mar-99	634	-0.652	0.388	S		C
23-Mar-99	638	-0.795	0.185	S		C
27-Mar-99	642	-0.832	0.152436	G		C
30-Mar-99	645	-0.842	0.117	S		C
02-Apr-99	648	-0.84	0.119503	G		C
06-Apr-99	652	-0.814	0.155	S		C
9-Apr-99	655	-0.08	1.87	S	Rain, 40's	C
13-Apr-99	659	-0.584	0.478	S	Partly Cloudy, 55F	C
16-Apr-99	662	-0.776	0.259375	G	Sunny, 50's	C
20-Apr-99	666	-0.819	0.174698	G	Partly Cloudy, 50's	C
23-Apr-99	669	0.242	2.242	S	Cloudy, 40's	C
27-Apr-99	673	-0.619	0.353198	G	Sunny, 60's	C
30-Apr-99	676	-0.782	0.205	S	Sunny, 60's	C
4-May-99	680	-0.837	0.125	S	Sunny, 60's	C
7-May-99	683	-0.702	0.301089	G	Overcast, 60's	C
########	688	-0.352	0.978	S	Cloudy, 50's	C
########	691	-0.781	0.206	S	Sunny, 60's	C
########	695	-0.257	1.14	S	Sunny-cloudy, 70;s	C
########	697	-0.683	0.33	S	Partly Cloudy, 60's	C
########	701	-0.722	0.28	S	Partly Cloudy, 55-	C
########	704	-0.825	0.144	S	Sunny, 80's	C
1-Jun-99	708	-0.853	0.107	S	Overcast, 60's	C
4-Jun-99	711	-0.844	0.119	S	65-70, showers	C
8-Jun-99	715	-0.826	0.143	S	Sunny, 80's	C
11-Jun-99	718	-0.726	0.275	S	Sunny, 80's	C
13-Jun-99	720	-0.1	1.49	S	Rain/estimate	C
15-Jun-99	722	-0.45	0.72	S	Sunny, 60's	C
18-Jun-99	725	-0.791	0.19	S	Sunny, 70's	C
22-Jun-99	729	-0.866	0.091288	G	Partly Cloudy, 75-	C
25-Jun-99	732	-0.873	0.096195	G	Sunny, 80's	C
29-Jun-99	736	-0.887	0.061	S	Partly Cloudy, 75	C

Date	Consec. Days	W2 - Coach Lamp Inn, Hwy 175 (Betty Baldwin) G Hgt (m)	Q (m3/sec)	G or S	Comments	Curve Type
24-Jun-97	1	-2.85	0.33	S	Curve Before	A
01-Jul-97	8	-2.905	0.1819	G	Sep'97	A
03-Jul-97	10	-2.868	0.274	S		A
07-Jul-97	14	-2.94	0.123	G		A
09-Jul-97	16	-2.86	0.293082	S		A
11-Jul-97	18	-2.923	0.1417	G		A
14-Jul-97	21	-2.955	0.1035	S		A
16-Jul-97	23	-2.985	0.0768	G		A
18-Jul-97	25	-2.958	0.1	S		A
21-Jul-97	28	-2.86	0.293082	G	storm high,btry,seaweed,m.	A
23-Jul-97	30	-2.936	0.146	S		A
25-Jul-97	32	-2.97	0.087	S		A
28-Jul-97	35	-2.932	0.105913	G		A
30-Jul-97	37	-2.981	0.0785	S		A
01-Aug-97	39	-2.994	0.062612	G		A
04-Aug-97	42					A
06-Aug-97	44	-3.014	0.051953	G	gage ht.? (-4.104)	A
07-Aug-97	45					A
08-Aug-97	46	-3.01	0.041089	G		A
11-Aug-97	49	-3.008	0.052	S		A
13-Aug-97	51	-2.944	0.117	S		A
18-Aug-97	56	-2.966	0.0915	S		A
20-Aug-97	58	-2.929	0.1375	S		A
22-Aug-97	60	-2.976	0.0825	S		A
25-Aug-97	63	-2.91	0.17	S		A
29-Aug-97	67	-2.973	0.084	S		A
01-Sep-97	70	-2.98	0.0785	S		B
06-Sep-97	75	-3	0.061	S		B
09-Sep-97	78	-3.001	0.059	S		B
12-Sep-97	81	-3.01	0.05	S		B
17-Sep-97	86	-2.943	0.1175	S		B
19-Sep-97	88	-2.994	0.067	S		B
23-Sep-97	92	-2.985	0.074	S		B
26-Sep-97	95	-3.002	0.058	S		B
30-Sep-97	99	-3.002	0.058	S		B
03-Oct-97	102	-2.995	0.03	S	Curve after	B
07-Oct-97	106	-2.989	0.034	S	Sep'97	B
10-Oct-97	109	-2.992	0.032	S		B
14-Oct-97	113	-2.974	0.046	S		B
17-Oct-97	116	-2.977	0.043	S		B
21-Oct-97	120	-2.972	0.05	S		B
24-Oct-97	123	-2.947	0.0565	S		B
28-Oct-97	127	-2.964	0.06	S		B
31-Oct-97	130	-2.966	0.0575	S		B
07-Nov-97	137	-2.963	0.062	S		B
11-Nov-97	141	-2.968	0.046853	G		B
14-Nov-97	144	-2.97	0.0515	S		B
18-Nov-97	148	-2.966	0.0575	S		B
21-Nov-97	151	-2.965	0.0585	S		B
25-Nov-97	155	-2.963	0.062	S		B

Date	Consec. Days	W2 - Coach Lamp Inn, Hwy 175 (Betty Baldwin) G Hgt (m)	Q (m3/sec)	G or S	Comments	Curve Type
29-Nov-97	159	-2.959	0.065	S		B
05-Dec-97	165	-2.967	0.0565	S		B
13-Dec-97	173	-2.954	0.072	S		B
19-Dec-97	179	-2.951	0.076	S		B
27-Dec-97	187	-2.96	0.064	S		B
02-Jan-98	194	-2.908	0.136	S		B
16-Jan-98	207	-2.927	0.103	S	Frozen	B
23-Jan-98	214	-2.937	0.092	S	Free	B
30-Jan-98	221	-2.928	0.1015	S		B
07-Feb-98	229	-2.924	0.1045	S		B
13-Feb-98	235	-2.853	0.273	S		B
21-Feb-98	243	-2.876	0.2125	S		B
22-Feb-98	244					B
27-Feb-98	249	-2.725	0.81	S		B
03-Mar-98	253	-2.89	0.177	S		B
07-Mar-98	257	-2.908	0.136	S		B
10-Mar-98	260	-2.93	0.0985	S	Top of Ice	B
13-Mar-98	263	-2.93	0.0985	S	Top of Ice	B
17-Mar-98	267	-2.94	0.088	S		B
20-Mar-98	270	-2.847	0.2975	S		B
24-Mar-98	274	-2.899	0.156	S		B
27-Mar-98	277	-2.903	0.146	S		B
31-Mar-98	281	-2.268	2.25	S		B
02-Apr-98	283	-2.802	0.498222	G		B
07-Apr-98	288	-2.9	0.154	S		B
09-Apr-98	290	-2.678	0.975	S		B
14-Apr-98	295	-2.842	0.317	S		B
17-Apr-98	298	-2.795	0.523	S		B
21-Apr-98	302	-2.849	0.287379	G		B
24-Apr-98	305	-2.898	0.158	S		B
28-Apr-98	309	-2.908	0.136	S		B
01-May-9	312	-2.804	0.4915	S		B
03-May-9	316	-2.907	0.138	S		B
08-May-9	319	-2.851	0.28	S		B
12-May-9	323	-2.925	0.106	S		B
14-May-9	325	-2.922	0.111	S		B
18-May-9	329	-2.955	0.07	S		B
21-May-9	332	-2.953	0.073	S		B
25-May-9	336	-2.959	0.067255	G		B
28-May-9	339	-2.938	0.0915	S		B
01-Jun-98	343	-2.962	0.068275	G		B
03-Jun-98	345	-2.966	0.0575	S		B
05-Jun-98	347	-2.972	0.05	S		B
08-Jun-98	350	-2.975	0.045615	G		B
11-Jun-98	353	-2.95	0.0765	S		B
12-Jun-98	354	-2.969	0.0525	S		B
15-Jun-98	357	-2.968	0.057256	G		B
18-Jun-98	360	-2.965	0.059	S		B
19-Jun-98	361	-2.931	0.098	S		B
22-Jun-98	364	-2.987	0.040955	G		B

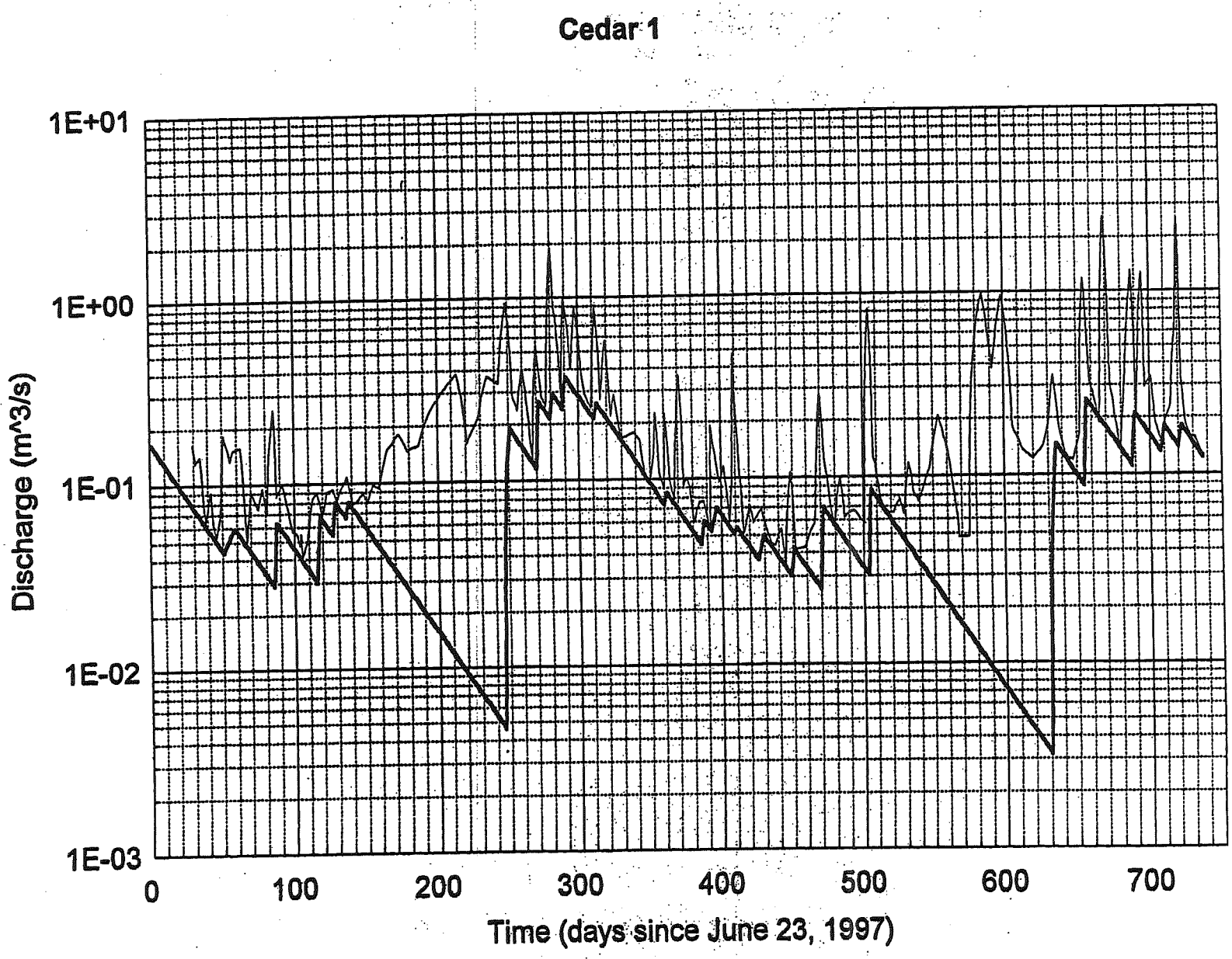
Date	Convec. Days	W2 - Coach Lamp Inn, Hwy 175 (Betty Baldwin) G Hgt (m)	Q (m3/sec)	G or S	Comments	Curve Type
25-Jun-98	367	-2.982	0.050269	G		B
29-Jun-98	371	-2.934	0.095	S		B
02-Jul-98	374	-2.98	0.051095	G		B
04-Jul-98	376	-2.978	0.049	S		B
06-Jul-98	378	-2.99	0.045537	G		B
09-Jul-98	381	-2.998	0.038	S		B
13-Jul-98	385	-3.008	0.031019	G		B
16-Jul-98	388	-2.998	0.038	S		B
20-Jul-98	392	-3.01	0.03	S		B
21-Jul-98	393	-2.951	0.077	S		B
23-Jul-98	395	-2.994	0.04	S		B
27-Jul-98	399	-3.008	0.031	S		B
30-Jul-98	402	-3.004	0.0325	S		B
03-Aug-98	406	-3.013	0.029	S		B
05-Aug-98	408	-2.99	0.0405	S		B
06-Aug-98	409	-2.964	0.0625	S		B
07-Aug-98	410	-2.972	0.054	S		B
10-Aug-98	413	-2.991	0.04	S		B
13-Aug-98	416	-2.998	0.0395	S		B
17-Aug-98	420	-3.005	0.032	S		B
20-Aug-98	423	-3.004	0.0325	S		B
25-Aug-98	428	-2.999	0.03408	G		B
28-Aug-98	431	-3	0.0345	S		B
01-Sep-98	435	-3.012	0.0295	S		B
04-Sep-98	438	-3.016	0.027113	G		B
08-Sep-98	442	-3.014	0.0285	S		B
11-Sep-98	445	-3.021	0.024	S		B
15-Sep-98	449	-3.001	0.034	S		B
16-Sep-98	452	-3.027	0.031048	G		B
22-Sep-98	456	-3.026	0.0275	S		B
25-Sep-98	459	-3.032	0.025	S		B
29-Sep-98	463	-3.028	0.0265	S		B
02-Oct-98	466	-3.026	0.0275	S		B
06-Oct-98	470	-2.99	0.044	S		B
09-Oct-98	473	-3.017	0.0325	S		B
13-Oct-98	477	-3.016	0.033	S		B
16-Oct-98	480	-3.01	0.035	S		B
20-Oct-98	484	-3.004	0.0375	S		B
23-Oct-98	487	-3.005	0.037	S		B
27-Oct-98	491	-3.004	0.0375	S		B
30-Oct-98	494	-3	0.0385	S		B
06-Nov-98	501	-3.017	0.027935	G		B
10-Nov-98	505	-2.799	0.505	S		B
13-Nov-98	508	-2.984	0.047	S		B
17-Nov-98	512	-3	0.0365	S		B
20-Nov-98	515	-3.005	0.037	S		B
24-Nov-98	519	-3.041	0.044367	G		A
27-Nov-98	522	-3.05	0.0375	S		A

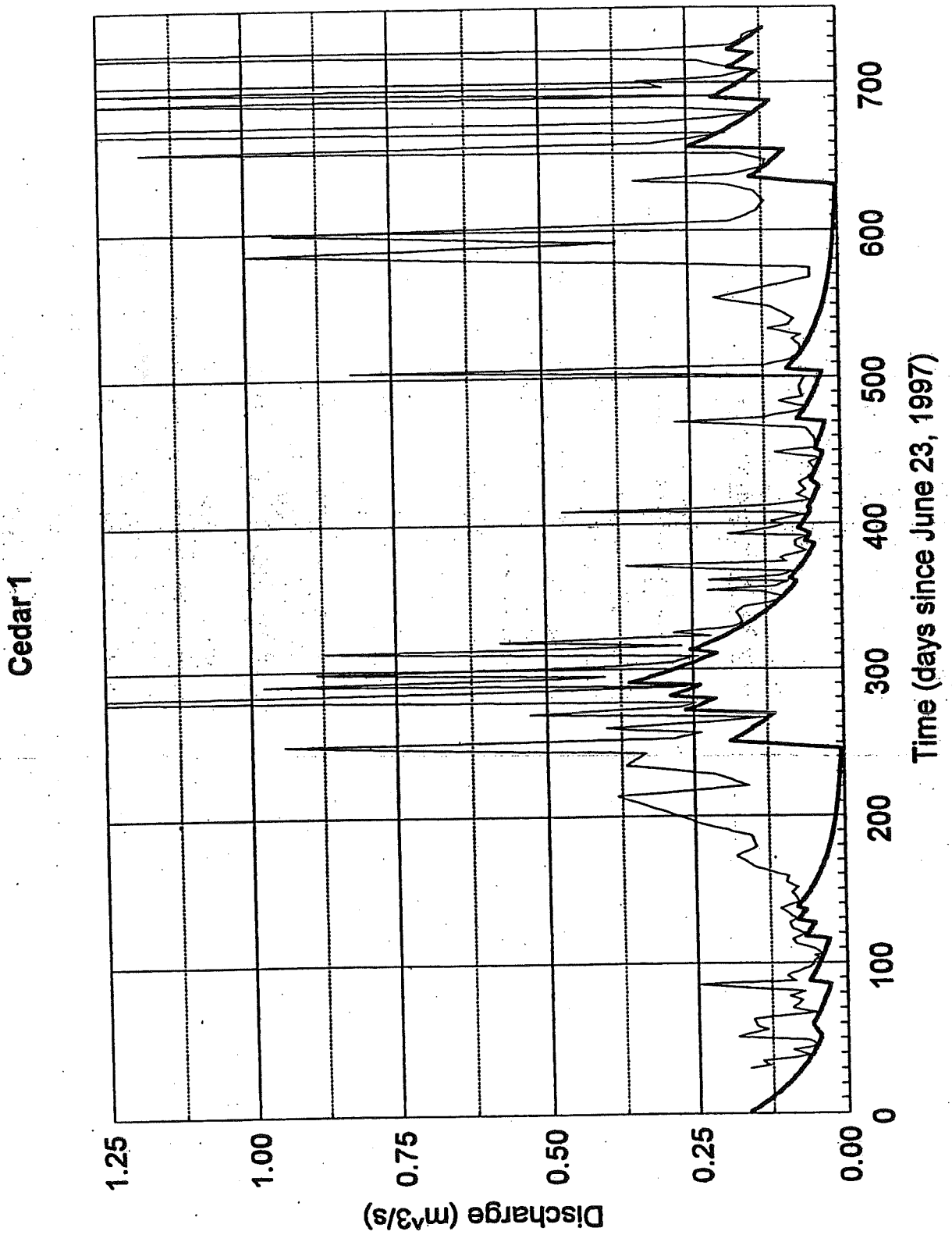
Date	Convec. Days	W2 - Coach Lamp Inn, Hwy 175 (Betty Baldwin) G Hgt (m)	Q (m3/sec)	G or S	Comments	Curve Type
01-Dec-98	526	-3.044	0.042	S		A
04-Dec-98	529	-3.047	0.100654	G		A
08-Dec-98	533	-3.018	0.052	S		A
11-Dec-98	536	-3.031	0.052191	G		A
15-Dec-98	540	-3.034	0.040569	G		A
23-Dec-98	548	-3.038	0.044	S	Frozen	A
29-Dec-98	554	-3.06	0.037	S	Frozen	A
12-Jan-99	568	-3.052	0.0325	S	Frozen	A
19-Jan-99	575	-3.006	0.0585	S	Frozen	A
29-Jan-99	585	-2.89	0.225684	G		A
05-Feb-99	592	-2.894	0.21	S		A
12-Feb-99	599	-2.749	0.67	S		A
19-Feb-99	606	-2.957	0.1	S		A
26-Feb-99	613	-2.989	0.07	S		A
05-Mar-99	620	-2.98	0.079	S		A
12-Mar-99	627	-2.978	0.08	S		A
16-Mar-99	631	-2.956	0.102	S		A
19-Mar-99	634	-2.888	0.225415	G		A
23-Mar-99	638	-2.962	0.095	S		A
27-Mar-99	642	-2.982	0.076	S		A
30-Mar-99	645	-2.991	0.069	S		A
02-Apr-99	648	-2.988	0.07	S		A
06-Apr-99	652	-2.981	0.078	S		A
36259	655	-2.657	1.02	S		A
36263	659	-2.893	0.21	S		A
36266	662	-2.953	0.105	S		A
36270	666	-2.977	0.08	S		A
36273	669	-2.208	2.4	S		A
36277	673	-2.908	0.176	S		A
36280	676	-2.959	0.098	S		A
36284	680	-2.991	0.069	S		A
36287	683	-2.923	0.148	S		A
36292	688	-2.779	0.57	S		A
36295	691	-2.962	0.095	S		A
36299	695	-2.75	0.67	S		A
36301	697	-2.911	0.212393	G		C
36305	701	-2.932	0.184	S		C
36308	704	-2.977	0.117934	G		C
36312	708	-2.996	0.089	S		C
36315	711	-2.993	0.091	S		C
36319	715	-2.988	0.090774	G		C
36322	718	-2.96	0.143124	G		C
36324	720	-2.65	0.98	S		C
36326	722	-2.998	0.247484	G		C
36329	725	-2.97	0.115619	G		C
36333	729	-0.301	0.06538	G		B
36336	732	-3.026	0.074032	G		B
36340	736	-3.043	0.051069	G		B

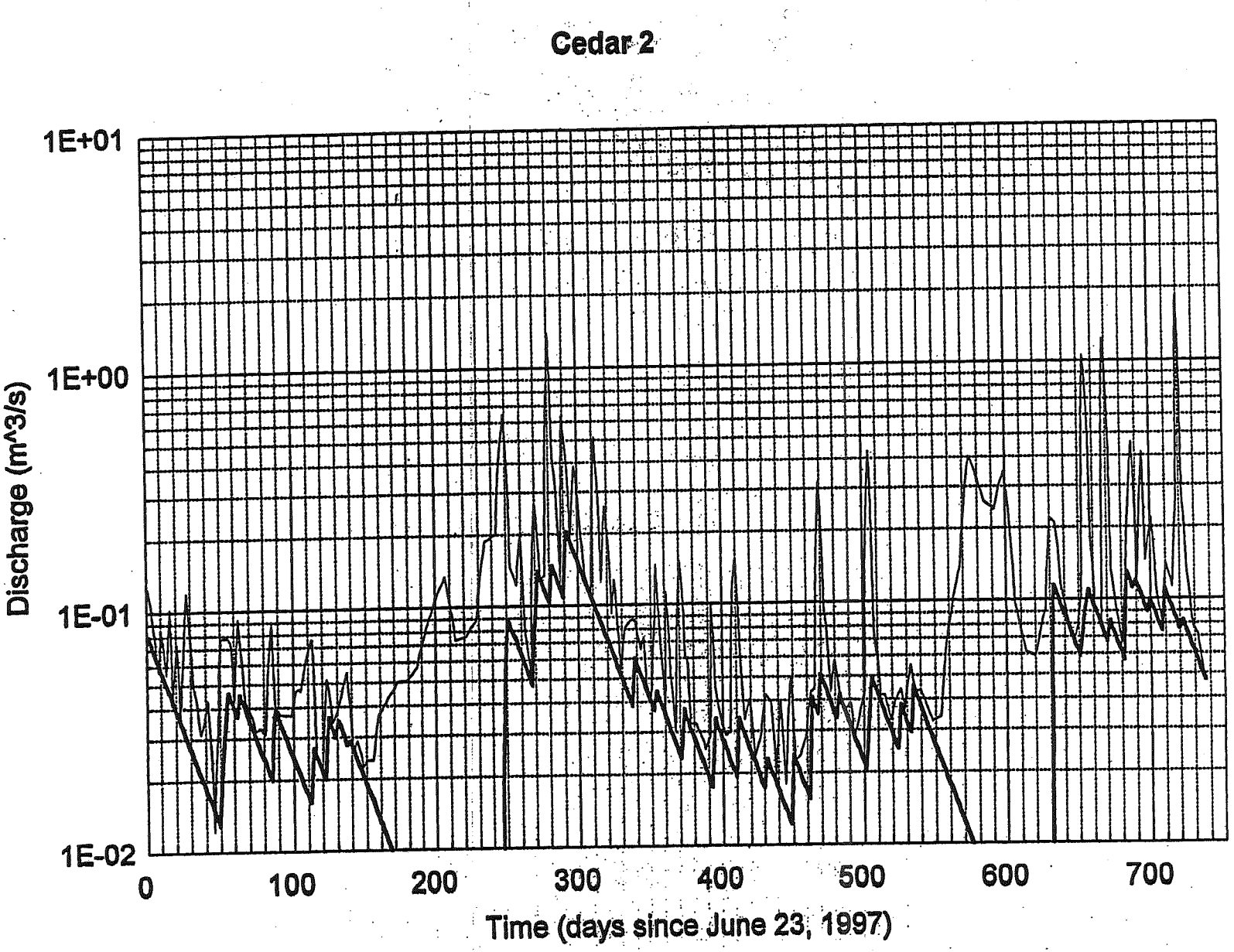
APPENDIX III. Two Year Hydrographs for the Study Gaging Sites

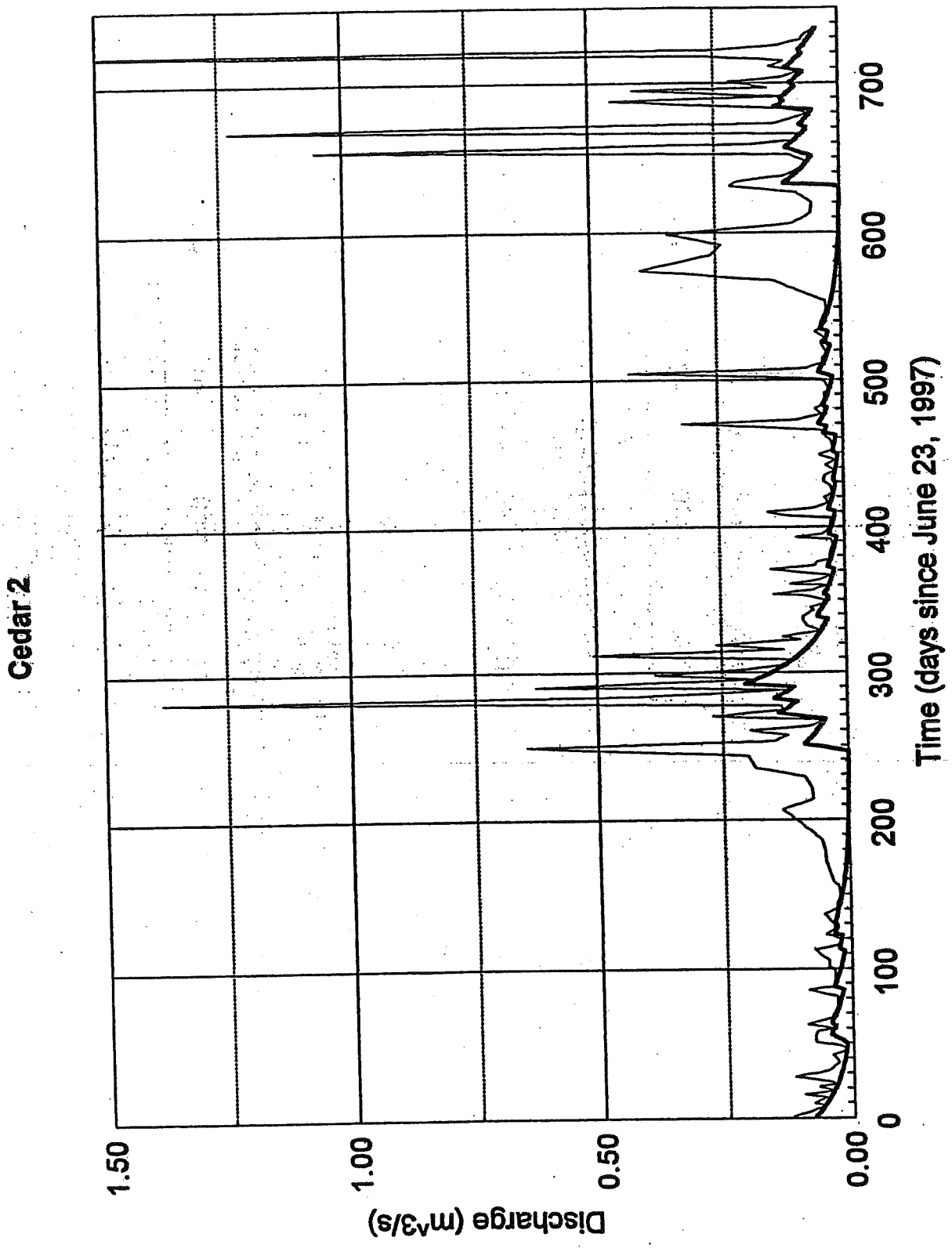
Two graphs are provided for each site. Both show the distribution of total stream discharge (light line) and baseflow (dark line) through the full two year study period. In each case, the first graph is semi-logarithmic and the second is an arithmetic plot. The Kinnickinnic River hydrographs, obtained from the USGS, are also included. All sites except the Kinnickinnic are located on Figure 1. The sites are arranged alphabetically.

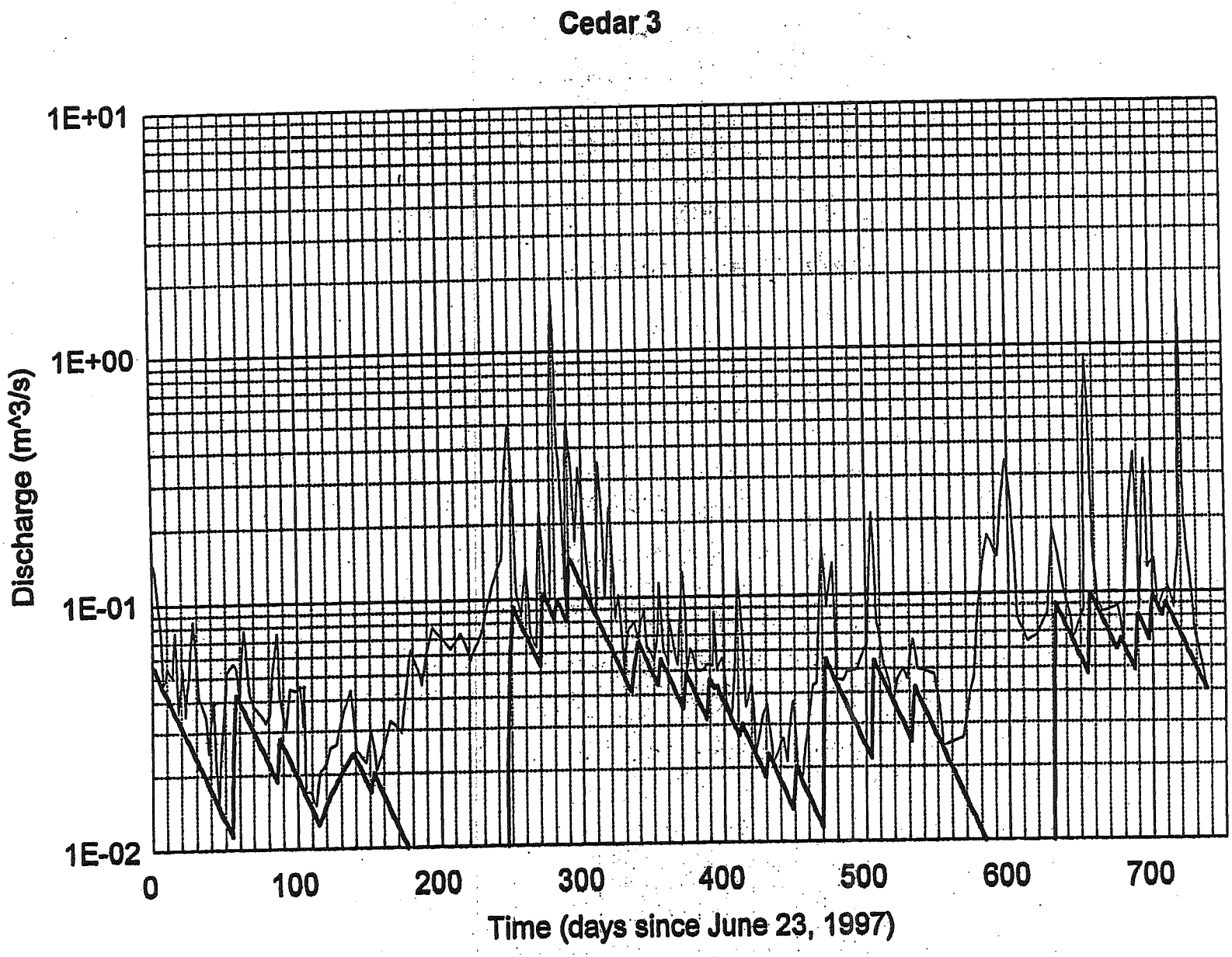
Cedar 1 (CE1)
Cedar 2 (CE2)
Cedar 3 (CE3)
Coney (CO)
Kinnickinnic (KK)
Menomonee (M1)
West Branch 1 (WB1)
West Branch 2 (WB2)
West Branch 3 (WB3)
Willow 1 (W1)
Willow 2 (W2)

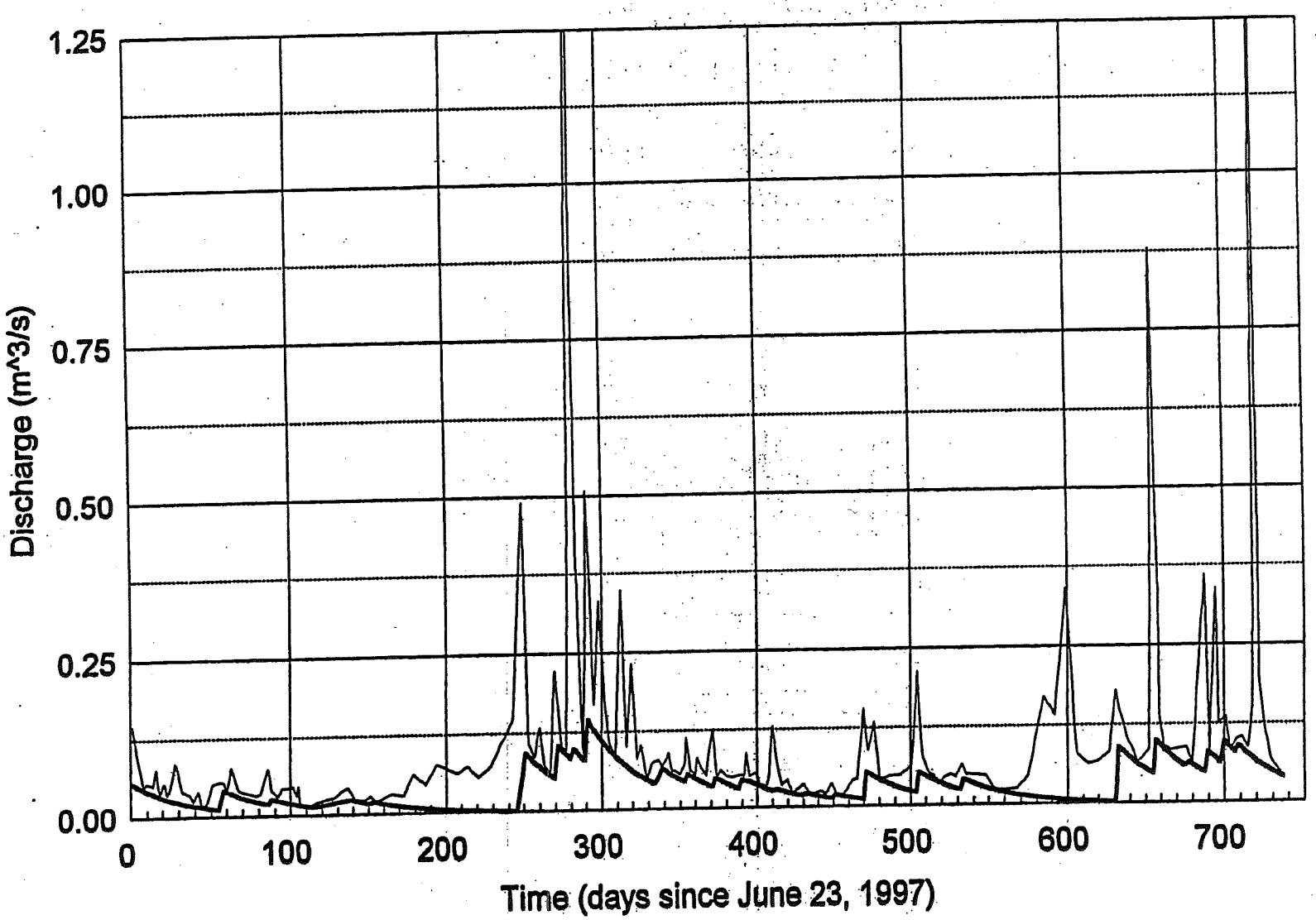

Cedar 1
1E+01
1E+00
1E-01
1E-02
1E-03
Discharge (m^3/s)
0
100
200
300
400
500
600
700
Time (days since June 23, 1997)

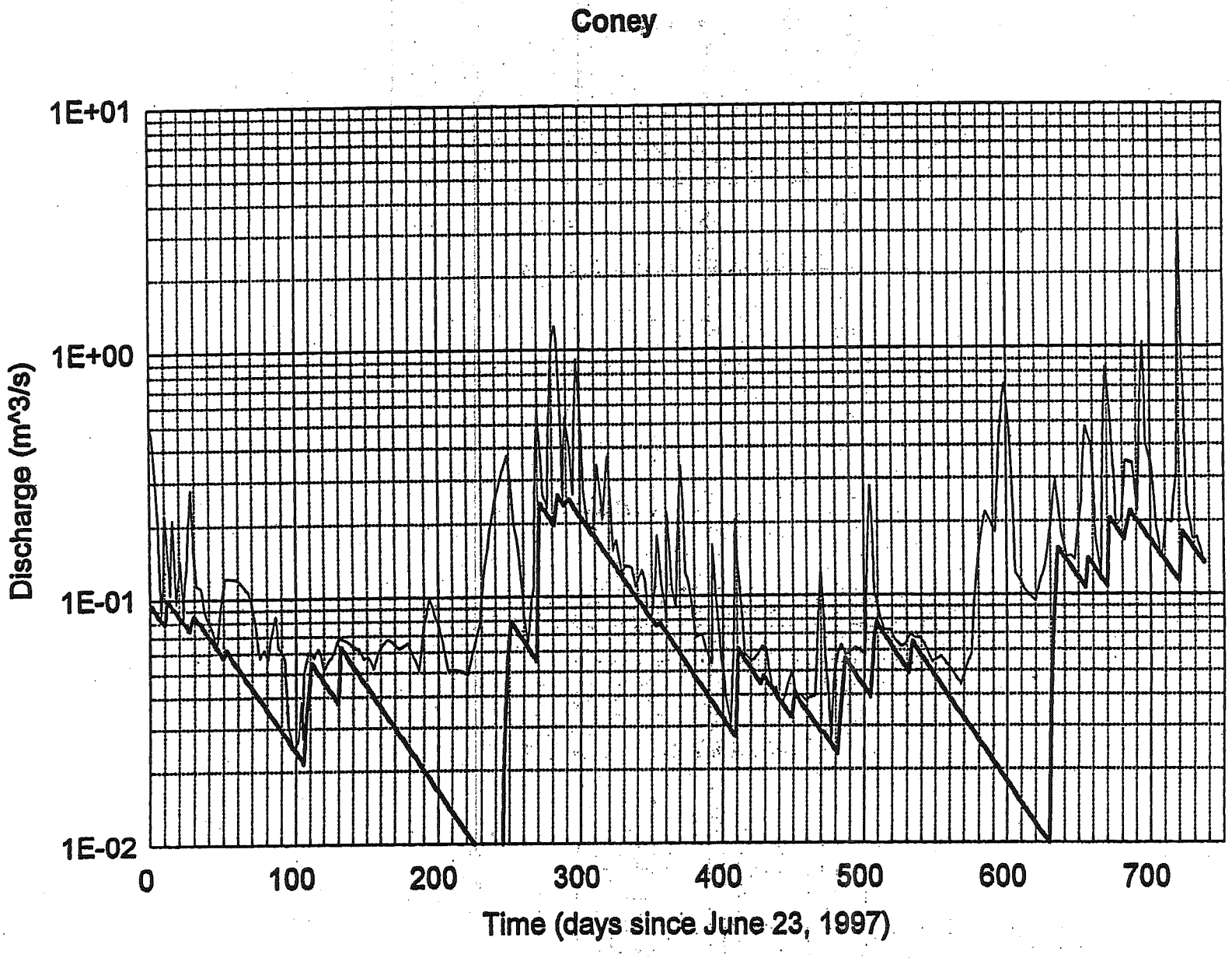

Cedar 1
Discharge (m^3/s)
1.25
1.00
0.75
0.50
0.25
0.00
0
100
200
300
400
500
600
700
Time (days since June 23, 1997)

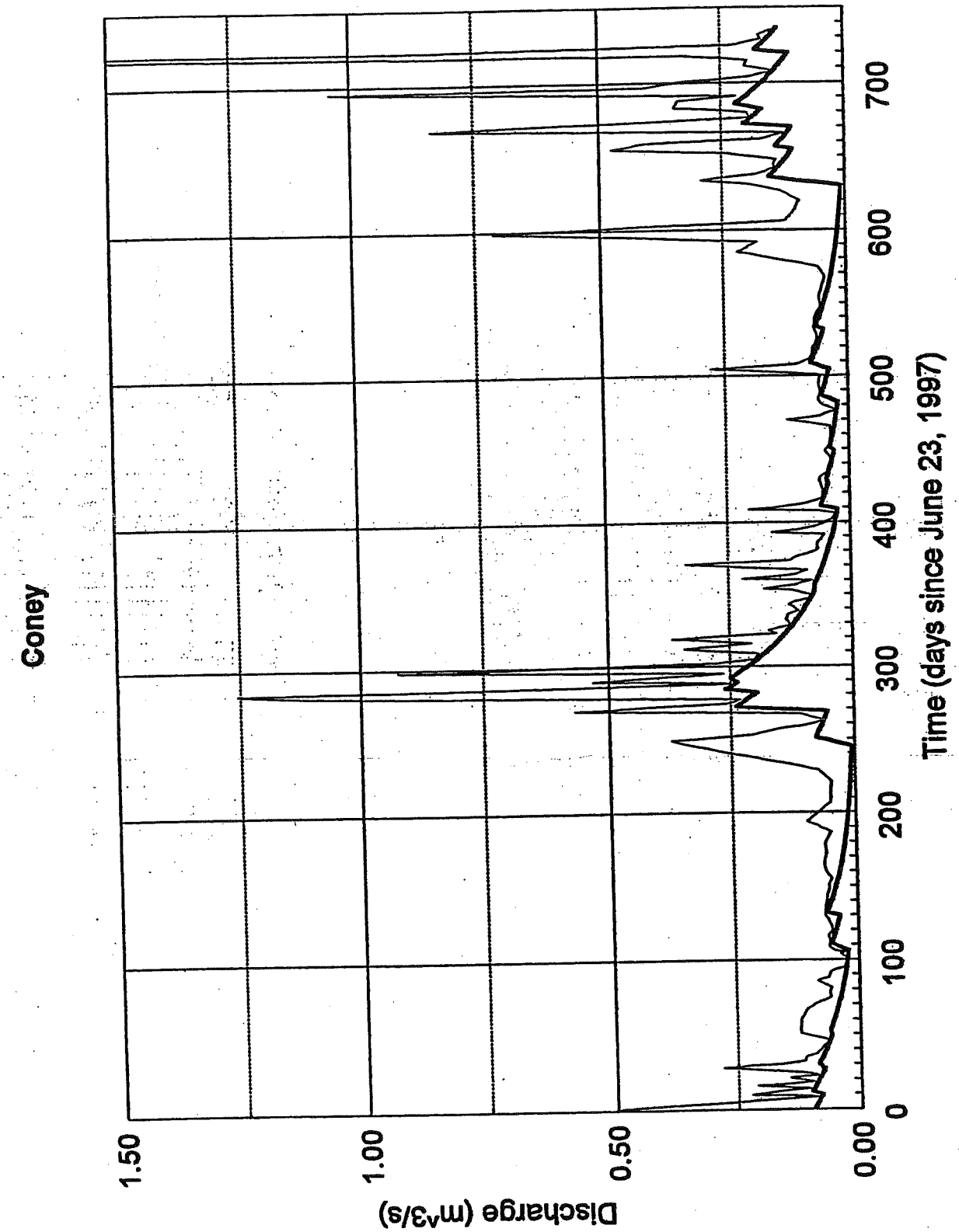

Cedar 2
1E+01
1E+00
1E-01
1E-02
Discharge (m^3/s)
0
100
200
300
400
500
600
700
Time (days since June 23, 1997)

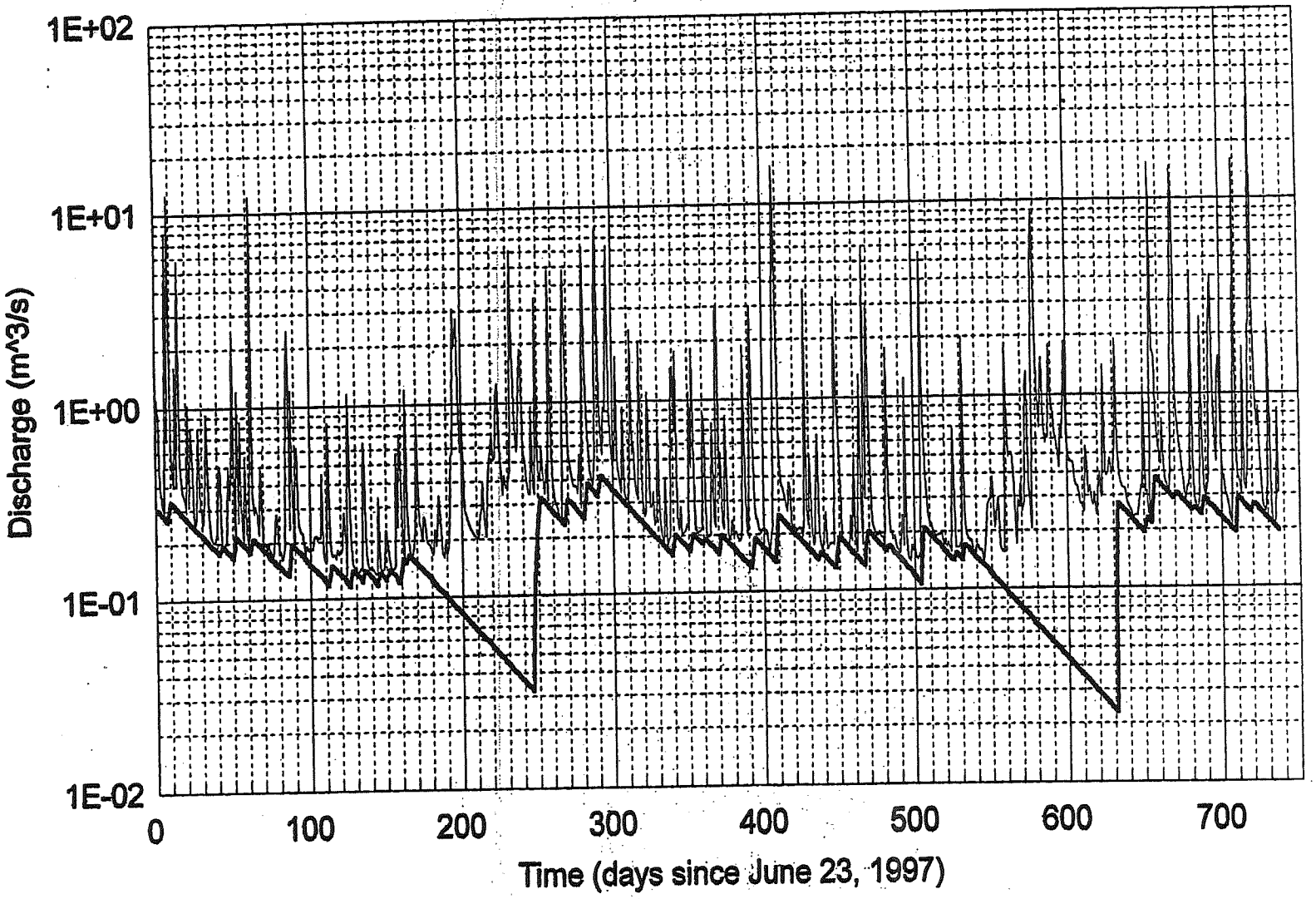

Cedar 2
Discharge (m^3/s)
1.50
1.00
0.50
0.00
0
100
200
300
400
500
600
700
Time (days since June 23, 1997)

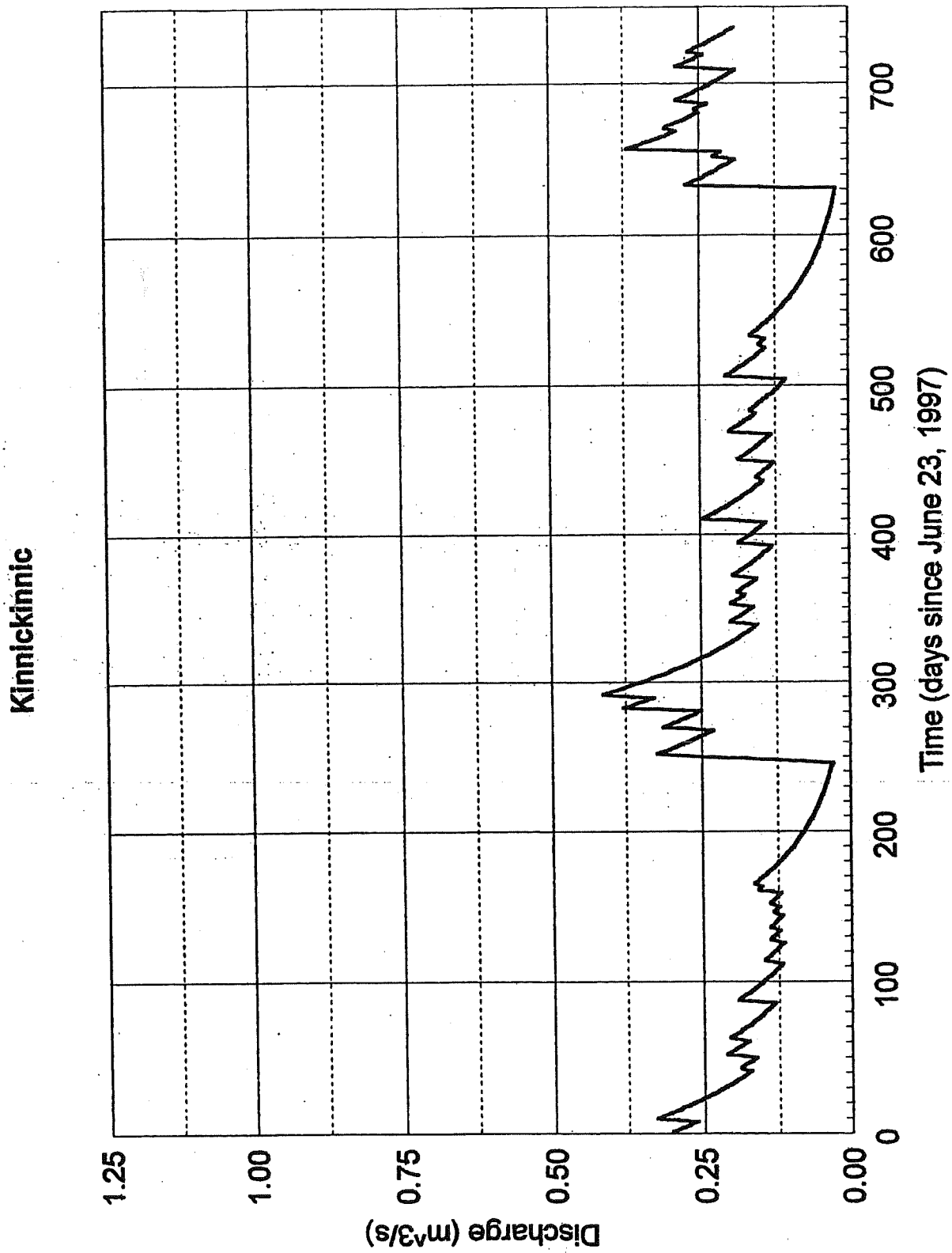

Cedar 3
1E+01
1E+00
1E-01
1E-02
Discharge (m^3/s)
0
100
200
300
400
500
600
700
Time (days since June 23, 1997)

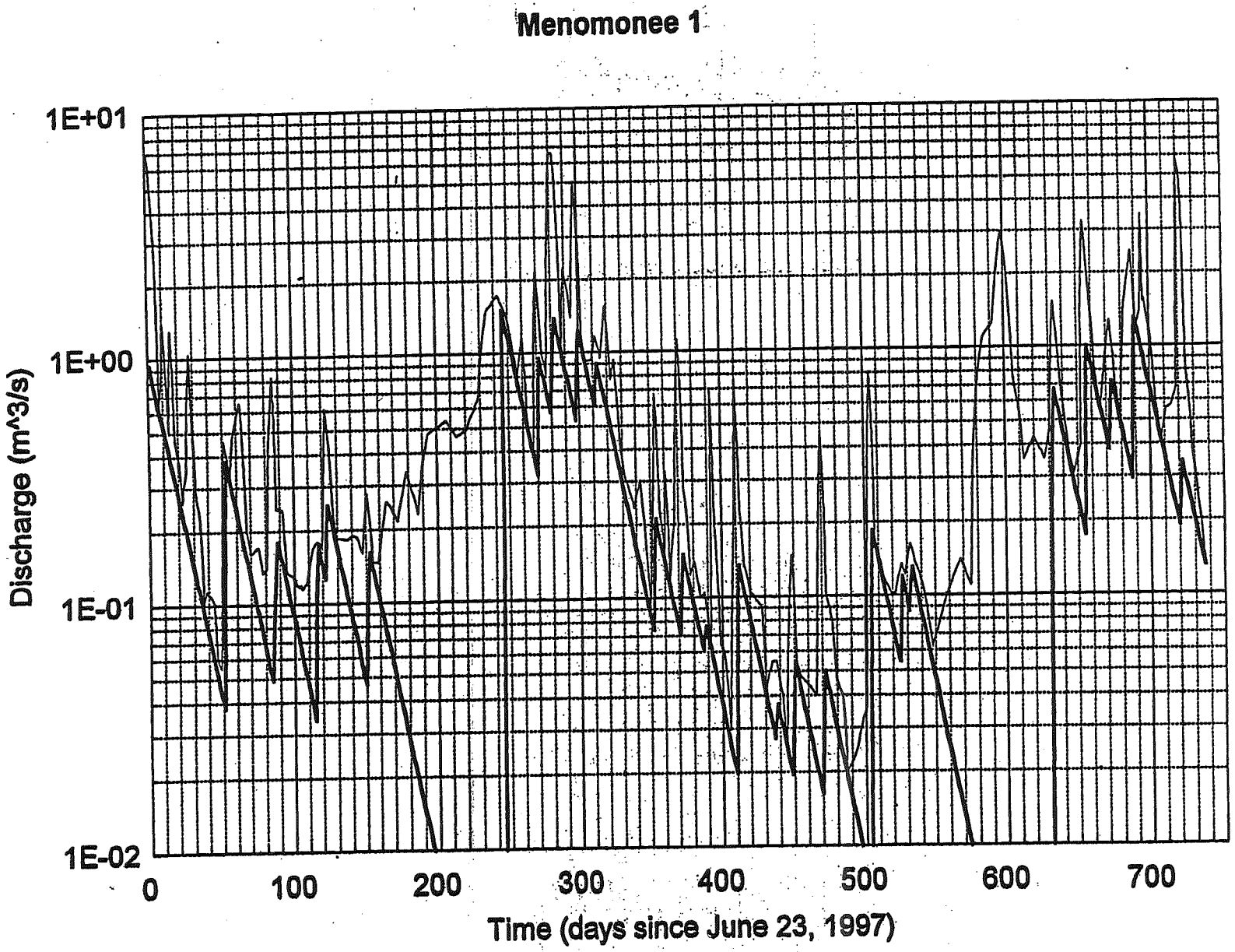

Cedar 3
1.25
1.00
0.75
0.50
0.25
0.00
Discharge (m^3/s)
0
100
200
300
400
500
600
700
Time (days since June 23, 1997)

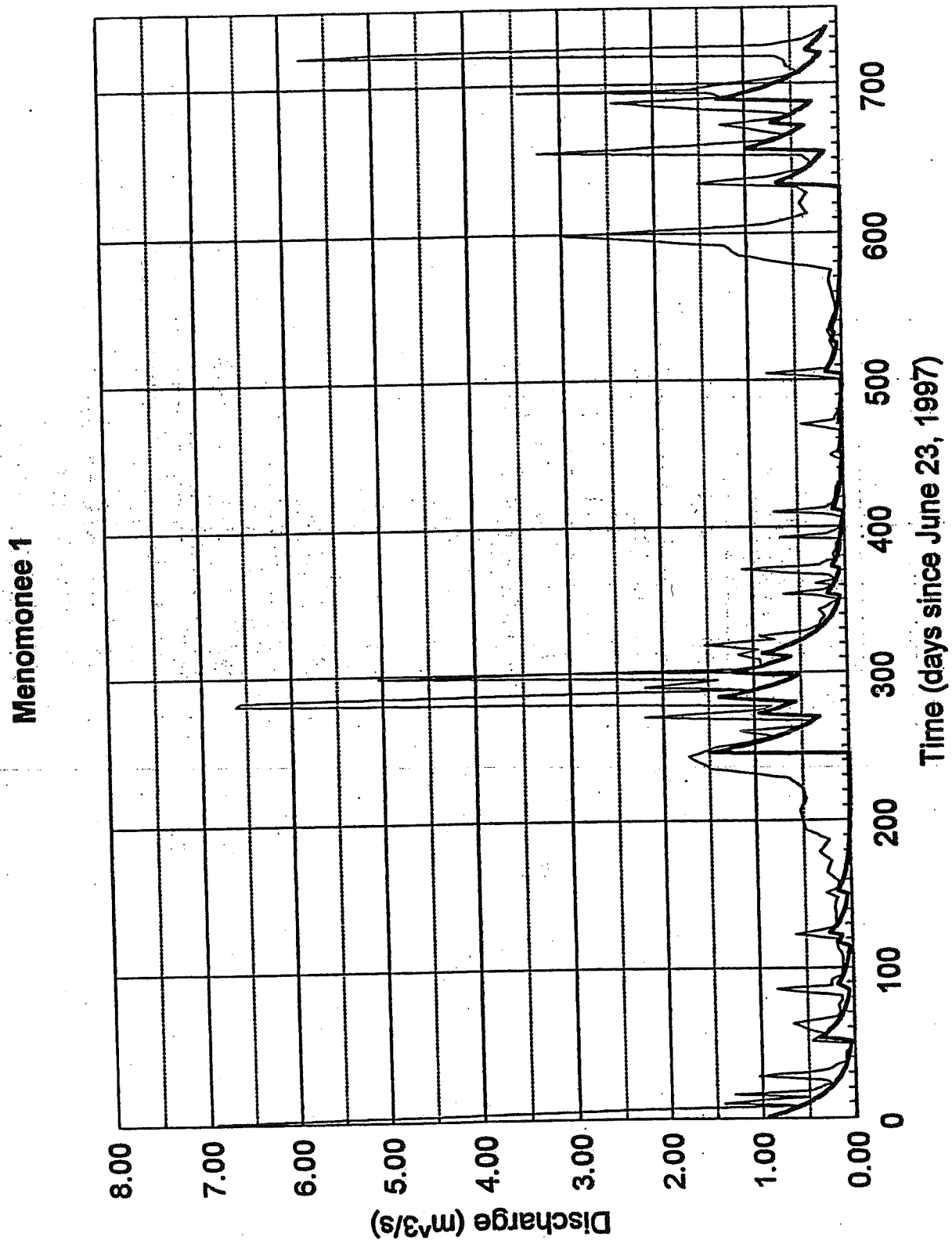

Coney
1E+01
1E+00
1E-01
1E-02
Discharge (m^3/s)
0
100
200
300
400
500
600
700
Time (days since June 23, 1997)

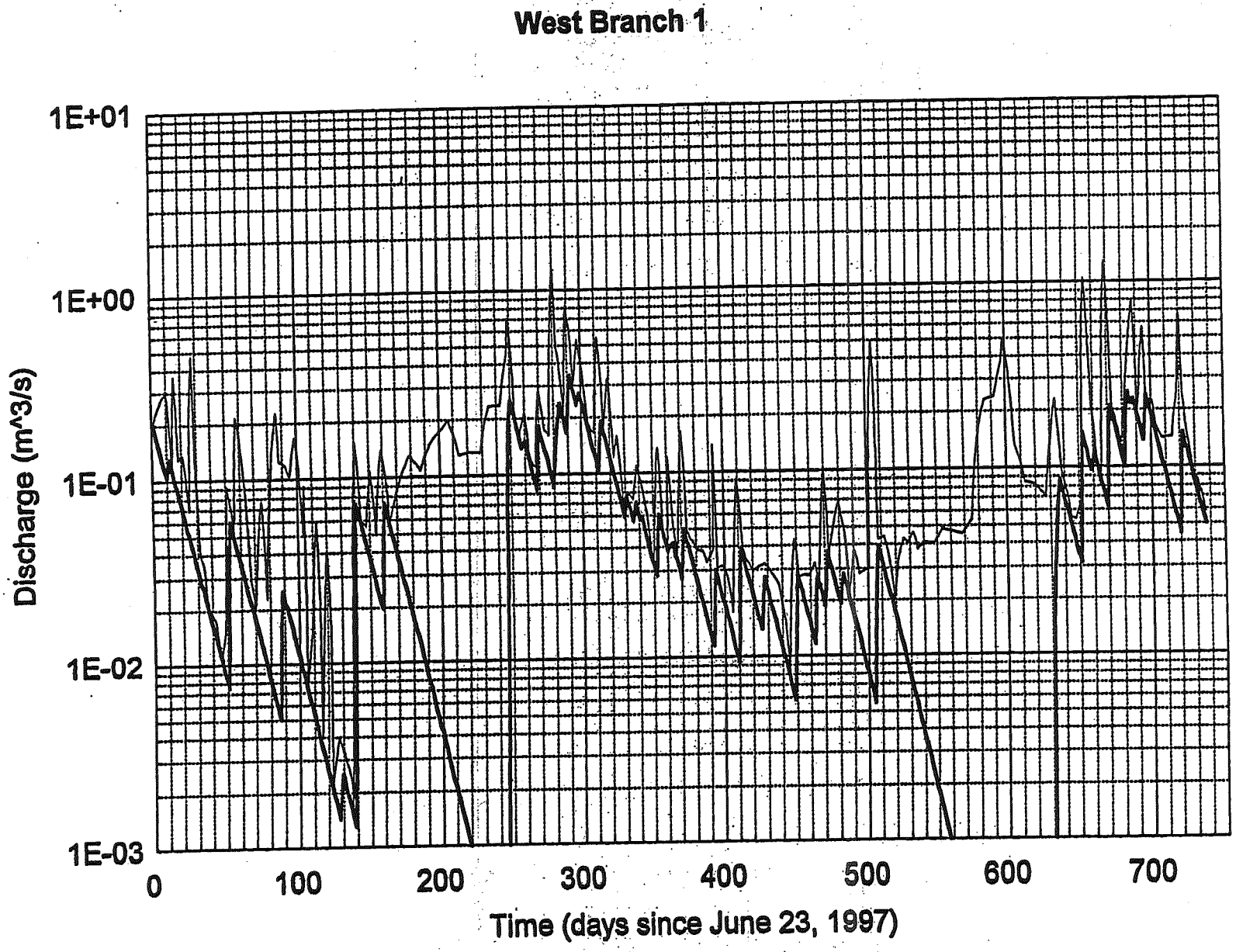

Coney
Discharge (m^3/s)
1.50
1.00
0.50
0.00
0
100
200
300
400
500
600
700
Time (days since June 23, 1997)

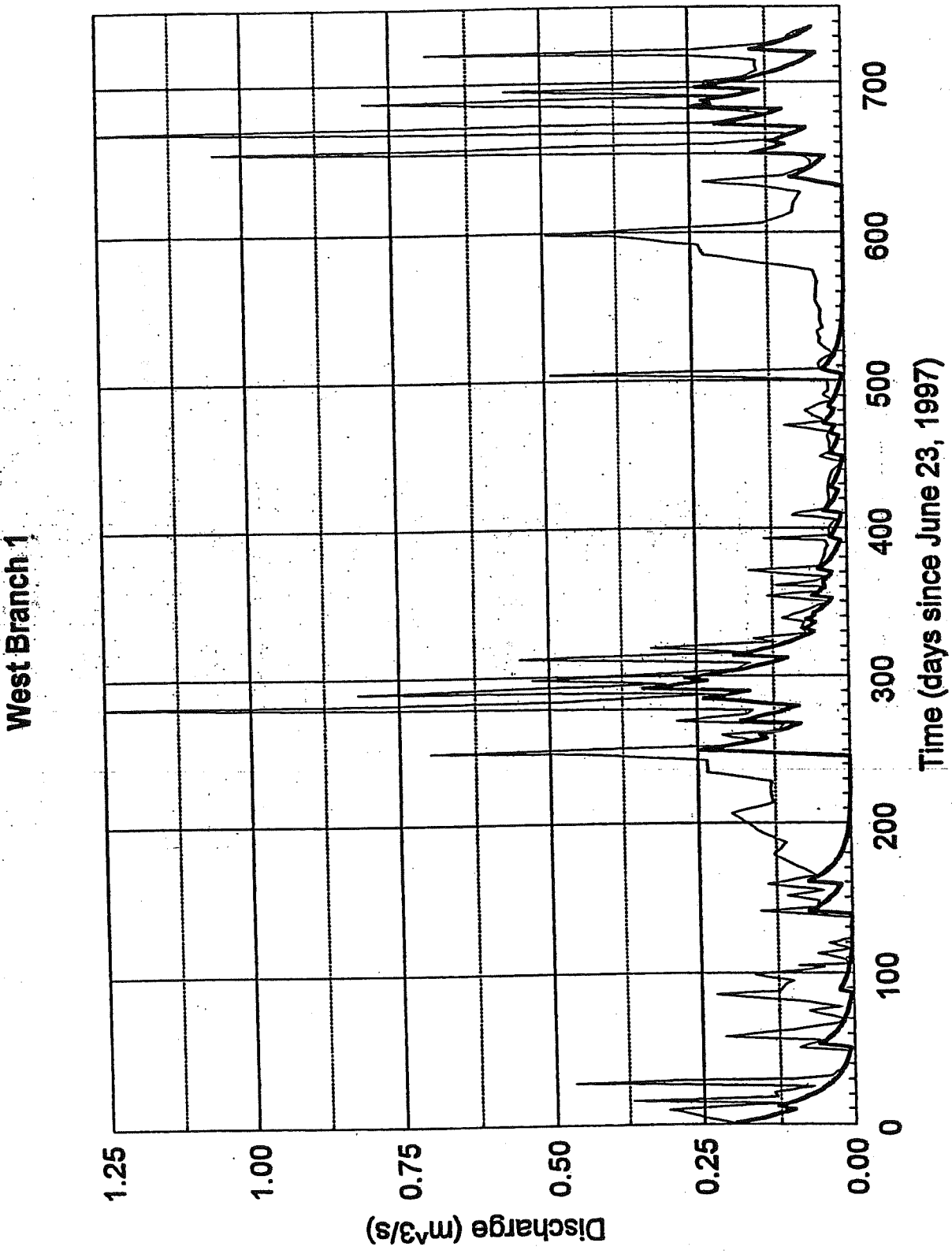

Kinnickinnic
1E+02
1E+01
1E+00
1E-01
1E-02
Discharge (m^3/s)
0
100
200
300
400
500
600
700
Time (days since June 23, 1997)

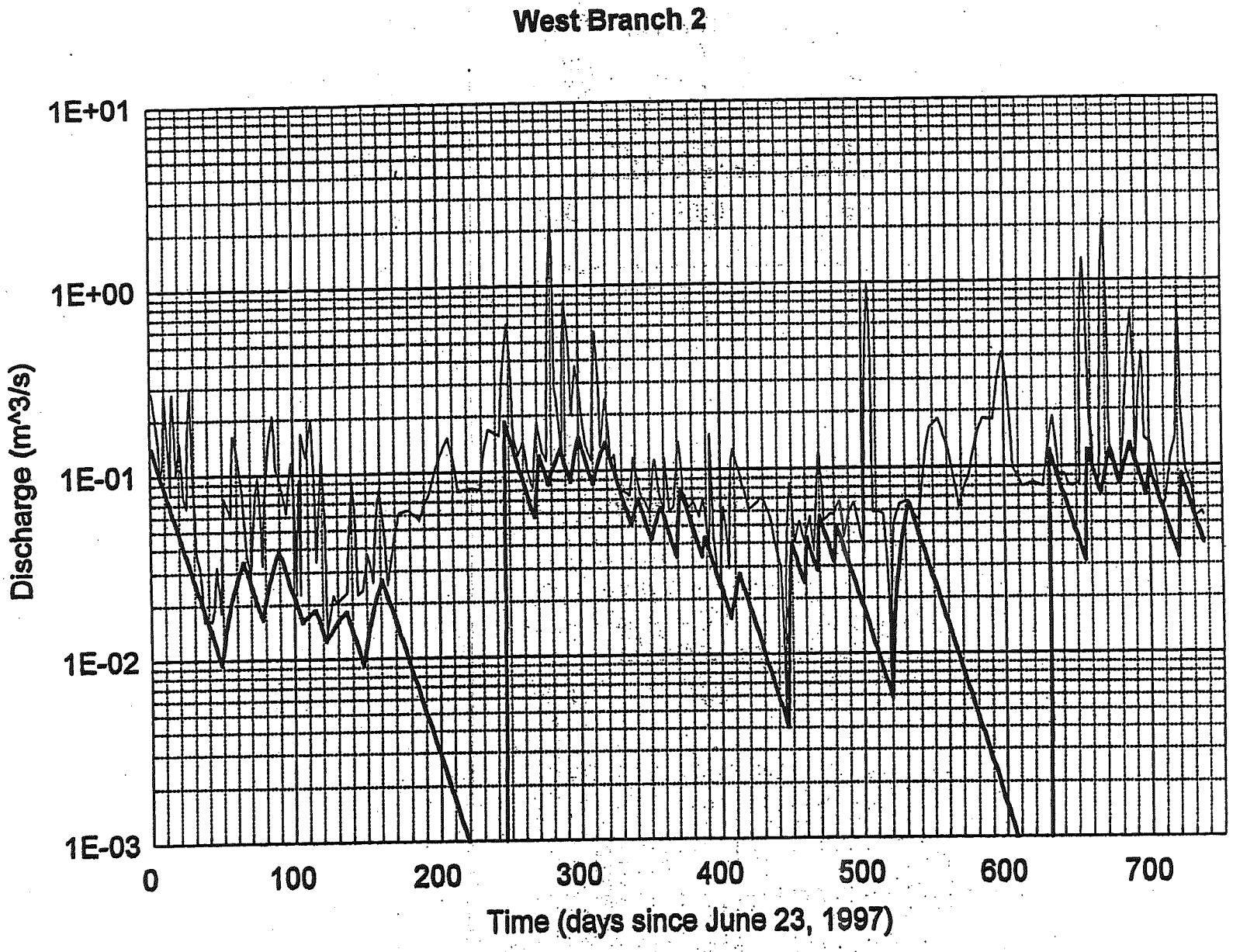

Kinnickinnic
Discharge (m^3/s)
1.25
1.00
0.75
0.50
0.25
0.00
0
100
200
300
400
500
600
700
Time (days since June 23, 1997)

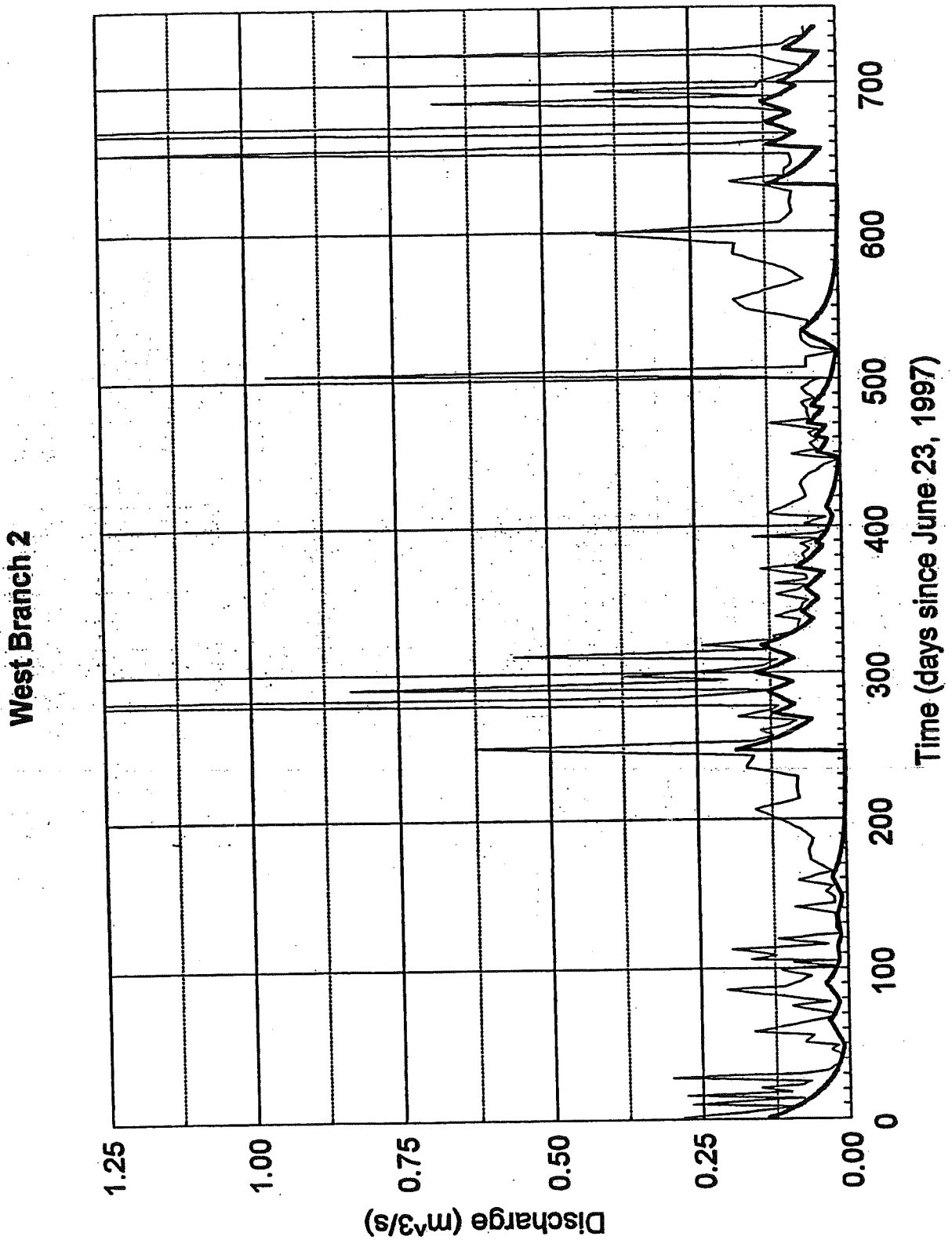

Menomonee 1
1E+01
1E+00
1E-01
1E-02
Discharge (m^3/s)
0
100
200
300
400
500
600
700
Time (days since June 23, 1997)

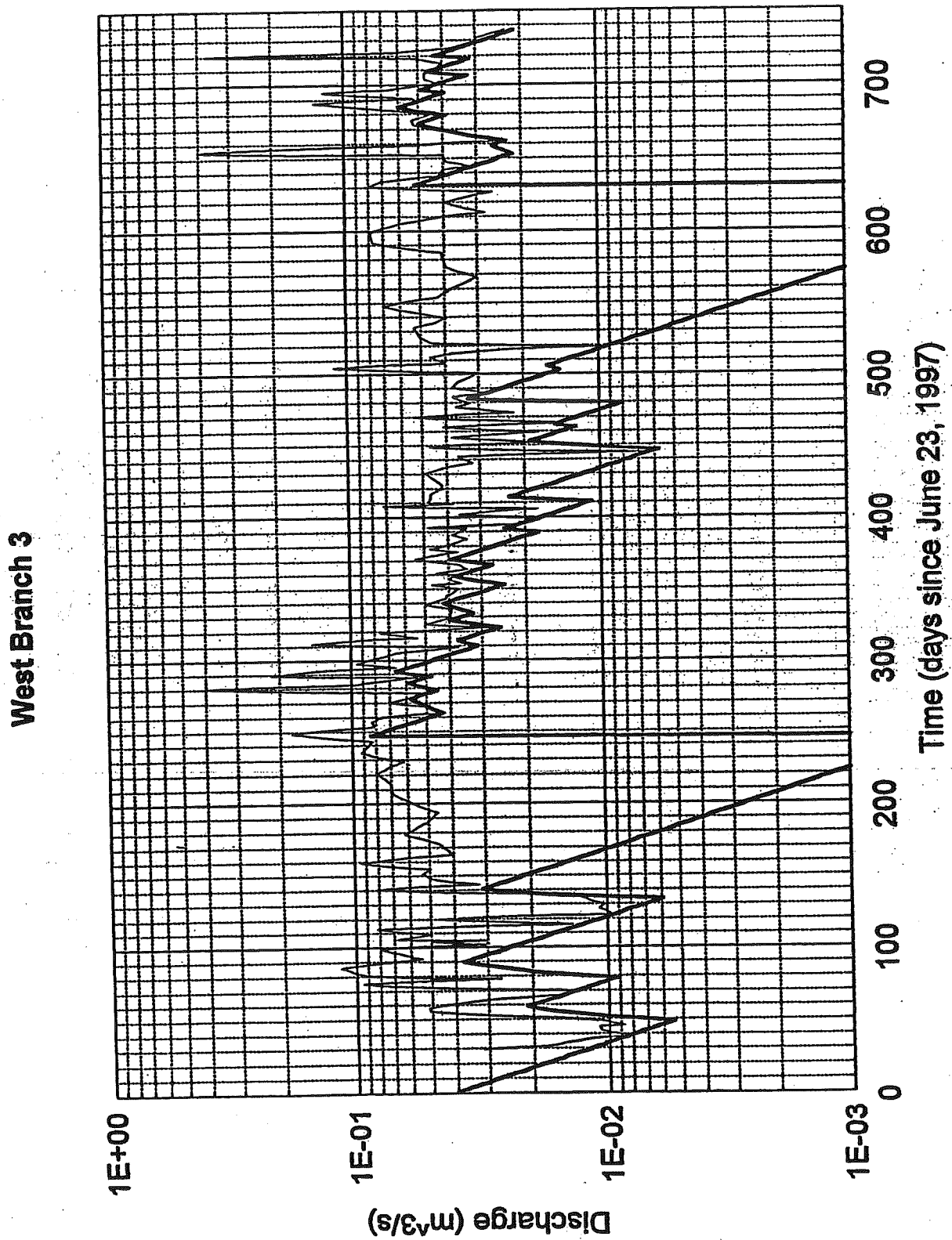

Menomonee 1
Discharge (m^3/s)
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0
100
200
300
400
500
600
700
Time (days since June 23, 1997)

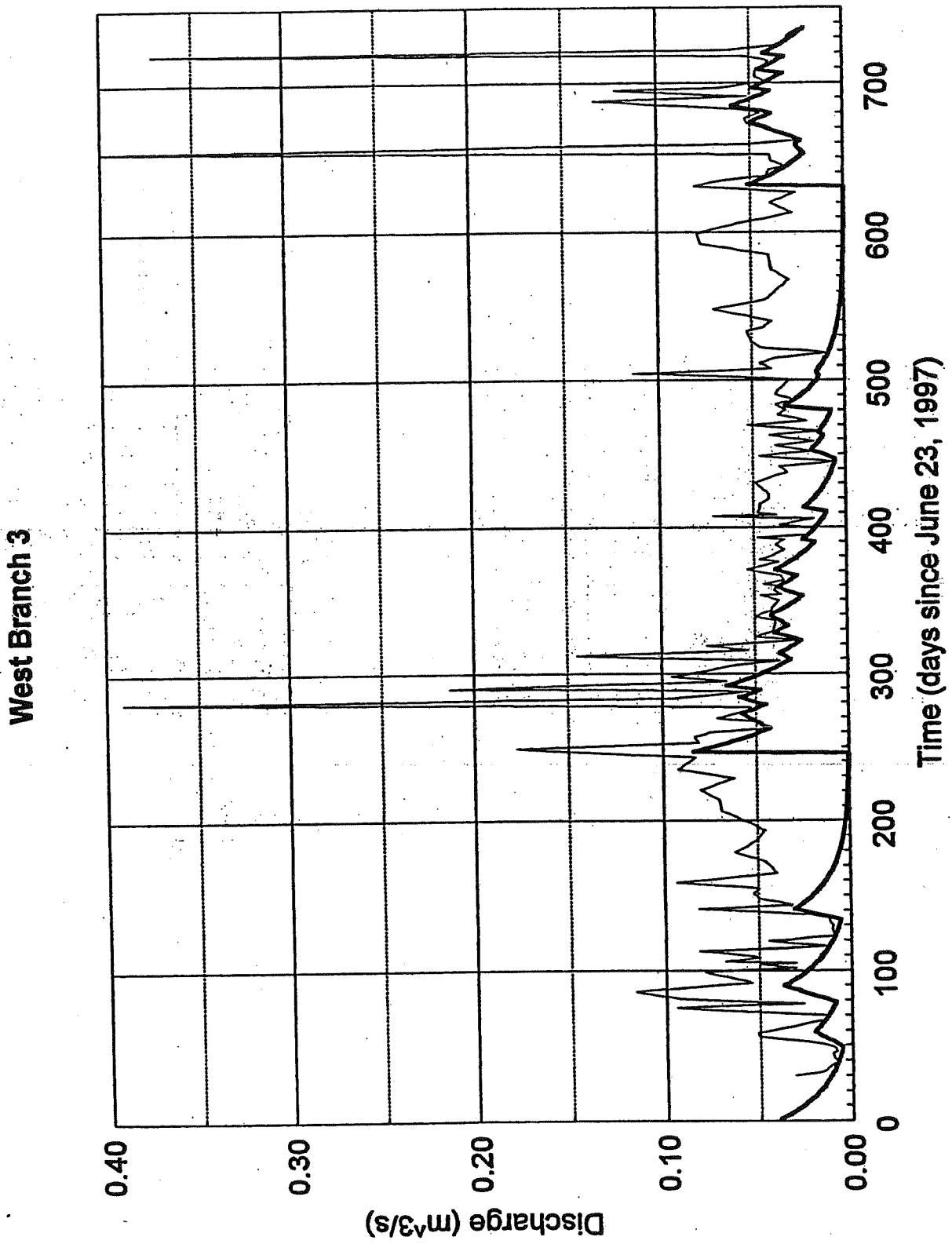

West Branch 1
1E+01
1E+00
1E-01
1E-02
1E-03
Discharge (m^3/s)
0
100
200
300
400
500
600
700
Time (days since June 23, 1997)

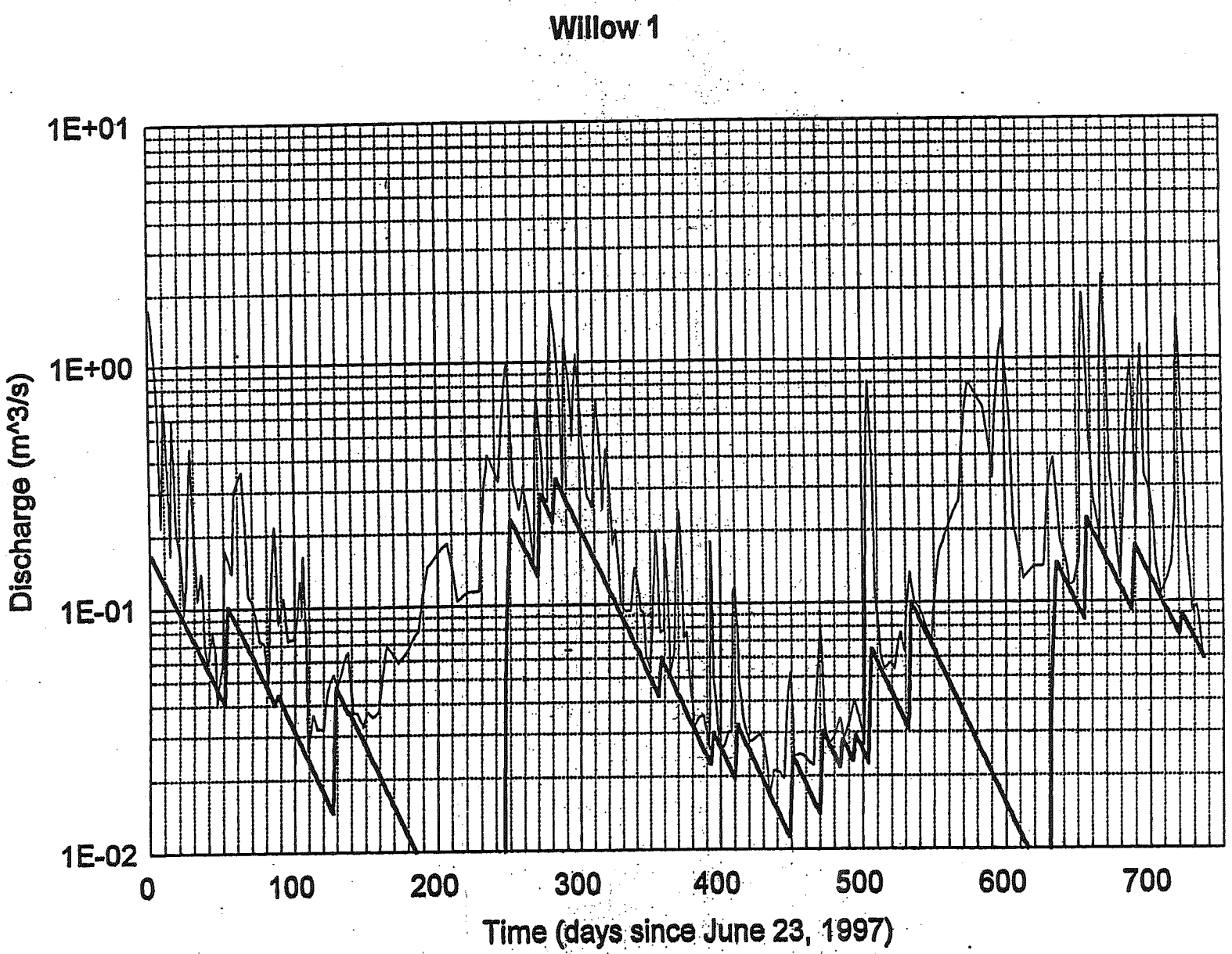

West Branch 1
Discharge (m^3/s)
1.25
1.00
0.75
0.50
0.25
0.00
0
100
200
300
400
500
600
700
Time (days since June 23, 1997)

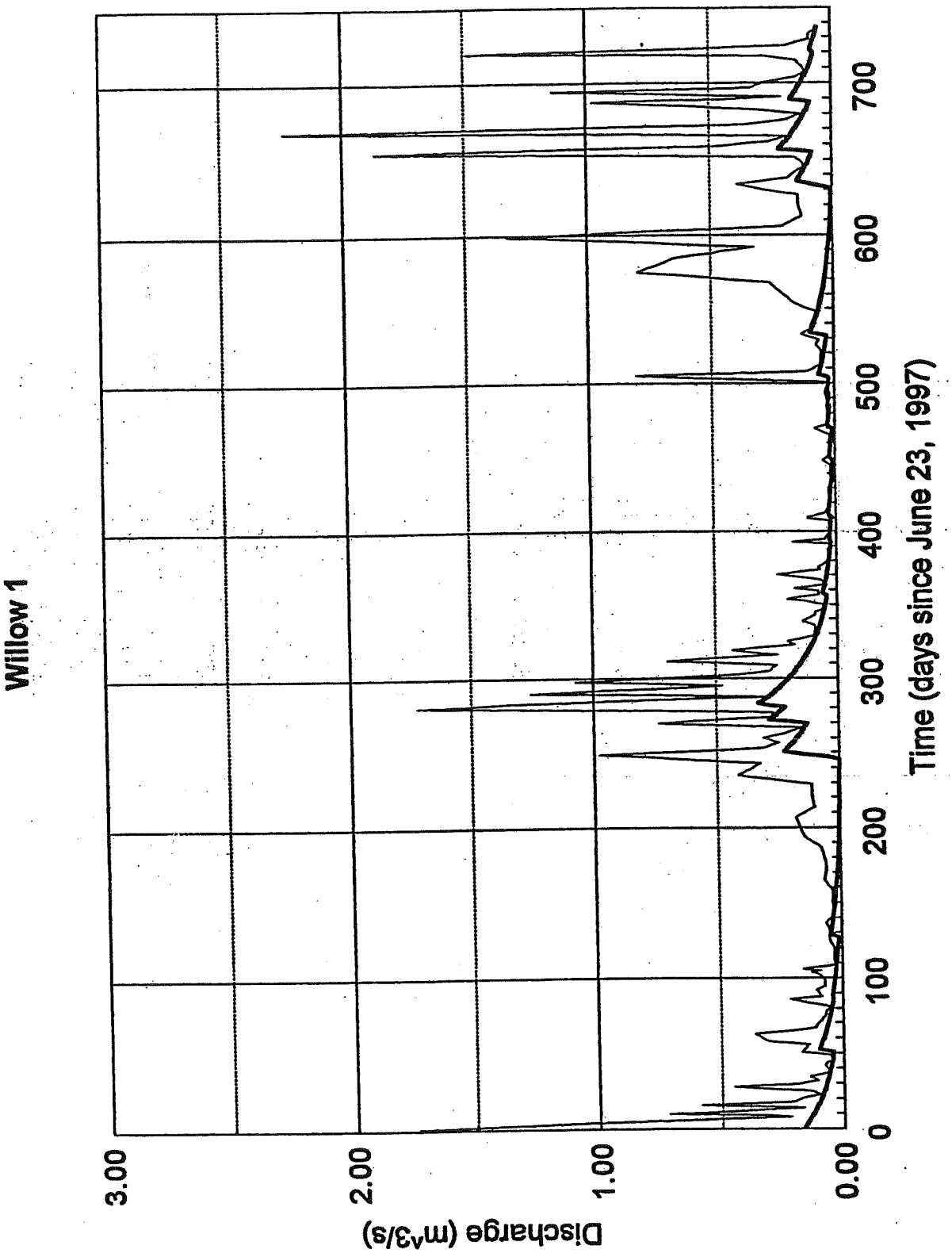

West Branch 2
1E+01
1E+00
1E-01
1E-02
1E-03
Discharge (m^3/s)
0
100
200
300
400
500
600
700
Time (days since June 23, 1997)

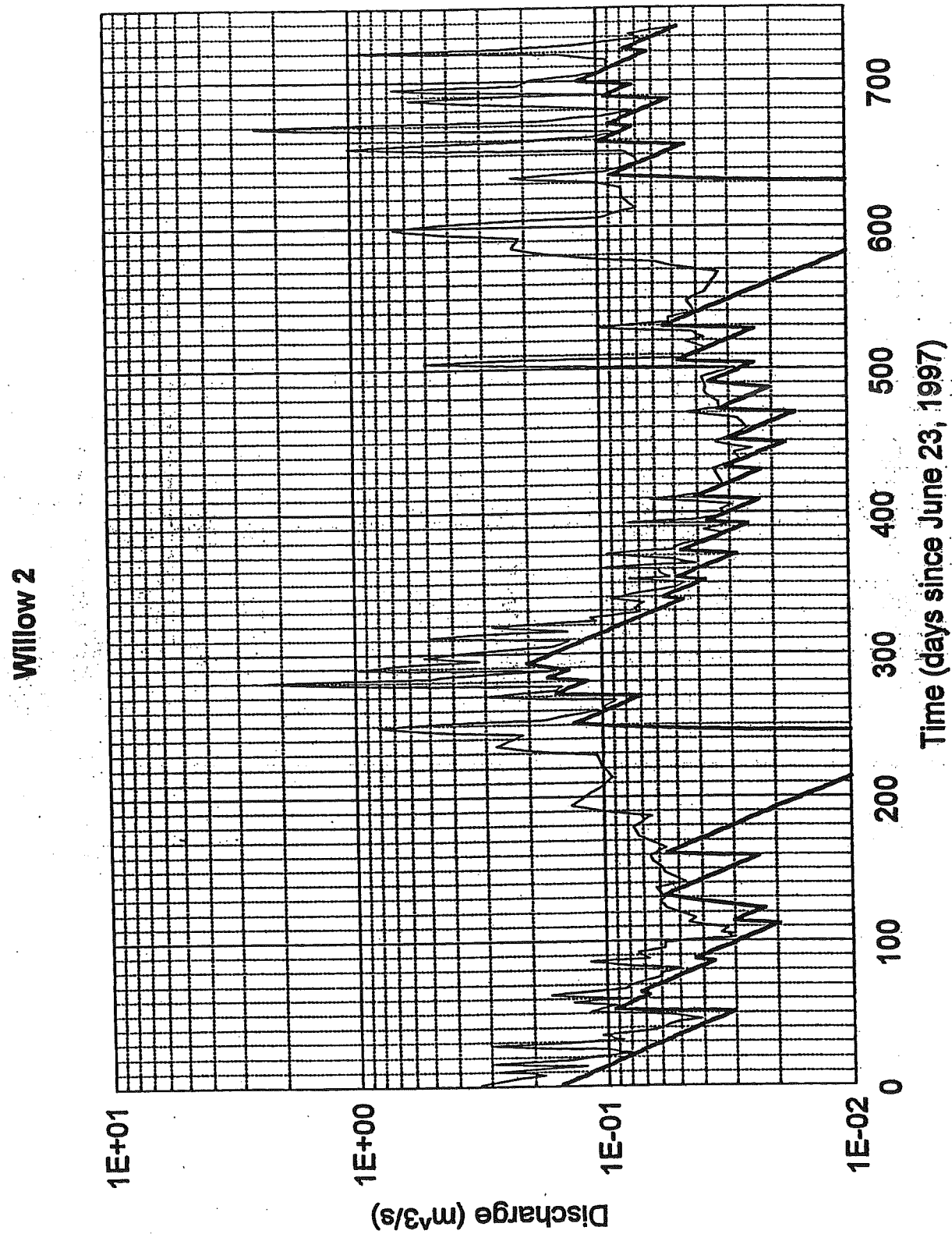

West Branch 2
Discharge (m^3/s)
1.25
1.00
0.75
0.50
0.25
0.00
0
100
200
300
400
500
600
700
Time (days since June 23, 1997)

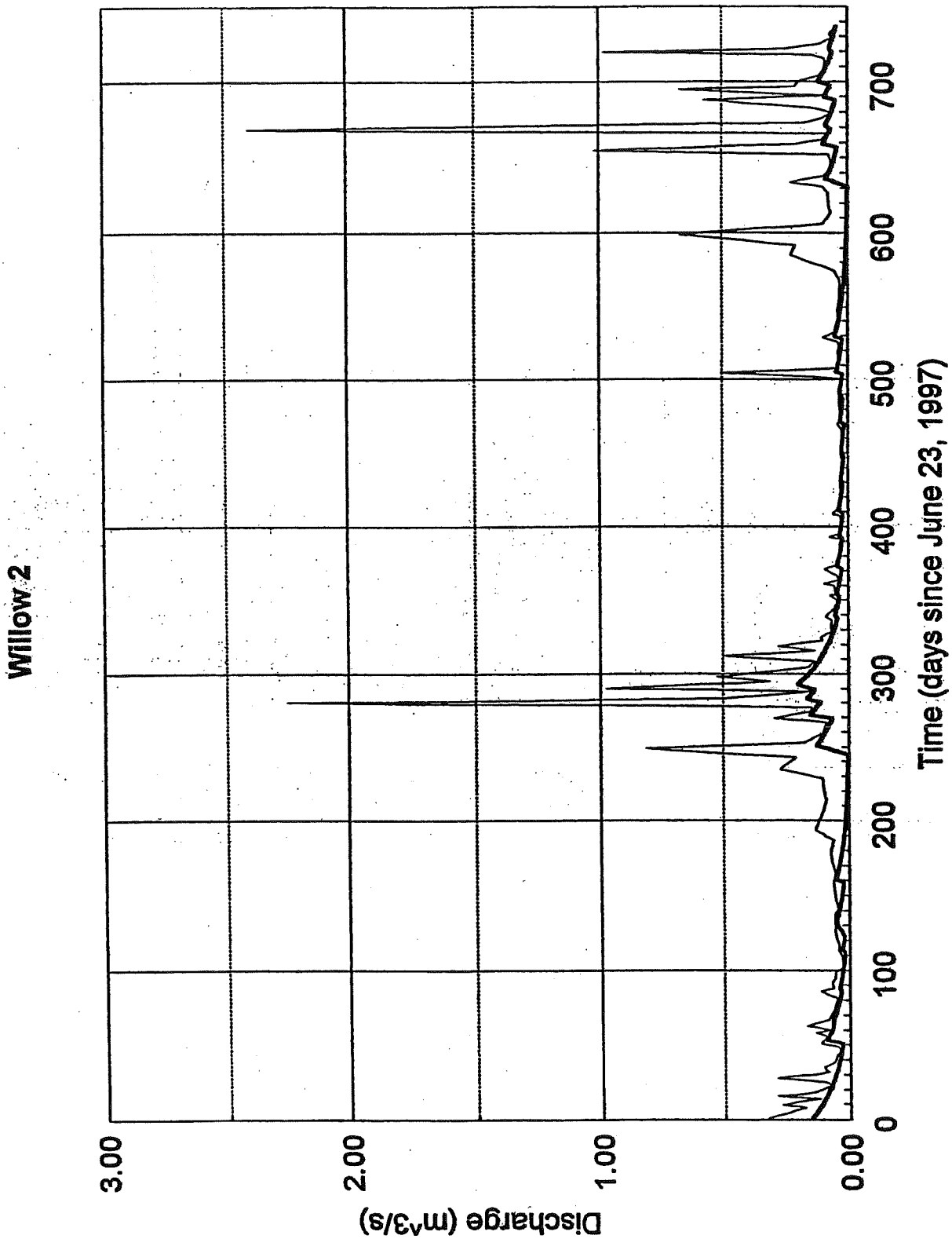

West Branch 3
1E+00
1E-01
1E-02
1E-03
Discharge (m^3/s)
0
100
200
300
400
500
600
700
Time (days since June 23, 1997)


West Branch 3
Discharge (m^3/s)
0.40
0.30
0.20
0.10
0.00
0
100
200
300
400
500
600
700
Time (days since June 23, 1997)


Willow 1
1E+01
1E+00
1E-01
1E-02
Discharge (m^3/s)
0
100
200
300
400
500
600
700
Time (days since June 23, 1997)


Willow 1
Discharge (m^3/s)
3.00
2.00
1.00
0.00
0
100
200
300
400
500
600
700
Time (days since June 23, 1997)


Willow 2
Discharge (m^3/s)
1E+01
1E+00
1E-01
1E-02
0
100
200
300
400
500
600
700
Time (days since June 23, 1997)


Willow 2
Discharge (m^3/s)
3.00
2.00
1.00
0.00
0
100
200
300
400
500
600
700
Time (days since June 23, 1997)